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ENGINEERING SOLUTIONS FOR PCB MANUFACTURING

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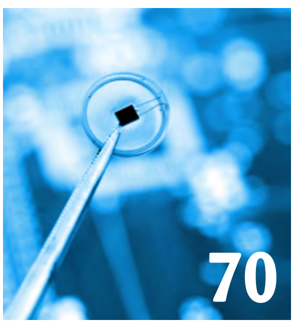
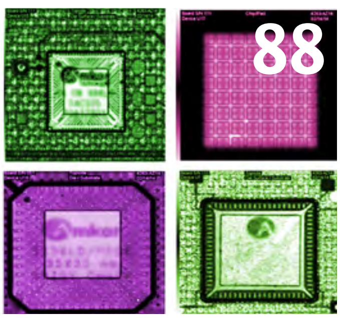
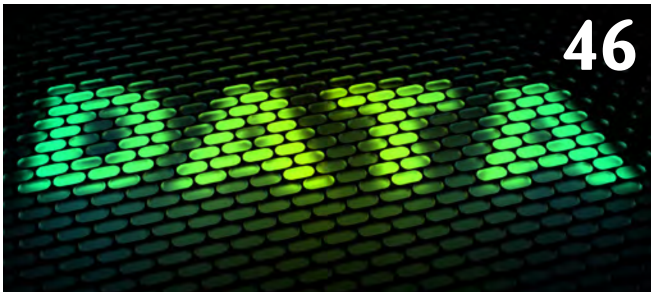
MILITARY and AEROSPACE

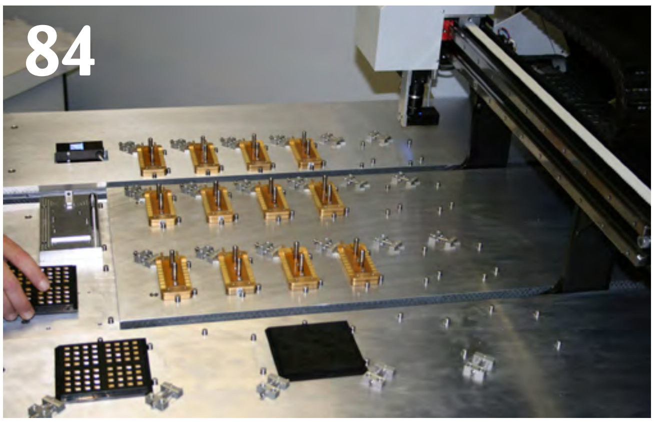




Military and Aerospace

This issue of *SMT Magazine* looks into the latest military and aerospace electronics technology trends, manufacturing challenges, and outlook, and how they impact the PCB assembly industry.





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Failure is Not an Option

by Stephen Las Marias
I-CONNECT007

The global aerospace and defense sector is expected to return to positive growth this year after several years of downturn, according to a study by Deloitte. The research pointed out the stable growth in GDP worldwide, lower commodity prices—in particular crude oil—and strong passenger travel demand as main drivers for the commercial aerospace subsector.

When it comes to the global defense sector, the resurgence of security threats and growth in defense budgets in many countries will likely promote the industry over the next few years. Deloitte's report noted increasing international demand for defense and military products as uncertainties brought on by regional tensions in the Middle East, Eastern Europe, North Korea, and the East and South China Seas may lead to increases in defense budgets and purchases of next generation military equipment.

Overall, Deloitte forecasts the global aerospace and defense sector revenues to grow by 3% this year.

Sitting in the Philippines, I can say that the trends mentioned in the study are true. Allow me to oversimplify some of these trends I am seeing. For one, the Philippines is currently having a territorial dispute with China regarding the West Philippine Sea (in the South China Sea). Despite a unanimous ruling recently by the Arbitral Tribunal at the Permanent Court of Arbitration in The Hague in favor of the Philippines in its case against China's claims to all of South China Sea, the situation remains tense as China refuses to recognize and accept the results of the arbitration. Because of this, the Philippines has been upgrading its naval capabilities to shore up its defense of the contested islands and waters. I believe the country will continue to do so, and expand the upgrades to other sectors of its armed forces—including army, air force, and coast guards. Next, the Philippines has been, and for the longest time that I can remember, engaged in a battle with terrorists in the southern part of the country. And I cannot

see it winning anytime soon because of matters that I won't bother to discuss here. So as I've said, quite simply, such threats to national security are driving the growth of the military/defense industry. And that's just in the Philippines alone.

On the aerospace front—let me touch on commercial aerospace—the growing middle class in the Philippines, and in fact all over the ASEAN region, for example, is fueling the growth of international travel within and outside of Asia. This, coupled with the lingering low cost of oil, is driving airline companies to modernize and expand their fleet.

Meanwhile, the military satellites market is also on the rise. According to market analyst visiongain, the military satellites market is set to be worth $14.37 billion in 2016, driven by national governments' ever-greater demands for military satellite bandwidth to ensure information superiority.

Another growing market is the smart weapons segment, which, according to MarketsandMarkets, is estimated to reach $15.64 billion by 2021. The global man-portable military electronics market, on the other hand, is poised to rise from a value of $15.1 billion in 2012 to $19.67 billion in 2019, according to a recent study by Transparency Market Research. Man-portable military electronics comprise portable electronics equipment that enhances the capabilities of military personnel in the battlefield.

All these broader trends are providing context to the rise in activities in the SMT, PCB assembly, and EMS industries catering to the military/defense and aerospace markets. After all, these systems—which are getting more and more advanced—have in their hearts the one thing that connects them all: electronics.

I don't know if you read about this, but in December 2014, AirAsia Flight 8501 bound for Singapore from Surabaya, Indonesia, crashed into the Java Sea—killing all 155 passengers and seven crew on board. One of the key points mentioned in Indonesia's transportation authorities' report about the incident after a year of investigation was a cracked solder joint in the rudder travel limiter (RTL) unit.

A cracked solder joint. Who would have known, right? But then again, someone should know—the electronics assemblers and manufacturers. In this industry, failure is not an option. Therefore, all checks and tests should have been made to ensure the reliability of these electronics systems given the harsh conditions they operate in.

According to our recent survey, among the greatest challenges faced by electronics assemblers when it comes to the military and aerospace markets are compliance, obsolete and fake components, and reliability—and in particular, long-term reliability. Miniaturization is also an issue, leading to challenges in soldering these smaller and smaller devices in smaller and smaller footprints, and the huge amount of testing involved to ensure the quality of the finished products.

This leads me to this month's issue of SMT Magazine, which includes strategies to address the manufacturing challenges and compliance issues when dealing with military and aerospace products and systems.

First, Mitch Holtzer of Alpha Assembly Solutions writes about reworking defective military and aerospace electronics assemblies, and recovering the value of the substrate and components without compromising the top secret design of the circuit.

David Pinsky of Raytheon Integrated Defense Systems, together with Tom Hester of Raytheon Space and Airborne Systems, Dr. Anduin Touw of Boeing, and Dave Hillman of Rockwell Collins write about a study performed by IPC Task group 8-81f about mitigating risks associated with whisker growth from pure tin solderable terminations to guide high-reliability end-users on the applicability and limitations of this mitigation strategy.

Michael Ford of Mentor Graphics, meanwhile, discusses the need for traceability standards in certain critical segments of the electronics manufacturing industry, including aerospace, automotive, and medical devices.

Dr. Reza Ghaffarian of NASA's Jet Propulsion Laboratory writes about an inspection technique to detect defects in flip-chip packages and assemblies.

I interviewed Albert Yanez of Asteelflash, Americas, to discuss the challenges and opportunities in the military and aerospace industries, including ITAR compliance. He also provides some points to consider when selecting an EMS provider.

I also spoke with Dr. Jay Sabido of Philippine-based Ionics EMS Inc. We discussed EMS trends and opportunities in the country, as well as talked about the challenges EMS firms faced when dealing with military/aerospace electronics, and ensuring supply chain integrity.

Allen Dill of Blackfox Training Institute writes about their advanced manufacturing program for military veterans, and how it enables these veterans to qualify for employment in aerospace, defense, medical, and other facets of electronic manufacturing. His colleague, Sharon Montana-Beard, meanwhile discussed the IPC Certification Program's Space Hardware Addendums training and certification, the topics covered in the training course, and the program benefits.

As always, we have our stable of expert columnists to provide their insights on the different aspects of the electronics manufacturing and assembly industry.

First, Dr. Jennie S. Hwang picks up from where she left a few months ago to write the fourth part of her column series on the theory behind tin whisker phenomena.

Robert Voigt, on the other hand, discusses specifying a custom machine when users are faced with an unusual product configuration, a unique space requirement, an unorthodox handling system, or an application totally unrelated to the PCB or SMT assembly business.

Ford's column this month, meanwhile, takes the lid off the shop-floor digitization issue once and for all, to determine how what the industry will do today will be different from past challenges that caused people to move forward cautiously when it comes to solutions related to Industry 4.0 or the smart factory.

Last but not least, Tom Borkes writes about how the complexity and rapid rate of change in the electronics assembly industry has not permitted the academic community to properly educate the student—and what must be done to address the issue.

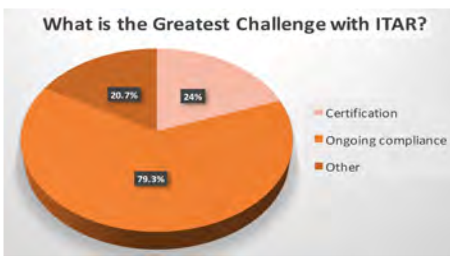
I hope you enjoy this month's issue of *SMT Magazine*. Next month, we will focus on leadership—what makes a great leader and the changing roles of the leader in this industry. Stay tuned! **SMT**

Stephen Las Marias is managing editor of *SMT Magazine*. He has been a technology editor for more than 12 years covering electronics, components, and industrial automation systems.

I-Connect007 Survey: A Look at the Mil/Aero Industry—ITAR

Source: I-Connect007

The International Traffic in Arms Regulations (ITAR) is a set of United States Government regulations on the export and import of defense-related articles, related technical data and defense services. EMS providers creating electronics subassemblies for military/defense applications are required to register with the Directorate of Defense Trade Controls (DDTC) in order to be ITAR compliant.



In our recent survey, we asked what the greatest challenge that manufacturers face when it comes to ITAR compliance. Majority of the respondents say ongoing compliance is the biggest issue, especially when their companies are global enterprises with many businesses outside of the United States.

According to the respondents, the classifications are not based on an understanding of the technology; rather they are political, and as such subject to intense lobbying efforts. They are changing frequently, which leaves companies scrambling to re-classify parts of their designs on the fly.

The Theory Behind Tin Whisker Phenomena, Part 4

by Dr. Jennie S. Hwang
H-TECHNOLOGIES GROUP

In this fourth installment of the series, we will continue discussing the likely key processes engaged in tin whisker growth. These key processes include:

- Grain boundary movement and grain growth
- Energy dynamic of free surface
- Role of recrystallization
- Solubility and grain growth in response to external temperature
- Lattice vs. grain boundary diffusion
- Reaction and dynamic of intermetallic compounds
- Crystal structure and defects

In Parts 2 and 3, we have discussed the first five processes: grain boundary movement and grain growth; energy dynamic of free surface; solubility and grain growth in response to external temperature; and the role of recrystallization. Now, we will outline the next two processes—lattice vs. grain boundary diffusion, and reaction and dynamic of intermetallic compounds.

Lattice vs. Grain Boundary Diffusion

Diffusion is a key part of crystal growth process; and whisker phenomenon is primarily a diffusion-controlled process. Since diffusion is a necessary path to grow whiskers, slowing the rate of diffusion of tin intra-granularly or along grain boundaries should be an effective approach to slow down the whisker growth.

The actual monitoring or controlling the processes between the lattice diffusion and grain boundary diffusion is a complex challenge. Nonetheless, understanding the main factors between these two diffusion processes will help navigate the practical solutions.

Diffusion through tin matrix is expected to be impeded by alloying element. One vivid example is SnPb. This binary system comprises two phases—a Pb-rich phase and Sn-rich phase. The fact that SnPb alloy alleviates tin whisker propensity largely attributes to that Pb slows the diffusion of Sn in the matrix and allows for rapid stress relaxation, which in turn, reduces or prevents continuing whisker growth.

Diffusion rates are also grain boundary (g.b.) sensitive; the greater the number of g.b., the faster the diffusion rate is. For a grain boundary rate-determining process, the greater the number of g.b. could lead to a faster rate of whisker growth. Increasing the grain size of the tin plating will reduce the number of grain boundaries, slowing the diffusion. Intermetallic compounds (IMCs) with "suitable" sizes tend to form preferentially along grain boundaries. Fewer grain boundaries offer fewer sites for non-uniform IMC growth, resulting in the reduced stress in the system.

> "Fewer grain boundaries offer fewer sites for non-uniform IMC growth, resulting in the reduced stress in the system."

Additionally, the diffusion rate varies with the crystallographic orientation. The interstitial diffusion of Cu/Ni along the c-axis of tin grains is much faster than along a,b-axes. Accordingly, grain orientation can affect diffusion rates in tin matrix. Controlling the grain orientation can alter the rate of diffusion. However, tin's anisotropic properties can be reduced by refining its microstructure.

Overall, increasing the grain size of the plating or controlling the grain orientation can slow the rate of diffusion.

Both lattice diffusion and grain boundary diffusion are participants in tin whisker growth. The relative rate of lattice diffusion and grain boundary diffusion varies with temperature, which plays a role to the actual mechanism of the process, as well as to the growth of whisker. However, as the temperature rises, in the case of tin to above 75°C, the lattice and grain boundary diffusion rates start to converge to a similar rate.

The relative diffusion rates between lattice and grain boundary in relation to the size, morphology, crystal lattice structure and external conditions (e.g., temperature) are more intricate than the first glance—indeed, a complex challenge to "conquer and control!"

Reaction and Dynamic of Intermetallic Compounds

Intermetallic compounds may exert additional effects in grain structure, as these compounds can form in various sizes, geometries and morphologies ranging from small, more-rounded particles to large, long needles. This formation creates either highly localized stress or well-distributed stress or both in the tin lattice structure. When IMCs are large, they tend to be dispersed in Sn matrix; if IMCs are small particles, they tend to reside along grain boundaries. In either situation, IMCs impede tin atom diffusion through Sn matrix or reduce g.b. mobility.

If IMCs are attracted to the grain boundaries in the atomic form or as small particles, they may act as impurities that reduce the mobility of grain boundaries and thus could promote "abnormal" grain growth. ("protruding" grain growth, i.e., tin whiskers), in lieu of normal grain growth. If IMCs form large particles at the substrate deposit interface or in the bulk of the deposit, their effect is similar to the effect of any embedded particles regardless of its nature. Embedded particles in tin coating are known to promote tin whiskers, as evidenced in published and unpublished results, which indicate that inclusion of inert particles (e.g., Teflon and carbon) increased whiskers. On the other hand, if IMCs impede tin atom diffusion, it could jeopardize the sustainability of tin whisker growth.

However, it is important to note that the presence of IMCs is not a necessary condition to the occurrence of tin whisker. This applies

to both types of intermetallics—at the interface between the tin coating and the substrate, and in the bulk of the tin coating.

When comparing Sn coating between Cu substrate and Ni substrate, Ni substrate tends to retard the whisker formation. This phenomenon related to inter-diffusion rate correlates well with the relative diffusion rates between Cu and Sn vs. Ni and Sn. Cu has a higher diffusion rate into tin than the tin into Cu. As a result, tin lattice is distorted and the tin lattice spacing is altered. The change in lattice spacing may impart stresses to the tin plating layer, and the stress may then seek to be relieved, which contributes to the driving force for the formation of tin whiskers. It also relates to the relative reactivity between Cu and Sn vs. between Ni and Sn for the formation of intermetallic compounds. The mobility of tin atoms and the level of net stress imposed by IMCs in bulk matrix appear to be a trade off to the propensity of whisker growth.

> "The mobility of tin atoms and the level of net stress imposed by IMCs in bulk matrix appear to be a trade off to the propensity of whisker growth."

It should be noted that the critical difference between SnPb and SnAgCu alloy is that SnPb does not (should not) form intermetallics in the bulk matrix, but SnAgCu alloys intrinsically contain intermetallics. The fact of the presence of intermetallics in SnAgCu and the absence of such in SnPb, in conjunction with micro structural and other metallurgical distinctions between SnPb and SnAgCu systems, account for the differences in most phenomena and properties between SnAgCu and SnPb, including tin whisker.

It is not an exaggeration to state that such differences in most phenomena and properties between SnAgCu and SnPb, including tin whisker, were expected even without conducting tests.

Part 5 will address the last process behind tin whisker phenomena—crystal structure and defects. SMT

Dr. Jennie S. Hwang is a forward thinker, an international businesswoman and speaker, and a business and technology advisor. She is a pioneer of and longstanding contributor to SMT manufacturing since its inception, as well as to the lead-free electronics implementation. Among her many awards and honors are induction into the International Hall of Fame—Women in Technology, election to the National Academy of Engineering, YWCA Women Achievement Award, and being named an R&D-Stars-to-Watch (Industry Week). Having held senior executive positions with Lockheed Martin Corp., Sherwin Williams Co., Hanson, plc, IEM Corp., she is currently CEO of H-Technologies Group, providing business, technology and manufacturing solutions. She serves as Chairman of Assessment Board of DoD Army Research Laboratory, National Institute of Standards and Technology (NIST), National Materials and Manufacturing Board, Board of Army Science and Technology, Commerce Department's Export Council, variou s national panels/committees, international leadership positions, and the board of Fortune 500 NYSE companies and civic and university boards. She is the author of 450+ publications and several textbooks, and a speaker and author on trade, business, education, and social issues. Her formal education includes four academic degrees (Ph.D., M.A., M.S., B.S.) as well as Harvard Business School Executive Program and Columbia University Corporate Governance Programs. For more information, click here.

The Blackfox Advanced Manufacturing Program for Military Veterans

by Allen Dill
BLACKFOX TRAINING INSTITUTE

Today there is a critical shortage of qualified workers. Worker shortages, as well as skill gaps and low unemployment rates, are making it very difficult to recruit talent.

Additionally, finding the right mix of intelligence, talent, work ethic, and cultural fit in an employee is no easy task. Employers are struggling to find just the right employee for a particular position, and are considering broadening their reach by recruiting trained military veterans.

You might be wondering why you should hire a military veteran, especially if your company has nothing to do with the military. According to *Business Insider,* there is a wealth of benefits that comes with hiring veterans. These benefits are summarized below.

Veterans value hard work. When on deployment, you work every single day with almost no breaks. The military instills a culture of accomplishment, which is very much ingrained in veterans. They take their responsibilities very seriously, they value commitment, and they carry out their assigned tasks with utmost precision.

The military also instills strong leadership skills. As one advances through the military's ranks, the burden of leadership increases. Veterans therefore have a deep understanding of the importance of cooperation and personal development to the success of a project.

In addition, the military helps one develop a strong intuition, given that military personnel often have to make quick decisions that could have life-or-death consequences.

Veterans have a questioning and honest mentality and openly express when something is wrong. They are not afraid to challenge ideas and to offer alternatives, which is an asset in any organization. They are also more likely than other demographics to start their own businesses, giving them the acumen and resourcefulness to help companies grow quickly from the inside.

The government sometimes pays for veteran education, so veterans can excel at their careers and consistently improve their knowledge

while on the job through continuing education programs, such as those offered by Blackfox. In addition, employers can receive Department of Defense credits and, depending on the state, payroll tax incentives and subsidies.

In an attempt to address this skilled labor shortage in the electronics industry, Blackfox has launched a program to prepare military veterans (and civilians) for employment.

Blackfox Training Institute, as an approved technical training center for eligible veterans launched a new training program in 2013. The "Blackfox Veteran's Training Program" is the first program of its kind to provide veterans with little to no industry experience with the skills to grow their careers in the electronic assembly industry. Upon completion of the course, veterans can qualify for employment in aerospace, defense, medical, and all facets of electronic manufacturing.

> "Upon completion of the course, veterans can qualify for employment in aerospace, defense, medical, and all facets of electronic manufacturing."

Blackfox prepares military veterans for employment supported by approval under the provisions of "Title 38, United States Code" and recognition by the State of Colorado as an approved private occupational school qualifies Blackfox as a training center for eligible veterans wanting to use their GI Bill for educational benefits.

This program has been mostly funded through State and Federal training grants. There is no cost to the veteran. There is no cost to the employer whatsoever. As a matter of fact, we have not had any veterans in this program tap into their post-9/11 GI Bill benefits. It's all been funded through State and Federal grants so far. What is amazing is how many employers aren't aware of this program.

This program was initially developed by Blackfox Training in cooperation with Lockheed Martin and the first program of its type to prepare veterans who have military electronics experience, as well as those who have little or no industry experience, with the skills training and certifications that enable them to enter and create a career path in this growing aerospace/defense industry.

The program was funded through the Colorado Department of Labor and Employment and has depended particularly on cooperation with Arapahoe, Denver, Douglas, Jefferson and El Paso counties' Workforce Centers.

I am very passionate about our program as it provides our military veterans an opportunity for a career path as a civilian. We work in conjunction and collaboration with various State Departments. Right now, we are primarily working with the Colorado State Department of Labor and Employment, Veteran Services Group, and with manufacturers that want to hire qualified people. We use the state agencies for recruiting veterans, who are transitioning or underemployed and want a career in electronic manufacturing. County agencies go through the list of interested individuals and select a group; they assess these individuals for their interest and their ability for this type of industry. Applicants then come to Blackfox, and we filter their interest and ability with skill-based assessments. Those individuals that express interest and ability are then scheduled for upcoming training sessions.

This is our third year, and it's going well. We've trained and certified over a 120 individuals and of these graduates, roughly 80% have made it through the program at a class-three level. All of the technical curriculum is developed at an IPC class-three level, the most stringent class, for mostly aerospace companies. The course curriculum is designed and developed based upon industry standards and input from our partnering employers to ensure that the curriculum addresses all of their specific and unique skill requirements. Lockheed Martin in Littleton, Colorado was our first employer to step up and really want to be a part of this program. Today, we have over a dozen of Colorado's top employers partnering in this program!

During this whole process, the employer that we work with has an opportunity to come in and meet with the veterans and interview with them. They can start the process running in parallel with the training for background checks and all the other things they require. By the time the veteran graduates, they're ready to go to work.

Richard Toya, manager of the Lockheed Martin-Blackfox Partnership, and a veteran who has been with Lockheed Martin since 2008 had this to say about the program:

"The goal is to create and maintain a top-of-the-notch talent pipeline for Lockheed Martin Space Systems, for our Electronics Manufacturing Facility. The aerospace industry is growing very rapidly here in Colorado and we reached out to Blackfox to customize a program with a good curriculum to develop the talent we need for our critical electronics assembly work."

At the program's inception, Lockheed says it found that the Denver manufacturing pool wasn't big or deep, but noted that there were 500 people per month coming out of the military in Colorado needing to transition to civilian life. The firm made a decision to focus on training veterans in the electronics certification needed for its space programs. Some 65% of those entering the program are veterans.

Graduates of the five-week program come out with nine Blackfox skillset certifications, known in the industry as IPC certifications. While several are needed for work in the Lockheed Martin EMF, others are marketable across other manufacturing categories outside aerospace.

"We'd love to keep every graduate, if not at Lockheed Martin, then within the robust aerospace industry here in Colorado," said Toya. "But the certifications are mobile for up to two years with the employee and these skill sets are very marketable across the country."

Since 2013, over 120 people have graduated from the five-week Blackfox program, which is funded through state and federal training grants. There is no cost to the veteran and there is no cost to the employer. If graduates don't go

Figure 1: Participants engage in a training and certification class at the Blackfox Training Institute. Certifications are good for up to two years and reflect industry-wide production standards. (Photos courtesy of Blackfox Training Institute.)

to Lockheed, they go to other aerospace companies into communications or work on weather satellites. Two thirds of graduates work at Lockheed Martin's Waterton Canyon EMF, an 85% retention rate. Among them is Johnny Grant, who separated from the Army in 2002 and jumped at the training chance.

"I went to the workforce center in mid-2013 to see what options there were. I went past my allotted time with Uncle Sam to use it at college and the workforce counselors at the Department of Labor told me about the program," said Grant. "It didn't cost me anything as a veteran, as long as I fulfilled the program. Everything is provided by Blackfox and it was all paid for by the workforce center."

Colorado Workforce Centers are aware that those attending such intensive programs are often between jobs and struggle with living expenses during the program.

"They even gave us King Soopers gas cards that we could use for groceries or fuel," said Grant. "When we got short during the curriculum and we needed a little bit of help, we got it."

EMF technician retention rates are improving at Lockheed Martin. Prior to the program's

Figure 2: Key roles of different stakeholders in Blackfox's training program.

inception, retention was about 50%, but since the program's 2013 inception, overall retention rate jumped 30% to above 80% and continues to improve.

"Since May of 2015 until now we've hired 35 from this partnership and our retention rate rose to 92%," said Toya. "It's higher than average—the state customized their recruiting and our job is retaining them. We've begun a veteran mentorship at Lockheed Martin with this program to cut the one-year attrition rates. Our veteran mentors meet with the vets in the Blackfox program, explain what it's like to work on the outside (of the military). He sees them before they're hired and stays with that group of employees for a year."

Program graduates are quick to explain the Blackfox Training benefits.

"I was given every tool I needed to succeed. If you're willing to sacrifice a little to get to school, you can do it," said Grant. "You get a sense of pride and fulfillment. I could take these certifications and go to Ford or Sony, but it wouldn't give me nearly the satisfaction of being here contributing to the aerospace mission."

The program manager says he has gained too. "Being the facilitator of this program is extremely rewarding, to give back to our veteran community," said Toya. "To further their education with our tuition supports a strong and capable workforce and helps veterans integrate back into the civilian workforce."

Today

In addition to Lockheed Martin, interested Colorado employer partnerships have grown to include many additional major aerospace companies and their supply chain. There is more demand for graduates of this program than there is Federal Funding available to support it.

Tuition for this program is less than $4k per student and has been funded primarily by Federal and State Grants (i.e., WIOA and VWIP). Funding is now limited, particularly with veterans as the VWIP is no longer available. Although Blackfox is approved by the VA for use of GI Bill funding, not all veterans qualify. Another challenge for veterans is the cost of transportation, food, and lodging during the five weeks.

Recruiting: We are marketing more to veteran organizations to help recruit veterans. The pool of veterans in the Colorado Department Labor Employment data base is limited. Transitioning veterans need to be aware of the opportunities.

To this point, this program has been funded mostly by State and Federal training grants that have paid for the student's tuition costs. Utilizing these grants have been useful, but not always dependable or available when needed.

We are looking for foundations and other organizations to sponsor grants for education as well as private funding in order to expand this program. If you are interested in learning more or participating as a sponsor or investor, please click here to contact Al Dill or call 303-684-0135 at any time. SMT

Allen Dill is the president/CEO of Blackfox Training Institute.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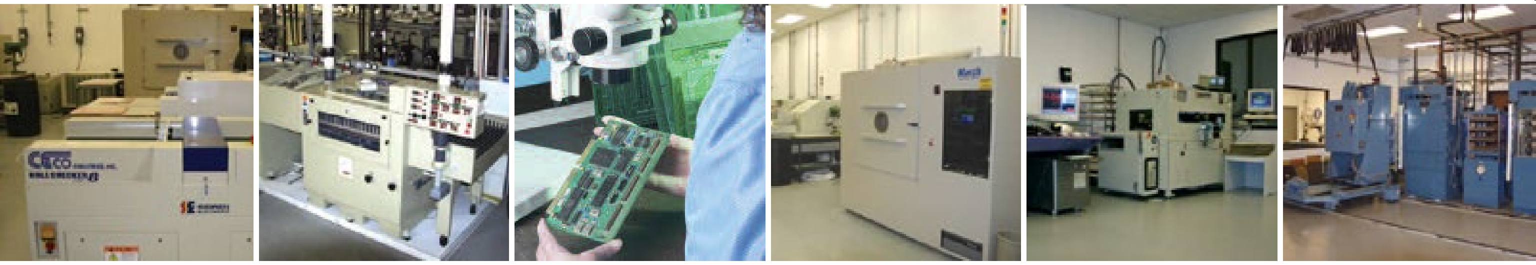


ASTEELFLASH on Mil/Aero Challenges, ITAR Compliance, and Opportunities

by Stephen Las Marias
I-CONNECT007

Asteelflash is a Tier-2 EMS provider with 18 manufacturing sites worldwide, including three sites in North America: Fremont, California (AS9100 ongoing); Raleigh, North Carolina (AS9100 and ITAR certified); and Tijuana, Mexico (AS9100 certified)—with a workforce 5,200 employees.

Founded in 1999, it is one of the fastest growing Tier 2 players among the contract manufacturing industry, being ranked 17th in Manufacturing Market Insider's (MMI) 2015 list of top 50 EMS providers worldwide. The company provides a full turnkey solution from design and engineering services to direct fulfilment to numerous industries including defense, military and aerospace, but also automotive, energy management/smart home devices, industrial, telecommunications and medical, to name a few.

In an interview with *SMT Magazine,* Albert Yanez, Corporate Executive VP and President of Asteelflash, Americas, discusses the challenges in the military and aerospace industries, ITAR compliance, and the opportunities in these sectors.

Stephen Las Marias: What are your greatest challenges when it comes to electronics assembly for the military and aerospace markets?

Albert Yanez: Military and aerospace markets present many challenges from a manufacturing perspective and requires a solid quality management system in place with a specific emphasis on how to avoid counterfeit parts and quality issues. This is an area that many EMS providers have issues dealing with when getting ready to enter the mil/aero market.

From a technology standpoint, thermal management remains the most critical aspect of complex electronic assemblies in the mil/aero industry. Your product has to be war ready, and this is not just a play word. The electronic products targeted to the military and aerospace industry are often used in very different environments, and the inners of these products has to be as robust as the outside, making sure the performance is delivered no matter how harsh the conditions: snow, humidity, heat, extreme des-

ert conditions, space, and pretty much everything else.

With the miniaturization of electronics nowadays, it is definitely a challenge to provide the perfect product in an optimized space without compromising on the thermal management systems. More of a design concern yet it can definitely have a huge impact on how hard it is to assemble a given product.

Albert Yanez

Las Marias: ***From your perspective, what are the greatest challenges that your customers face?***

Yanez: Reliability and time to market. A lot of peers in the industry see the mil/aero industry as a headache because of very long gestation periods. Have you seen the time needed to fully manufacture and assemble an airplane? You can count on delays to be there. But the outcome is often very positive both in terms of experience and in terms of business.

Reliability is a must. And of course everybody will say that reliability is a must for any type of customer no matter which industry they play in, but in my opinion, mil/aero presents a higher level of requirements on that matter and therefore more resources in place to sustain this level of performance.

Las Marias: ***How does Asteelflash help customers address those challenges?***

Yanez: Speedy time to market is one of our core strengths. Our ultimate objective is to make sure our customers are able to tackle the growth they expect with our support on overachieving on delivery dates, reactivity on design changes and proactivity on process improvements. Having a seasoned EMS partner is critical in the aerospace market. The certifications are one thing. The flexibility on the floor is another, one we are proud to put forward on a daily basis.

Las Marias: ***Are lead-free components still causing problems in the supply chain?***

Yanez: I think it is safe to say that it was a challenge a few years back especially in the transition phase from leaded to lead-free components without compromising on the reliability of the products. Again, related to the challenges of field reliability and resistance to extreme conditions, the military/aerospace products require a level of reliability of more than 20 years, very different from the consumer electronics segment for instance. Lots of researches and tests have been conducted and specific groups and associations—such as the Aerospace Industries Association (AIA), the Avionics Maintenance Conference (AMC) or the Government Electronics and Information Technology Association (GEIA)—took leader-ship in making this transition easier and efficient. Some researchers even concluded that lead-free components and assemblies could provide better levels of reliability to a certain extent.

Las Marias: ***Your company is compliant with ITAR. What are the greatest challenges with ITAR?***

Yanez: Our facility in Raleigh-Morrisville, North Carolina, is ITAR certified. Given the number of years of compliance and certification, it is no longer a challenge but has actually become a routine to sustain that level of compliance. Resources in place and integration of the ITAR restrictions into our business model were definitely a challenge in the early days but they've been overcome for several years now by maintaining discipline and keeping each and any of our employees focused and vigilant to the rules.

Las Marias: ***According to our survey, ongoing compliance with ITAR is a challenge. Do you agree?***

Yanez: It definitely can be if you don't create very solid procedures, commit to them—from top to bottom—and follow them on a daily basis. Without that level of commitment starting from the top management, it can be very difficult to stay ITAR compliant.

Las Marias: How do you ensure your company's continued compliance with ITAR?

Yanez: Putting the relevant resources in place is key. At Asteelflash, we have developed procedures that are directly based on ITAR requirements. We have also appointed a full time dedicated ITAR Officer at each plant who reports directly to our plant managers, conducting self-audits throughout the year to insure compliance at all times. This provides us confidence that the recertification process will always be a positive outcome.

Las Marias: What opportunities are you seeing in the military and aerospace sectors?

Yanez: In the military sub-segment, we see tremendous growth in drones, unmanned vehicles and man-portable electronics. The latter is actually set to reach $19.6 billion by 2019 and we already feel it with our existing customers, but also through ongoing NPIs currently taking place at our facilities now.

In the aerospace industry, all the products we often talk about are still up to date (beacons, radars, security portals, data processing and telecommunication products, seats electronics). But we definitely have seen an increasing demand for on-board infotainment/avionics products as well as electrical related assemblies (battery management systems, inverters, and power conversion systems) aimed at powering airplanes.

Las Marias: What trends are driving these opportunities?

Yanez: The rise of connected devices, the new technologies and the international geopolitical situation are definitely impacting the defense related projects. You could see that the major defense/military OEMs are growing at a very fast pace. On the aerospace side, we are seeing the "connected era" creating more opportunities and more demand for electronics, which could be comparable to the transformation the automotive industry is currently experiencing with increasing presence of electronics per vehicle.

Las Marias: What do you think should customers consider when selecting their EMS provider?

Yanez: Selecting an EMS provider is never easy. And the huge competition between EMS providers does not make it any easier for OEMs to make the right decision. However, with that said, if reliability and quality are critical, the flexibility and the level of attention provided by the EMS plays a key role on how to address customer specific problematics. This is where Asteelflash and other Tier-2 providers have something really important to offer: top management involvement. Of course, working with the Top 5 EMS could be of interest, but unless you have a very big spend, you will just be "another customer", while we deploy resources to be very flexible if any issue arises (they always do arise) on our side. We value the quality but the relationship is equally important.

Las Marias: What can you say about the future of the mil/aero industry?

Yanez: The future of this industry is bright. If you can stomach the long gestation periods of product development, you're definitely at the edge of tremendous growth with customers who are usually very loyal once the business and the process is secured. In terms of growth, the opportunity is interesting and we at Asteelflash pay a specific attention to the aerospace segment which is perfectly in line with our offering: high complexity boards requiring technological knowledge, expertise and reliability. More and more aircrafts, combined with an increasing presence of electronics with the rise of new technologies, makes it a segment to go for us. **SMT**

Recycling Substrates and Components in Mil/Aero Assemblies: Secure Metals Recovery

by Mitch Holtzer
ALPHA ASSEMBLY SOLUTIONS

Minimizing scrap and waste from the process of assembling military and aerospace electronics should always be a top priority for design and production engineers.

However, the critical reliability requirements of these types of assemblies and the risk/reward proposition of manual or semi-automatic rework/repair make the decision to scrap defective assemblies easy. When lives, military mission success and millions of dollars of equipment value are at stake, reworking a $200 assembly with different touch-up fluxes or manual soldering with cored wire may create an unacceptable result when a FEMA is analyzed.

So once the decision has been made to scrap a quantity of defective boards that were destined for the cockpit of a large volume stealth fighter, there is only one question that needs to be answered: How can the value of the substrate and components used to create the defective assembly be recovered without compromising the top secret design of the circuit?

Keeping the scrapped materials within the United States is an obvious first principal. Selling the scrap to a broker or dealer could easily result in the scrapped circuit board being shipped to a foreign country for disassembly or disposal. Obviously, this outcome should be

prevented at all costs. To do so, the assemblies need to be destroyed by an International Trade in Arms Regulations (ITAR) certified service provider. This would assure that the scrap boards do not leave the United States. It also assures that a government review of the service provider's business practices has met a high-level of scrutiny.

Another principal to consider is the reclamation method itself. Economic circuit destruction could be accomplished in one of two ways: incineration or granulation followed by metal recovery. Either method effectively secures the security of the design intellectual property, which again is of paramount importance for military and aerospace applications, but one method proves more advantageous.

"Incineration is inexpensive; however it makes the metal recovery process more difficult."

Incineration is inexpensive; however it makes the metal recovery process more difficult. A hot fire oxidizes valuable base metals such as copper and tin. Once oxidized, a chemical or electrochemical process must be used to make the tin and copper reusable. Some would argue the additional process work makes this an unpopular option. The second method is granulation. In this process, a mill is used to grind or crush circuits into a powder like intermediate. This process has several advantages. Granulation obviates the design of the circuit and the identity of the components. Once granulated, calculating the value of this powder is very straightforward. The weight percent of the base and precious metals (i.e., gold, platinum, silver, and palladium) can be easily measured, thus giving a direct method to determine the value recovered from the scrapped assemblies.

Another source of scrap and waste from the production of military and aerospace electronic circuit assemblies that can be recycled is the solder paste remaining on a stencil when production switches from one assembly to another. The paste bead diameter on the last assembly produced needs to be very similar to the bead diameter used on the first assembly. Around 1.5–2 cm is the most common process recommendation to reduce defects. When a different assembly begins production on a SMT line, obviously the stencil will be changed. The solder paste left on the previously used stencil must be routed to an appropriate reclaim container.

During the course of its use, solder paste's ratio of metal to flux increases (paste flux is selectively transferred through a stencil aperture at a higher rate than solder powder). This phenomenon is referred to as flux drift. If the used paste, subjected to flux drift, is mixed with fresh paste, the resulting homogeneous concoction will be subject to process variation. Anyone familiar with Six Sigma principles knows that process variation leads to defects, which leads to scrap.

In summary, the cost of producing advanced technology military or aerospace assemblies is highly dependent on the first pass yield. In the risk of repairing an assembly designed for use in a demanding mission critical or life-saving application, high reliability far outweighs the saving of a flawed circuit. And when scrapping such sensitive materials with design intellectual property that can compromise national security, one must enlist an ITAR-certified service provider to ensure scrap boards do not leave the United States.

Minimizing losses by obtaining the highest return on scrapped assemblies and unusable solder paste should be a high consideration for military and aerospace circuit assemblers as you begin budget conversations for 2017. **SMT**

Mitch Holtzer is global director of customer technical service (CTS) for Alpha Assembly Solutions. To reach Holtzer, click here.

Supply Lines Highlights

The Pasternack Story

John Farley, director of marketing for Pasternack Enterprises, speaks with I-Connect007's Judy Warner during the recent International Microwave Symposium event about their experience at this year's show. John also discusses the multiple layers of Pasternack's RF products and services and the unique way they do business.

EPC's Michael de Rooij Discusses Strategic Partnership with Wurth Electronik

Michael de Rooij, PhD, of Efficient Power Conversion Corp. (EPC) talks to I-Connect007 guest editor Kim Sauer about their strategic alliance with Wurth Electronik, how their cooperation works, and how the technology solution they are co-developing can address the wireless power challenge as a whole.

Delta Electronics Installs 15th ACE Selective Soldering System in Thailand

Delta Electronics Inc. has invested in two additional selective soldering systems from ACE Production Technologies—the KISS-102ILDP and KISS-102IL selective soldering systems—which will be installed at its facility in Amphur, Thailand.

P. Kay Metal's MS2 Technology Group Adds James Goyne to Management Team

P. Kay Metal's MS2 technology group has announced the addition of James Goyne to its management team as distribution/business development manager.

Innovative Microscopes Announces New Stereo Microscope Line

Innovative Microscopes is introducing a new line of stereo microscopes featuring four models, each of which is equipped with high-performing quality optics, with the eyepiece having inclination between 35° to 45° for comfortable observation. The microscopes are suitable for all electronic production lines.

Mycronic Acquires Shenzhen Axxon Automation

Mycronic has signed an agreement to acquire 75% of Shenzhen Axxon Automation Co. Ltd for a cash consideration of approximately SEK 430 million. As part of the agreement, Mycronic will acquire the remaining shares of the company in two steps – an additional 5% will be acquired within this year and the last 20% after three years.

Indium Receives ON Semiconductor Award for "Perfect Quality" in 2015

Indium Corporation has been recognized by ON Semiconductor for "perfect quality" in 2015.

Alpha Launches Web Search Tool for GHS Safety Data Sheets

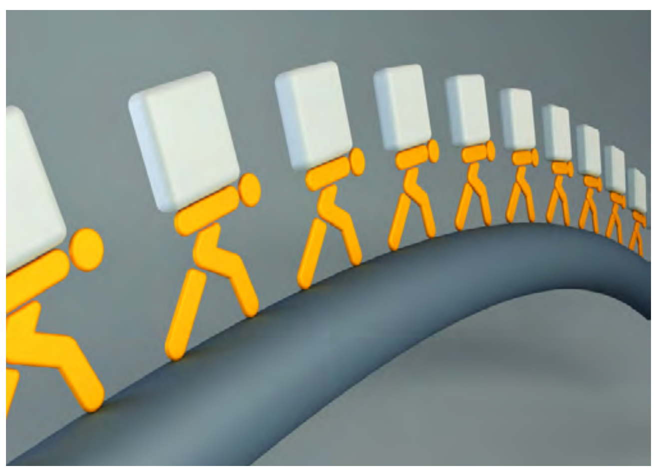
Alpha Assembly Solutions recently launched a new search tool on its website that allows users to search for GHS Safety Data Sheets (SDS) on all ALPHA Products that are commercially available worldwide.

Japan UNIX Launches Robotic Soldering Modules to Automate Soldering Operations

Japan UNIX has incorporated core technologies from its accumulated soldering expertise into various soldering modules and unit products to automate soldering operations.

Nordson DAGE Announces European Distributor Network Changes

Nordson DAGE, a division of Nordson Corporation, announces changes to its European Distributor network to enhance the present pan-European operation to provide full support for all its X-ray products.



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Mitigation of Pure Tin Risk by Tin-Lead SMT Reflow—*Results of an Industry Round-Robin*

by David Pinsky,
RAYTHEON INTEGRATED DEFENSE SYSTEMS;
Tom Hester,
RAYTHEON SPACE AND AIRBORNE SYSTEMS;
Dr. Anduin Touw, THE BOEING COMPANY;
and Dave Hillman, ROCKWELL COLLINS

Abstract

The risk associated with whisker growth from pure tin solderable terminations is fully mitigated when all of the pure tin is dissolved into tin-lead solder during SMT reflow. In order to take full advantage of this phenomenon, it is necessary to understand the conditions under which such coverage can be assured. A round robin study has been performed by IPC Task group 8-81f, during which identical sets of test vehicles were assembled at multiple locations, in accordance with IPC J-STD-001, Class 3. All of the test vehicles were analyzed to determine the extent of complete tin dissolution on a variety of component types. Results of this study are presented together with relevant conclusions and recommendations to guide high-reliability end-users on the applicability and limitations of this mitigation strategy.

Background

Manufacturers of high reliability electronics have been working for many years to mitigate the deleterious effects of tin whisker formation. One highly effective means to suppress the growth of tin whiskers is to replace the pure tin plating with reflowed tin lead solder. (This approach is only available to manufacturers whose products are not subject to RoHS.) One approach to achieve total replacement of tin with tin lead solder is to perform a special hot solder dip process on the piece parts prior to assembly. Another approach is to fully consume the tin plating by tin lead solder during the SMT reflow process that occurs during circuit card assembly. This phenomenon of tin replacement during SMT reflow has been termed "self-mitigation," because the components mitigate by themselves without the need of any special additional processing. Self-mitigation has many advantages over other forms of tin mitigation because it is: highly effective, adds no additional cost, and subjects the components to no additional handling.

The principal challenge to implementing self-mitigation as a standard practice is lack

of confidence in the conditions under which components will reliably self-mitigate. Prior work concluded that for a specific set of process conditions, board finish, and pad design, self-mitigation can be predicted by the geometry of the component terminations[1]. It is not clear, however, how these results apply for different manufacturing processes, board finishes, and pad sizes. Without this understanding, the only reliable means for systems integrators to be confident that self-mitigation has been achieved on a given set of assemblies is to duplicate the conditions of the prior study, or to perform direct measurements on the as-received hardware.

The existence of this knowledge gap prompted the Pb-free Electronics Risk Management Council (PERM, IPC Committee 8-81) to initiate a project in 2014 under IPC task group 8-81F, to perform a study. The first phase of that study has been completed, and this report describes that study and the results to date.

Design of Experiment

The task team agreed to perform a new set of experiments involving the manufacture of identical sets of test vehicles at a number of different locations, all assembled to the requirements of IPC J-STD 001, Class 3. For simplicity, and to permit direct comparison with the results of the prior study, it was decided to use

Experimental Factor	Settings
Component Packages	16 different part numbers (details below)
Board finish	OSP and Sn Pb HASL
Pad size	Per initial study and 25% smaller
Manufacturing site	Seven different locations

Table 1: Design of experiment.

Part Number	Package Style	Quantity per vehicle	Length (mils)	Height mils)
06035C103KAT2A	0603 chip	10	31	13
0603YD225KAT2A	0603 chip	10	31	13
A3PN030-ZVQG100	TQFP100-14mm	1	40	16
ADM213EARSZ	SSOP28-5.3mm	2	59	31
EPM7032AETC44-10N	A-TQFP44-10mm-.8mm	1	40	16
IR2156SPBF	SO14G-3.8mm	2	41	23
LM2901DG	SO14G-3.8mm	2	41	23
LTC3703EG_PBF	SSOP28-5.3mm	2	59	31
MBRM140T1G	DO-216AA	5	49/17	20
MC9S08GT16AMFBE	QFP44-.8mm	1	66	36
MC9S08QE4CLC	LQFP32-7mm-.8mm	1	42	25
OP482GSZ	SO14G-3.8mm	2	46	19
PZT2222AT1G	SOT223	5	69/73	20
STAC9200X5TAEB1X	LQFP48-7mm-.5mm	1	42	25
W3L1YC474MAT1AF	0612 chip	5	12	39
XC9572XL-5TQG100C	LQFP100-14mm-.5mm	1	39	23

Table 2: Component packages used in the study.

the same board layout and components from the prior study. Many potential factors for inclusion in the DOE were considered. The factors chosen for consideration are described in Table 1.

Each test vehicle consisted of a PCB with each of the package types attached (quantities of each described below). There were four "flavors" of boards for the four combinations of pad size/board finish. Each assembler was provided with two replicants of each board type, for a total of eight test vehicles. An assembled test vehicle is shown in Figure 3.

Component Packages

The components used in this study are summarized on Table 2. Measurements of the length and height of the solderable terminations were measured as illustrated in Figures 1 or 2 below, for leaded and chip devices respectively.

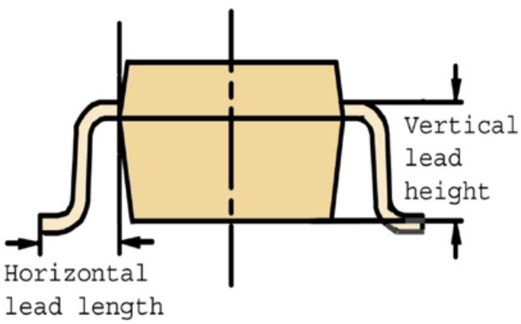

Figure 1: Termination height and length measurements for leaded devices.

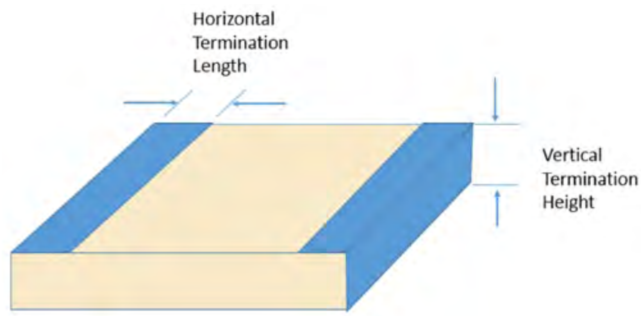

Figure 2: Termination height and length measurement for chip devices.

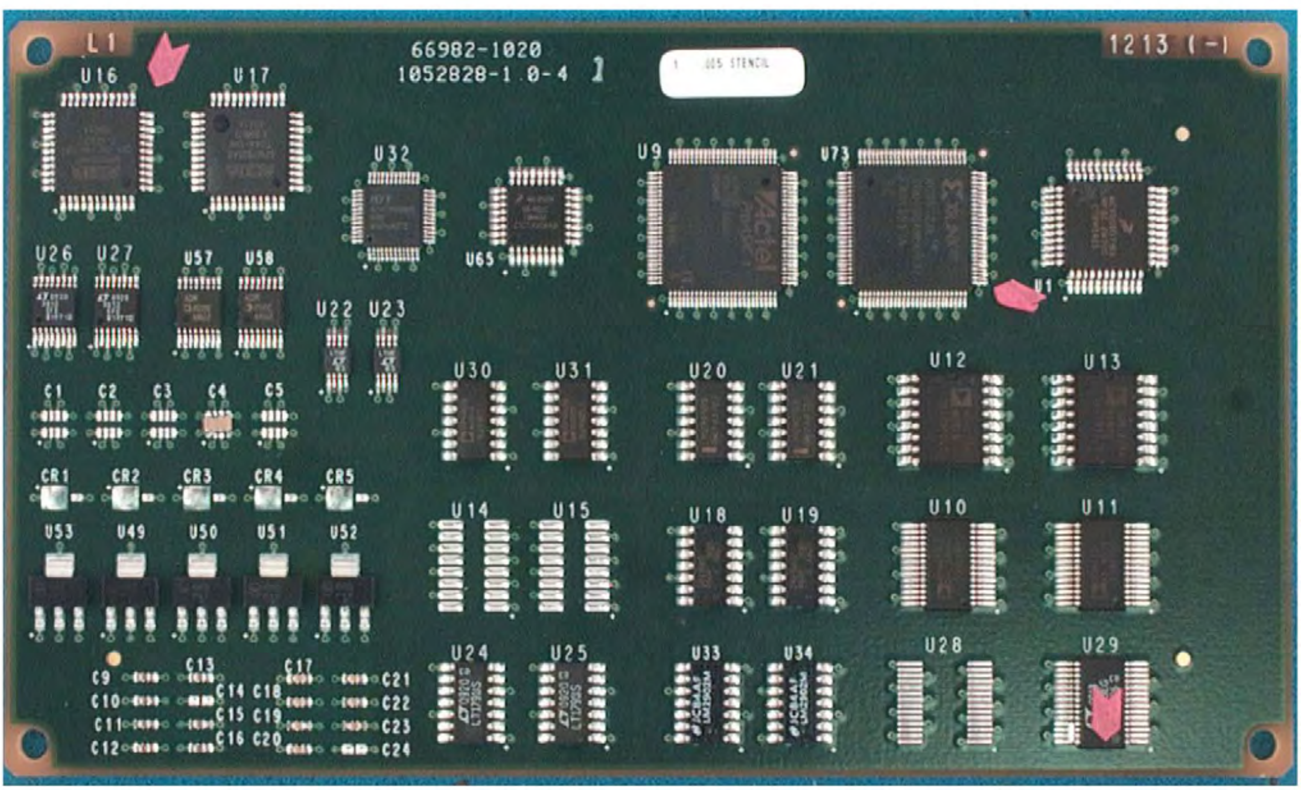

Figure 3: Photograph of an assembled test vehicle.

Assembly Processes

Each assembler was provided an identical kit with eight bare boards, together with the components needed to populate them.

The processes employed by each of the assemblers was recorded and are summarized in Table 3.

X-Ray Fluorescence Measurements

Evaluation of the extent of solder coverage of component terminations was performed using X-ray fluorescence (XRF). All XRF measurements were performed using the production XRF instrument and a 97% by weight tin materials standard. This instrument's principal features include a PIN diode solid state X-ray detector, a capillary tube collimation for 3-micron X-ray beam size, a fine position controlled automatic sample stage, a 50 Kilo-electron-volt X-ray source, and X-ray fundamental parameters based quantitative analysis software. Data collected at each measurement location included: thickness of coating, weight fraction of tin and of lead in the coating, and count rate.

Measurements were performed in identical locations on each of the test vehicles. Measurements were performed on two leads from each of the leaded devices. For each lead analyzed, measurements were taken in three locations: at the toe of the lead adjacent to the pad, at the midpoint of the lead, and at the very top of the lead where it protrudes from the package. For the non-leaded passive devices, measurements were performed at the pad and on the top of the device where the termination finish was farthest from the pad.

X-Ray Fluorescence Results

Raw data was collected at each measurement location for: weight percent tin, weight percent lead, and coating thickness. Information on the x-ray count rate for tin lead were also recorded.

Results of the XRF measurements for boards from Assembler A are summarized in Appen-

Setting	Process A	Process B	Process C	Process D	Process E	Process F	Process G
Reflow type	Vapor Phase	Convection Oven	Convection Oven	Convection Oven	Oven	Convection Oven	Convection Oven
Flux	ROL0	ROL0	ORM0 63/37	ROL0	Sn62 RMA No-Clean solder paste (Alpha 9086)	No clean	Tacky Flux
Stencil thickness	5 mils	5 mils	5 mils	4 mils	Laser 5 mil	5 mils	5 mils
Time above Liquidus	90s	60-75s	66s	90s	45 sec	60s	70s
Peak temperature	218°C	215°C	220°C	225°C	220°C	213°C	220°C
Atmosphere	Air	Nitrogen	Nitrogen	Nitrogen	Nitrogen	Nitrogen	Nitrogen
Number of reflow cycles	1	1	1	1	1	1	2
Rework	None	None	None	None	None	None	Yes

Table 3. Summary of assembly process details.

dix A. This table summarizes the data for the eight test vehicles assembled using the same assembly process, as indicated in Table 3 above. A similar table was created for all of the test vehicles. (The complete data sets in digital format can be made available to investigators upon request.) Three measurements taken on the 97% tin calibration standard are shown in the last three rows of Appendix A. All thicknesses are given in micro inches. All compositions are given in weight percent tin (the remainder is lead). All tin measurements in excess of 97% are shaded pink, and all thickness measurements less than 10 micro inches are shaded blue. The locations for each measurement are indicated by abbreviations as follows:

"E" – Where the lead is protruding from the package
"M" – The midpoint of the lead
"P" – At the pad
"TL" – Top left side of the package
"BL" – Bottom left side of the package
"TP" – Tab where it meets the pad
"TE" – Tab where it is protruding from the package
"EL", "ML", and "PL" – For the lead, where it is protruding from the package, at its mid-point, and at the tab, respectively

The data was reviewed for consistency and to determine the validity. Some measurements, particularly ones taken near where the lead protrudes out from the package (E) of certain components, were found to exhibit unreasonably low coating thickness readings. Inspection of some of the suspect components revealed that there was bare copper exposed at this location, resulting in the collection of no meaningful data on solder coverage at these locations.

Analysis of results

Preliminary data analysis has commenced to help with data summary. To begin with, the data was examined for suspect data readings, in light of the issue with unreasonably thin readings discussed above. For this preliminary summary any reading with a thickness measurement less than 15 µin was eliminated from the dataset. The tin and lead content from these samples were considered suspect and would need additional review to be considered accurate.

Some basic parameters were examined for significance. ANOVA analysis with backwards deletion was used to examine the significance of pad size, board type, and soldering process. Board type (HASL or OSP) was found to be an insignificant explanatory variable (F-value 2.34, Pr>F: 12.6%). While pad size was found to be significant during the analysis (F-value 5.8, Pr>5: 1.6%), the difference between means for the two sizes was less than 3%, so on a practical basis it is not expected to be a factor. The differences between soldering processes is significant, but will require more in depth analysis to determine the specific differences in the processes driving the differences in performance.

When rating the relative performance of the different packages and soldering processes, we were more interested in the extremes than in the average behavior. For example, we were concerned whether 99% of parts would be compliant in a production setting. Therefore, we performed our rating based on tolerance intervals. Tolerance intervals are confidence intervals for a covering of a fixed percentage of the population. For this analysis, we used formulas for one-sided tolerance intervals for a normal distribution.[2] These were calculated for three difference confidence levels and looking at several different percentiles of interest.

The data was analyzed at three difference confidence levels: 60% confidence (little confidence over expected value), 80% confidence (adding some margin), 90% confidence (high confidence needed for critical systems). The results are summarized in Tables 4–6 that follow. The following color code is used:

- Green means the chance of being <97% tin is at least 0.99
- Yellow means the chance of being <97% tin is between 0.9 and 0.99
- Orange means the chance of being <97% is between 0.75 and 0.9
- Pink means the chance of being <97% is between 0.5 and 0.75
- Red means the chance of being <97% is less than 0.5

For example, the 0603 chip is green for all processes at all confidence levels. That means that there is greater than 0.99 chance that a part will have the required <97% tin once soldered. On the other hand, the SSOP28-5.3 mm is colored yellow for process G at 60% confidence because we expect a greater than 0.9 chance that a part will have <97% tin. At higher confidence levels, however, this part process combination turns orange because at higher confidence, it is more likely to be between 0.75 and 0.9 chance of having <97% tin. Although the higher confidence levels have lower probabilities of parts having <97% tin, generally the part-process combinations stay in the same category regardless of confidence level. This suggests that the results are not being driven by a lack of sample size.

Conclusions

The data clearly indicates that the probability for self-mitigation is strongly depen-

Termination				Assembly Process						
Length	Height	Package Style	Part_Number	A	B	C	D	E	F	G
31	13	0603 chip	06035C103KAT2A	0.996	1.000	1.000	1.000	1.000	1.000	1.000
31	13	0603 chip	0603YD225KAT2A	0.998	1.000	1.000	1.000	1.000	1.000	1.000
40	16	TQFP100-14mm	A3PN030-ZVQG100	0.836	0.770	0.779	0.822	0.966	0.810	0.995
59	31	SSOP28-5.3mm	ADM213EARSZ	0.729	0.692	0.736	0.710	0.582	0.710	0.892
40	16	A-TQFP44-10mm-.8mm	EPM7032AETC44-10N	0.863	N/A	0.847	0.792	0.831	0.820	0.985
41	23	SO14G-3.8mm	IR2156SPBF	0.996	1.000	1.000	1.000	1.000	1.000	1.000
41	23	SO14G-3.8mm	LM2901DG	1.000	1.000	1.000	1.000	1.000	1.000	1.000
59	31	SSOP28-5.3mm	LTC3703EG_PBF	0.729	0.692	0.717	0.721	0.738	0.684	0.904
49/17	20	DO-216AA	MBRM140T1G	1.000	0.777	0.866	0.776	0.764	0.762	0.955
66	36	QFP44-.8mm	MC9S08GT16AMFBE	0.767	0.505	0.687	0.678	0.704	0.691	0.745
42	25	LQFP32-7mm-.8mm	MC9S08QE4CLC	0.839	0.692	0.755	0.735	0.728	0.698	0.904
46	19	SO14G-3.8mm	OP482GSZ	1.000	1.000	1.000	1.000	1.000	1.000	1.000
69/73	20	SOT223	PZT22222AT1G	0.931	0.804	0.803	0.767	0.872	0.852	0.698
42	25	LQFP48-7mm-.5mm	STAC9200X5TAEB1X	0.781	0.713	0.774	0.767	0.802	0.736	1.000
12	39	0612 chip	W3L1YC474MAT1AF	0.743	0.000	0.000	0.430	0.003	0.001	0.432
39	23	LQFP100-14mm-.5mm	XC9572XL-5TQG100C	0.815	0.731	0.763	0.768	0.771	0.738	0.991

Table 4. Self-mitigation probabilities with 60% confidence.

Termination				Assembly Process						
Length	Height	Package Style	Part_Number	A	B	C	D	E	F	G
31	13	0603 chip	06035C103KAT2A	0.995	1.000	1.000	1.000	1.000	1.000	1.000
31	13	0603 chip	0603YD225KAT2A	0.997	1.000	1.000	1.000	1.000	1.000	1.000
40	16	TQFP100-14mm	A3PN030-ZVQG100	0.816	0.748	0.757	0.802	0.957	0.790	0.993
59	31	SSOP28-5.3mm	ADM213EARSZ	0.707	0.669	0.712	0.688	0.558	0.688	0.876
40	16	A-TQFP44-10mm-.8mm	EPM7032AETC44-10N	0.837	N/A	0.816	0.762	0.803	0.792	0.978
41	23	SO14G-3.8mm	IR2156SPBF	0.995	1.000	1.000	1.000	1.000	1.000	1.000
41	23	SO14G-3.8mm	LM2901DG	1.000	1.000	1.000	1.000	1.000	1.000	1.000
59	31	SSOP28-5.3mm	LTC3703EG_PBF	0.707	0.668	0.695	0.697	0.715	0.659	0.888
49/17	20	DO-216AA	MBRM140T1G	0.999	0.758	0.850	0.757	0.745	0.743	0.945
66	36	QFP44-.8mm	MC9S08GT16AMFBE	0.736	0.471	0.654	0.645	0.672	0.658	0.714
42	25	LQFP32-7mm-.8mm	MC9S08QE4CLC	0.811	0.659	0.720	0.703	0.696	0.665	0.882
46	19	SO14G-3.8mm	OP482GSZ	1.000	1.000	1.000	1.000	1.000	1.000	1.000
69/73	20	SOT223	PZT22222AT1G	0.919	0.784	0.784	0.745	0.857	0.836	0.671
42	25	LQFP48-7mm-.5mm	STAC9200X5TAEB1X	0.749	0.681	0.739	0.736	0.772	0.705	0.999
12	39	0612 chip	W3L1YC474MAT1AF	0.719	0.000	0.000	0.404	0.002	0.000	0.406
39	23	LQFP100-14mm-.5mm	XC9572XL-5TQG100C	0.786	0.699	0.729	0.737	0.741	0.706	0.986

Table 5. Self-mitigation probabilities with 80% confidence.

Termination				Assembly Process						
Length	Height	Package Style	Part_Number	A	B	C	D	E	F	G
31	13	0603 chip	06035C103KAT2A	0.993	1.000	1.000	0.999	1.000	1.000	1.000
31	13	0603 chip	0603YD225KAT2A	0.996	1.000	1.000	1.000	1.000	1.000	1.000
40	16	TQFP100-14mm	A3PN030-ZVQG100	0.801	0.732	0.739	0.787	0.950	0.774	0.991
59	31	SSOP28-5.3mm	ADM213EARSZ	0.689	0.651	0.693	0.670	0.540	0.670	0.863
40	16	A-TQFP44-10mm-.8mm	EPM7032AETC44-10N	0.815	N/A	0.791	0.739	0.781	0.769	0.970
41	23	SO14G-3.8mm	IR2156SPBF	0.993	1.000	1.000	1.000	1.000	1.000	1.000
41	23	SO14G-3.8mm	LM2901DG	1.000	1.000	1.000	1.000	1.000	1.000	1.000
59	31	SSOP28-5.3mm	LTC3703EG_PBF	0.690	0.649	0.677	0.679	0.698	0.640	0.874
49/17	20	DO-216AA	MBRM140T1G	0.999	0.743	0.837	0.742	0.730	0.728	0.937
66	36	QFP44-.8mm	MC9S08GT16AMFBE	0.712	0.446	0.629	0.620	0.646	0.633	0.689
42	25	LQFP32-7mm-.8mm	MC9S08QE4CLC	0.788	0.634	0.693	0.678	0.671	0.640	0.864
46	19	SO14G-3.8mm	OP482GSZ	1.000	1.000	1.000	1.000	1.000	1.000	1.000
69/73	20	SOT223	PZT22222AT1G	0.908	0.769	0.769	0.728	0.845	0.823	0.651
42	25	LQFP48-7mm-.5mm	STAC9200X5TAEB1X	0.724	0.656	0.711	0.711	0.749	0.680	0.998
12	39	0612 chip	W3L1YC474MAT1AF	0.701	0.000	0.000	0.385	0.001	0.000	0.387
39	23	LQFP100-14mm-.5mm	XC9572XL-5TQG100C	0.763	0.675	0.702	0.712	0.717	0.681	0.980

Table 6. Self-mitigation probabilities with 90% confidence.

dent upon the component termination geometry, confirming the conclusion from the previous study. It is also clear that the assembly process has a meaningful effect on self-mitigation, which is a new finding.

The difference between HASL and OSP pad finish has no significant impact on self-mitigation.

Variation in pad size exhibits a statistically significant, but very minor impact on self-mitigation, for the range of pad sizes investigated in this study.

Self-mitigation of the various packages in the study can be broken down into three broad groupings:

1. Packages that exhibit a near certain probability of self-mitigation over the entire range of processes examined in this study (0603 chips, SO14Gs).
2. Packages that exhibit a near certain probability of self-mitigation, but only for one particular assembly process (TFQP100 and LQFP48 for Process G).
3. Packages that exhibit a very low probability of self-mitigation under all conditions (0612 chip).
4. Packages that exhibit a moderate probability of self-mitigation within the range of 0.6–0.9 (all other packages).

Readers should note that 0603 chip components are available in a wide variety of component heights and termination lengths, so the results shown here would only be applicable to chip components with heights and links that were equivalent or smaller than those used in this study.

Future Work Plans

IPC task group 8-81f plans to continue investigating this hardware over the next year.

A comprehensive plan of cross sectioning and SEM/EDS analysis will be developed and implemented. The intent of this is to understand the causes for the very low thickness readings and determine which if any of this data is valid. Also, we will validate where the original tin finish has been completely consumed, and to cross check the composition measurements.

A detailed statistical analysis will be performed to identify any meaningful correlations between the various process parameters associated with the assembly processes and self-mitigation behavior of the various components.

Two additional boards have been assembled using components that were in uncontrolled storage for a number of years. The effect of this storage on self-mitigation will be investigated.

Acknowledgments

The authors wish to acknowledge the valuable contributions from the following individuals and companies, without which this work would not have been possible:

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- Dr. Ross Wilcoxon, Rockwell Collins
- David Vicari, Universal Instruments
- Mike Robinson, Judy W. Little, Milea Kammer, and Dr. Joseph Juarez, Honeywell **SMT**

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1. T. Hester and D. Pinsky, "Tin Whisker Self-Mitigation in Surface Mount Components Attached with Leaded Solder Alloys," SMT Magazine, October 2015.

2. Tolerance Intervals for a Normal Distribution.

Editor's Note: Appendix A can be found here.

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South Carolina's Aerospace Industry Trends Towards Sustainable Growth

According to two new studies released at the recent SC Aerospace Conference & Expo, South Carolina's aerospace industry is trending towards diversified and sustainable growth. An economic impact study released by the South Carolina Council on Competitiveness shows that the impact of aerospace on South Carolina's economy has grown to $19 billion, an increase of $2 billion since last measured in 2014.

The Council's study finds that for every 10 jobs that are created in the private sector component of the aerospace cluster in South Carolina, an additional 13 jobs are created elsewhere in the state's economy. The average total compensation for private sector aerospace employees is $70,000 per year, and still far exceeds the state average of $41,338, and the manufacturing industry as a whole, which averages $53,350.

The second study released at the conference, the 2016 Southeast Manufacturing Study, was conducted by Aviation Week during May and June 2016. Alabama, Florida, Georgia, North Carolina and South Carolina participated. The purpose of the study was to better gauge the need for manufacturing workers in the Southeast, the region experiencing the highest rate of growth in terms of manufacturing operations in the United States.

Respondents to the survey indicate steady increases in manufacturing jobs across the board. The six most in-demand job categories in South Carolina's aerospace manufacturing sector (in descending order of demand) are: engineering technicians, aircraft painters, production technician, machinist, inspector and A&P mechanic.

Smart for Smart's Sake, Part 1

by Michael Ford
MENTOR GRAPHICS CORPORATION

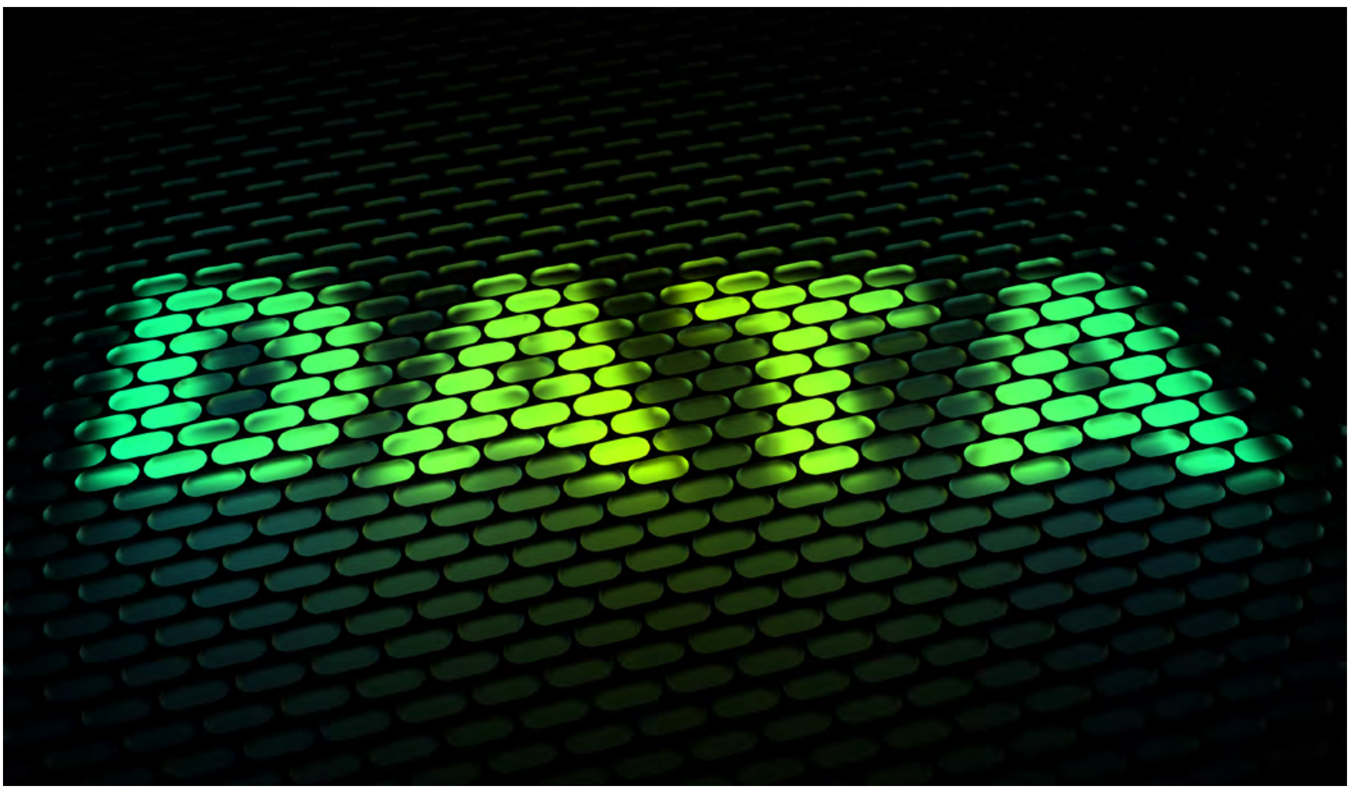
In this so-called digital revolution in electronics manufacturing, we seem to be inching forward. This slow progress may be because the electronics manufacturing industry has special needs, being somewhat more complex than other areas of manufacturing. Previous generations of software systems applied to electronics manufacturing achieved limited benefits while introducing additional costs, so it is understandable that seasoned management are sceptical about this new breed of Smart Factory or solutions related to Industry 4.0.

Let's take the lid off this shop-floor digitization issue once and for all, to determine how what we do today, for example, with Open Manufacturing Language (OML), will be different from past challenges that caused people to move forward cautiously.

Previously in this column, we discussed the various historical methods of collecting data from shop-floor processes, and how it compares to the fully normalized approach of OML, where data from any machine operation can be expressed in a single interoperable language. Let's progress now to the next layer of activity—where the data collected is to be used. In this first part of the Smart for Smart's Sake series, we consider the most basic of uses for the data: asset utilization and productivity.

Once a reliable flow of information from all the various processes on the shop-floor is established with OML, the natural inclination then is to store all of the information into a huge database, so that anyone can use it for whatever purpose they like. Nowadays, thoughts go immediately to the cloud, which we imagine is like a huge data repository that the likes of Google would use to find information on whatever you are searching for. Unfortunately, it is not quite like that.

Sending data to the cloud, through ERP, MES, or some sort of middleware, seems like an



ideal IT solution. However, we are talking about a lot of data. At each process, for each PCB or assembly, a range of data is collected, most of which is only available in real-time, such as:

- Arrival of the unique product at the process
- Start of the production cycle
- Completion of the production cycle
- Product leaves the process
- Operational warnings such as material pick-up errors
- Messages that describe various reasons that the machine might stop, such as material exhaust
- Other process exceptions
- Verification of each material
- Unique feeder information
- Traceability information, which can be a list of all reference designators and the code of the exact material ID that was used
- Image information including material pickup and placement, leads, etc.
- Machine usage statistics

Beyond SMT, the messages can get more complex, for example:

- Operational result information (pass or fail)
- Electronics repair ticket
- Detailed test results or operational measurements
- Operation guidance step increments and confirmations
- Diagnosis and repair information
- Routing confirmation

For a single operational production flow, end-to-end, many messages are generated each second. Some of the messages contain many kilobytes of data. Multiply that by the total number of production flows in the factory and, now we are wanting to store more and more data in the cloud, second by second, month after month. What makes electronics yet more of a challenge compared to other industries is the sheer size and complexity of the bill of materials and the number and diversity of the various production processes.

The danger of taking all of the data from all of the processes and simply stuffing it into a cloud is that it will make that cloud "heavy." Suddenly, impressions of the big fluffy white masses in the sky come a lot closer to the ground, and they look menacingly dark. Standard data analytical tools make heavy work of looking through complex data to generate reports, based on time, processes, materials, or any of the dozens of key metrics. Generating near-real-time graphs, charts, or dashboards of live production information is a serious challenge.

The good news is that the latest generation of business intelligence or data analytics software is able to cope with immense volumes of information. However, the issue is that we are putting raw data into the cloud. Even where this data is fully normalized into a single language like OML, the process of reporting is an order of magnitude more complex than simply going through the data and adding up the numbers in different ways.

For example, consider a fairly standard SMT machine, labeled "Z." After working for some time, Z completes the placement process, and the current PCB leaves the machine. It then looks to start the next, but no PCB has arrived. An event or status message is sent into the machine log and out to external systems, such as "Stopped. Waiting for PCB." Z has limited visibility outside of itself. What happens inside the machine can be reported, but any external causes of issues can only be represented by the symptoms.

For machine-based reports, around 80% of the information is just symptom, without a known reason or cause. Smart computerization, on the other hand, can take the "Waiting for PCB" message from machine "Z" and start the process to discover the reason behind the event. The Smart computerization knows the flow of the current production work-order or job, so the process immediately before "Z" can be identified, which may simply be a connected machine upstream in the line, or it could be a completely different machine process or logistics operation.

Using a common platform for the information such as OML, what is going is much easi-

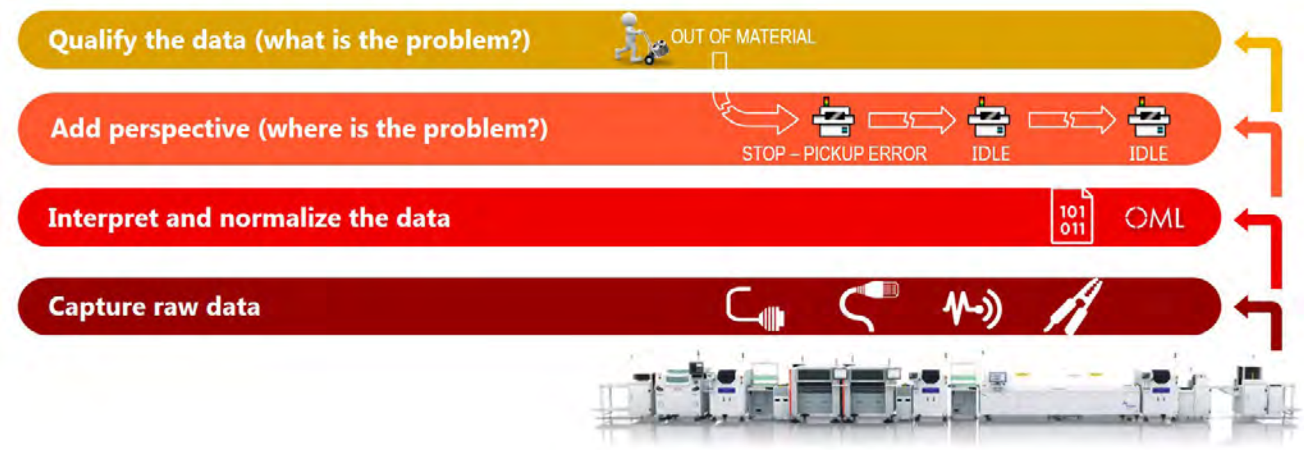


Figure 1.

er to identify. For example, machine "X" earlier in the line had stopped, which starved the delivery of PCBs to subsequent machines "Y" and "Z." Working up the line, the computerization will find the source of the issue. Perhaps the earlier machine "X" stopped because of a material pickup error. The subsequent stop events downstream that happened as a result of this machine stopping for the material pickup error can now be assigned responsibility for the correctly assigned stop-time.

The OML-driven computerization can actually go further. A material pickup error may occur for many reason, such as:

- Missing material in pocket on a reel
- Material not correctly positioned in pocket
- A feeder error occurred
- Material was exhausted
- An incorrect material was loaded, such as a different size
- The material was exhausted, but the replacement material had not arrived
- The material was exhausted, but the replacement material was incorrect, damaged, or had moisture sensitivity device (MSD) issues

The responsibilities for each of these causes of the material pickup error are different, but now the issue can be qualified. The Smart computerization can look at the material verification operation to determine what happened at that point in time, at that materials position. In some cases, the machine or material operator can interact, using a mobile device, with the computerization at the machine to add a qualification to the event. In this example, the issue was that the material had an MSD timeout.

For the OML-based Smart computerization, putting together the events around the symptoms reported from each of the machines is a relatively simple process. Using a data analytics tool to reconstruct these events over and over potentially billions of times to create a report would be completely ridiculous. But if the qualified data is put into the cloud, once the event has been fully explained by the computerization, the data analytics software becomes practical and usable even with the huge amounts of data still required.

The Smart computerization also can be used to extract more value. For example, local data storage of normalized and qualified events by the computerization is available, which also makes that data available for Smart systems, such as asset utilization and productivity reporting.

As many of us know, when it comes to performance reporting, the data can be looked at in many different ways, which allows many different ways to measure performance, depending on the specific point of view. In our example, we had machine "X" that was stopped for an MSD issue that then subsequently stopped other machines "Y" and "Z" further down the line. Asset utilization looks broadly at the time for which the machine was "operational," compared to when it was "available," and is often used to compare the performance of manufacturing sites.

However, the way of measurement can potentially be different depending on the specific focus or purpose of the report. Let's take a look at the following scenarios to illustrate how this might work.

• The machine is present in the factory, fully installed, and ready for operation. It is available 24 hours per day, seven days a week. The asset was paid for, and, in theory, it should be adding value at all times, the more the better; so no excuses, measure the operational time purely against the physical availability.

• Perhaps though, the manufacturing site has vacation periods. Different sites have different vacation times, so why penalize a factory and its assets because of something that is beyond the control of factory management? If the site is on vacation, then we could argue that the machines are not available during that period.

• Some times in the factory not all lines are utilized. Scheduled downtime could also be removed from the calculation because it is not a reflection on the machine performance that the factory is not fully loaded. In many cases, knowing the performance of the machine while actually active in production is more valuable.

• Given these scenarios, what about the changeover time? It is not the fault of the machine that manual verification of materials has to take place. The machine can only be operational during actual production, so perhaps excluding the changeover time from the availability calculation adds more value in some cases.

• In our example, machines "Y" and "Z" were in production, but stopped because of another machine, "X," earlier in the line. From the equipment performance perspective, this is not a fault of either "Y" or "Z", and so it can be argued that this external stop time should also be removed from the availability calculation.

• How about machine "X" though? The reason for the stop of "X" was not related to the machine itself. Moisture contamination of a material is a reason that is completely external to the machine. If we want to compare machine performance, model-to-model or site-to-site, then perhaps all external reasons for stoppage should be eliminated from the machine availability time.

• There are also times that the machine is operating, but, in a way that is defective. Perhaps this time should also be removed because the machine operation was not adding value. The measurement of performance should be altered according to the quality data, so that it is only included when the machine is working perfectly, which would be then the definition of it being operational.

• Whenever materials need to be replenished, the SMT machine may need to stop. Should this also be regarded as a machine responsibility, or external?

• How about the cases for more complex machines, where there are two or even three conveyors for different PCBs through the machine simultaneously, with multiple modules of machine operation each with multiple heads? Rarely are all parts of the machine working at the same time, and it is equally rare during operation that they are all stopped. Different areas and elements of the machine will start and stop as required, but how can this be measured and accounted as run time or stop time, availability, and operation?

• Finally, what about the loss time within the machine while executing a program that is not 100% efficient. Excess movement of heads should be avoided as far as possible during the programming sequence creation. But how to account for the different losses when you're comparing a program that is optimized for a single product versus that which is optimized for a range of products so that additional distance for travel to pick up parts is required which slows the cycle time of the machines? How about the case where feeders are not placed on the machines in optimized positions (random feeder setup), and the machine has to compensate accordingly with significant increase of cycle time?

These are all simplified arguments that have been a part of industrial engineering for many years. Because of the complexity of the issues, a specific method or perhaps a couple of different methods for the calculation are decided on and followed. Metrics are described as equipment productivity, absolute equipment productivity, asset utilization, total equipment productivity, effective equipment productivity, or overall equipment effectiveness. Many more of these terms attempt to offer some kind of standard method to measure production performance, but, in many cases, they are customized because of industrial engineers who override decisions, believing that different element combinations are a better measure for them.

It is hard to disagree with anyone who has an opinion on this matter because different roles within manufacturing are responsible for different elements of the operation, and so they require differences in the way of calculation. In reality, perhaps all the ways of calculation are potentially important, as over time different metrics are used to expose and correct different weaknesses or operational losses.

When it comes to data collection, normalization, and qualification, Smart computerization should be able to calculate the performance of manufacturing in any of these many different ways. However, it needs to include information from all of the different elements to be able to create an added value record of events. This contrasts with somehow putting together the events in whatever way seems appropriate later during the reporting cycle. Instead, this becomes the work of the Smart asset management computerization, which takes the normalized data, for example, in OML format, from all machines, processes, and operations, and builds up a live digital map of the production operations. The data can then be represented in any way as desired in reports, dashboards, and, of course, to send to the cloud. The data in the cloud, which in raw format would likely have been only 20% useful, is now with input from the Smart computerization virtually 100% added-value.

The Smart asset management computerization is valuable because it can expose oppor-tunities in the operation where losses can be saved. Through the Smart logic, what would have been difficult situations to analyze can now be seen quickly and easily, which results in significant increased opportunity for operational performance improvement compared to using just the raw data. This is not just "Smart for Smart's" sake. The justification for the computer-ization could end there, with return on investment easily achieved within a year, but, in our smart factory, we want to go further to use the information for other smart purposes, which we will discuss in Part 2. **SMT**

Michael Ford is senior marketing development manager with Mentor Graphics Corporation Valor division. To read past columns, or to contact the author, click here.

I-Connect007 Survey: A Look at the Mil/Aero Industry—Lead-Free

Source: I-Connect007

One of the issues encountered in the high-reliability electronics sector when the industry moved to adhere to the Restriction of Hazardous Substance (RoHS) directive is the use of lead-free components in manufacturing. Using lead-free solder, for one, has put a squeeze on military and aerospace systems designers because of the problem on tin whiskers.

However, that was ages ago, and the industry has moved to adapt lead-free alternatives and solutions. In fact, according to our survey, most companies no longer have any issues on lead-free components. They said that right now, the supply chain consists of lead-free components, so companies have figured out what to do to work with them. However, the only problem is cost, as they are more expensive.

Some issues, on the other hand, include controlling phosphate levels in lead plating; reflow temperature compatibility, and still for others, connection reliability.

MilAero007 Highlights

Milwaukee Electronics: Screaming-Fast in Pursuit of 'Perfect Products'

Jered Stoehr, VP of sales and marketing at Milwaukee Electronics, discusses with I-Connect007's Judy Warner the innovative ways their company is meeting the needs of today's OEMs. He also talks about the challenges and opportunities they are seeing in their markets.

Sparton Gets Navy SeaPort-e Contract

Sparton's wholly owned subsidiary Sparton DeLeon Springs was awarded a contract under the U.S. Navy SeaPort Enhanced (SeaPort-e) Indefinite Delivery/Indefinite Quantity (ID/IQ) Multiple Award Contract (MAC), allowing Sparton to supply a broad range of engineering and technical support services to U.S. Navy programs.

Jabil Releases Social and Environmental Responsibility Report

Jabil has released its Fiscal 2015 Social and Environmental Responsibility (SER) Report detailing the company's global SER strategy and performance.

Rocket EMS Purchases Fortus 3D Production System from Stratasys

Rocket EMS Inc. announces the purchase of the Fortus 3D Production System, a 3D printer that allows prototype design parts to be created faster and at a lower cost compared to traditional machining, resulting in more design iterations and a more refined end product.

Cobham Lands $8M Satellite Motion Control Order from Northrop Grumman

Cobham recently received an award from Northrop Grumman valued at approximately $8 million for motion control technology for the Advanced Technology Microwave Sounder instrument to be flown on the Joint Polar Satellite System 3 and 4 satellites.

TRICOR Systems Receives Boeing Performance Excellence Award for the 6th Consecutive Year

Electronics manufacturing services (EMS) provider TRICOR Systems Inc. has received the prestigious 2015 Gold Boeing Performance Excellence Award from The Boeing Company. This is the sixth consecutive year that TRICOR Systems received the award from Boeing. The award is issued annually to recognize suppliers who have achieved superior performance.

Season Group Invests in New Equipment for USA and Mexico Operations

Season Group, the global, vertically integrated EMS company, has announced that it has made a significant investment in new SMT and cable assembly equipment for its San Antonio, Texas and Reynosa, Mexico sites.

Nortech Systems 2Q Revenue Up 8%

Nortech Systems reported net sales of $28.9 million for the second quarter ended June 30, 2016, an eight percent increase over net sales of $26.8 million for the second quarter of 2015.

Orbit International to Commence Material Procurement Process for $825,000 Contract

Orbit International Corp.'s Electronics Group has received a letter contract from a major prime contractor for approximately $700,000, authorizing it to commence the procurement of material, while negotiations for the final purchase order are being concluded.

James Long Promoted to VP and GM of Sypris Electronics

Sypris Solutions has promoted James M. Long to the position of Vice President and General Manager of its subsidiary, Sypris Electronics.

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IPC Certification Program's Space Hardware Addendums Training and Certification

by Sharon Montana-Beard
BLACKFOX

Program Benefits

Space Hardware Addendums are developed by the IPC Committee Membership in addition to the base certification programs to include the extended requirements for products that must survive the vibration and thermal cyclic environments of getting to and operating in space. The aerospace industry, when specified, recognizes the Space Hardware Addendums in addition to the base standards as meeting many of the requirements for workmanship and specification acceptability.

The Space Hardware Addendums are included as modules for the J-STD-001, IPC/WHMA-A-620 and IPC-6012 Certified IPC Trainers and Certified IPC Specialist programs.

The IPC training and certification programs have two tiers of instruction. Certified IPC trainer candidates are sent to an official IPC certification center by their parent companies to receive intensive training and are then certified to provide application specialist or certified IPC specialist training. The term for certification is two years.

J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies with Space Hardware Addendum

The IPC J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies has emerged as the preeminent authority for electronics assembly manufacturing. The standard describes materials, methods and verification criteria for producing high quality soldered interconnections. The standard emphasizes process control and sets industry-consensus requirements for a broad range of electronic products.

Certified IPC trainer candidates who successfully complete the soldering workmanship portions of the course and the certification examination are given the instructional materials needed for training application specialists. The application specialists training is modularized, meaning that training on the entire document is not required. Application specialists must be trained on the introductory section, and then

may be trained on other modules covering: wires and terminals, through hole technology, surface mount technology and inspection.

J-STD-001 Space Hardware Addendum

An optional module for those wishing to understand the extended requirements for products that MUST survive the vibration and thermal cyclic environments of getting to and operating in space in addition to or in place of the NASA 8739 .2 and .3 as detailed in the NASA 8739.6. Hands on skills are included in this course.

Topics Covered in the Training Courses:

- General requirements, such as safety, tools and electrostatic discharge (ESD)
- Wire and terminal assembly requirements, demonstrations and laboratory
- Through hole technology requirements, demonstrations and laboratory
- Surface mount technology requirements, demonstrations and laboratory
- General soldered connection acceptance requirements (including lead free)
- Machine and reflow soldering process requirements
- Test methods and related standards
- Using statistical process control methodology

Who Should Become an IPC J-STD-001 Certified IPC Trainer or Certified IPC Specialist?

The requirements for soldered electrical and electronic assemblies has emerged as the preeminent authority for electronic assembly manufacturing. This standard defines the materials, methods and verification criteria for producing high quality soldered interconnections. This standard emphasizes process control and gives companies the tools they need to increase employee skills and performance. J-STD-001 sends a strong message to customers that your company is serious about implementing companywide quality assurance initiatives. Anyone responsible for quality and reliability of soldered electronic assemblies should attend this hands-on soldering course. Assembly process engineers, quality assurance supervisors, training managers and others responsible for the quality and reliability of soldered electronic assemblies are excellent candidates for the program. Optional Space Hardware Addendum is available and the training is offered in many languages.

IPC/WHMA-A-620 Requirements and Acceptance for Cable and Harness Assemblies with Space Hardware Addendum

This standard describes acceptability criteria for crimped, mechanically secured and soldered interconnection and the corresponding lacing/restraining criteria associated with cable and harness assemblies.

IPC/WHMA-A-620 Space Hardware Addendum

The students will demonstrate the ability to build and install in a unit three complete cables. This will involve soldering, cup terminals, crimping, machine contacts, insulated lugs, IDC connections, wire splices, coaxial connectors, shield terminations, including routing using ty-raps/lacing cord, shielding braid and shrink tubing and testing of the final product.

IPC/WHMA-A-620 Training Course Topics:

- Cable and wire dimensioning, tolerances and preparation
- Crimp terminations:
  - Stamped and formed contacts
  - Machined contacts
- Insulation displacement connections
- Ultrasonic welding
- Soldered terminations
- Splices
- Connectorization
- Molding and potting
- Marking and labeling
- Co-axial and twin-axial assembly
- Wire bundle securing
- Shielding
- Installation
- Wire wrap (solderless)
- Testing of cable/wire harness assemblies

Who Should Become an IPC/WHMA-A-620 Certified IPC Trainer or Certified IPC Specialist?

IPC/WHMA-A-620 is the industry's first standard for cable and wire harness fabrication and installation. IPC/WHMA-A-620 describes acceptability criteria for crimped, mechanically secured and soldered interconnection and the corresponding lacing or restraining criteria associated with wire and cable harness industry. This certification will demonstrate your commitment to customer requirements and greatly facilitates other quality assurance initiatives. Anyone responsible for quality, reliability and integrity of end use cable or wire harness assemblies should attend this in-depth program. Optional Space Hardware Addendum available. Assembly process engineers, quality assurance supervisors, training managers and others responsible for the quality and reliability of soldered electronic assemblies are excellent candidates for the program. Optional Space Hardware Addendum is available and the training is offered in many languages.

IPC-6012 Qualification and Performance Specification for Rigid Boards with Space Hardware Addendum

IPC-6012 Qualification and Performance Specification for Rigid Boards

This specification covers qualification and performance of rigid printed boards, including single-sided, double-sided, with or without plated-through holes, multilayer with or without blind/buried vias and metal core boards. It addresses final finish and surface plating coating requirements, conductors, holes/vias, frequency of acceptance testing and quality conformance as well as electrical, mechanical and environmental requirements. Revision C incorporates many new requirements in areas such as selection for procurement, new surface finishes, hole plating thickness, measling, weave exposure, copper cap plating of filled holes, laminate cracks and voids, etch back, blind and buried via fill, acceptance testing and frequency, and requirements for thermal stress testing. This revision synchronizes to the IPC-A-600. For use with IPC-6011.

IPC 6012 Space Hardware Addendum

The Space Hardware Addendum is included as a required module for the IPC 6012 Certified IPC Trainer and as an optional module for the Certified IPC Specialist programs for those wishing to understand the extended requirements for products that MUST survive the vibration and thermal cyclic environments of getting to and operating in space.

Topics covered in the training courses:

- IPC-6012 Scope/Applicable Documents
- Material requirements
- Visual requirements
- Dimensional and conductor requirements
- Structural integrity requirements
- Solder mask, electrical and cleanliness
- Special requirements
- Quality assurance provisions
- Appendix A—supplemental requirements

Who Should Become an IPC-6012 Certified IPC Trainer or Certified IPC Specialist?

IPC-6012—A must-have certification for board fabrication technicians and engineers, the IPC-6012 thoroughly defines the standard requirements for rigid bare board fabrication. This course covers qualification and performance of rigid printed boards, including single-sided, double-sided, with or without plated-through holes, multilayer with or without blind/buried vias and metal core boards. It addresses final finish and surface plating coating requirements, conductors, holes/vias, frequency of acceptance testing and quality conformance as well as electrical, mechanical and environmental requirements. This class also addresses the separate requirements for space and military avionics hardware. Assembly process engineers, quality assurance supervisors, training managers and others responsible for the quality and reliability of soldered electronic assemblies are excellent candidates for the program.

Optional Space Hardware Addendum is available and the training is offered in many languages. **SMT**

Sharon Montana-Beard is the vice president of sales and operations for Blackfox.

The Child is Father of the Man:
Turning the Relationship Between the Electronic Product Assembly Employer and Recent Graduates Upside Down

by Tom Borkes
THE JEFFERSON PROJECT

Occam's razor suggests that when confronted with several competing solutions to a problem, the simplest solution is normally the best one (or, the correct one). This 14th-century principle suggested by William of Ockham has had seven centuries of positive reinforcement to demonstrate its wisdom.

Question: For a given problem, when is a complex solution preferred over a simple solution?

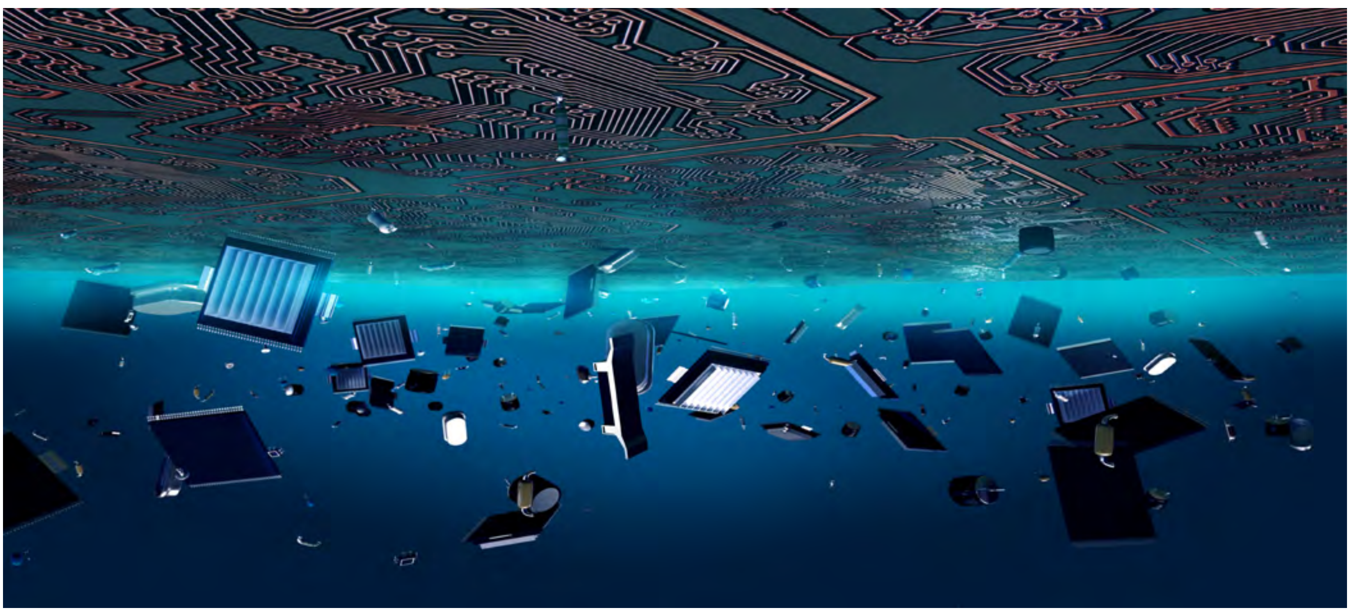
Answer: When the problem is government funded and you rely on government funding for your livelihood.

By the end of the 18th century the world had a vexing problem: The lack of a standardized system of weights and measures. Global mercantilism (trade) exacerbated the dilemma that already severely plagued commerce between states in the nascent United States. The trading countries (and individual states) were confronted with a measurement hodge-podge that rivaled today's quantum theory in complexity[1].

Within the United States, each state had its own system. So the size of a bushel in Maryland was different than that in Georgia.

Surveying land in the new America was crucial since the sale of this land was an important source of revenue to help pay the revolutionary war debt. Again, confusion reigned as an acre of land on a forested plot was larger in size than an acre of land on a treeless lot.

The Gunter Chain, a tool adopted in the 17th century, helped by providing a standard length. It also tried to reconcile the English system based on increments of four (it was 66 feet long—a foot being 12 inches), and the new decimal system based on 10 (it was composed of 100 links). An acre was equal to 10 square chains[2].



The 18th century embodied the continuation of the scientific revolution, the Age of Reason and the Age of Enlightenment. It begged for a scientific solution to the problem. Improved measurement instruments like a better theodolite were now available to lend precision and accuracy to measurements. If only standard, uniform units could be defined and accepted by the trading partners and the buyers and sellers of land.

The starting point was to create a measurable, repeatable basis as the datum for both weights and measures.

"The starting point was to create a measurable, repeatable basis as the datum for both weights and measures."

Since trading was international, any new standardized system had to be approved and adopted by the major trading countries: England, France and the United States. England and France were archenemies. The new kid on the block, the United States of America, with strong traditional ties to British custom, had largely evolved from that culture. American independence provided the opportunity to develop a standard weights and measures system that served U.S. interests.

There was a sense of urgency in the U.S. because of the building pressure to purchase and settle land, as well as to speculate in buying and selling massive amounts of land. It demanded a reliable way to measure and document a land buyer's purchase.

In 1790, as the country's first Secretary of State under the new Federal constitution, Thomas Jefferson was tasked with the problem of resolving this mess. He had already essentially created a monetary decimal system for the new country with a new U.S. dollar equal to 100 cents as its basis—rejecting the English pound, shilling, pence system, where 12 pence equaled one shilling and 20 shillings equaled one pound.

As a scientist, he knew the weight and measure system solution needed to be built on a common, scientific foundation, and thought it essential that the resulting system should be simple enough so that the average citizen could understand it. Therefore, they would be able to compute for themselves whenever they had occasion to buy, to sell, or to measure, which the present complicated and difficult ratios place beyond their computation for the most part[3].

This would permit the average citizen to more easily improve his lot in life through trading the excess goods they produced, and acquire the necessary wealth to buy land. In addition, it would add sanity to the business practices of an emerging middle class of business owners.

Clearly, the decimal system provided the simplicity. So why in the U.S. are there still 12 inches in a foot, and not 10?

The answer is France who, although totally committed to a decimal system, wanted to establish the standard length by physically measuring the length of a meridian. Once the meridian's length was known, one ten-millionth part of it would be defined as a meter. The U.S. preferred Jefferson's proposal of using the length of a pendulum with a period of one second. Why was France's National Assembly in favor of a standard length that was much more difficult to determine? The answer was they wanted to keep their scientists at work after their traditional government home, the Academie, was abolished.

Measuring a meridian on the earth was far more complex and time consuming than measuring the length of a pendulum with a period of one second in a laboratory (and, the more time, the more government money—the French legislative body, the National Assembly, voted to fund this project with an additional 300,000 livres)[4].

Politics trumps Occam!

Remember, this was 1791. The Bastille in Paris had been stormed in 1789 (Jefferson was a firsthand witness). He lived in Paris as U.S. Minister to France from 1784–1789, soon to return to the U.S. after this early first rumbling of the French Revolution, arriving in New York in April 1790.

King Louis XVI and Queen Marie Antoinette were soon to have their heads separated from their bodies during the terror in early 1793.

Here is the rest of the story.

As Secretary of State in 1791, Jefferson proposed to Congress a decimal system. The system had as its basis the length of a pendulum that had a period of one second of time (at a point on the earth at a latitude of 45 degrees (i.e., Paris, France—could King Louis refuse?). One second of time was relatively easy to measure and very repeatable since it was based on the elapsed time it took the earth to rotate once on its axis—one day (divided into 86,400 parts or seconds).

Ingenious, really—tying the standard for length to time, and time to the physical invariance of the earth's rotation!

The Senate committee tasked with instituting a standard system accepted Jefferson's proposal. They further suggested the pendulum length be divided into five equal parts, each one called a foot. The foot would be subdivided into 10 equal parts called an inch. What was needed for full congressional approval was the agreement for adoption by England or France, preferably both.

Two factors caused the project to get mired down:

1. France did not accept Jefferson's method. They chose instead the labor-intensive, protracted method of physically measuring the meridian. For the needed accuracy they would measure the meridian from Dunkirk, France to Barcelona, Spain—about 9.5 degrees of the total meridian's pole-to-equator 90.0 degrees.

2. U.S./Native American hostilities in the Northwest Territory.

The first was problematic. There was a sense of urgency in the U.S. It was considered critical by Jefferson and others that the U.S. had a standard system of measurement to lend credence to the settling of the Northwest Territory. The second factor actually bought the U.S. government time since it greatly slowed down settlement and surveying.

By the early 1793, the latest attempt by the French to measure the meridian was still not complete—it would take years. So, the French settled on the length of the meter based on prior meridian surveys. In addition, it defined a standard weight: the kilogram as the weight of one cubic decimeter of water.

In the meantime, in the U.S., wars with the Native Americans continued. This significantly slowed settlement in the Northwest and bought time for adoption of a standardized measurement system.

Time ran out in 1795. The Native American wars were winding down (for now) and the signing of Jay's Treaty that once and for all ended England's claim to the territory. There was a mad rush to settle the land and still no metric-based, standard measurement system in place.

The attempt to get the U.S. to agree to the French standards of the meter and the kilogram was scuttled when an attempt to provide the U.S. with a physical rod that was one meter long and a weight that was one kilogram had big problems making it across the ocean. By the time these physical samples finally made it to Philadelphia in 1794, Jefferson had retired to Monticello. Congress continued to kick around a standard system, never seeing the French physical samples, and would never come to adopting a metric-based system, much less the specific French standards of the meter and the kilogram. The Northwest Territory was surveyed using the standard length provided by the "Gunter chain" that was based on increments of 4, not 10. And, that's why in the U.S. there are still 12 inches in a foot and not 10, and an American football field is 100 yards long (90.46 meters), not 100 meters long.

"There was a mad rush to settle the land and still no metric-based, standard measurement system in place."

We see in this example that goes back to the country's founding how politics can drive policy, and how the people's will and interest can be thwarted by their elected representatives. How about educational policy, both public and private?

That brings us to this month's topic: The interaction between employers in the private sector world and recent graduates who have been educated in the academic world. Prior *Jumping off the Bandwagon* columns over the last five months have addressed the issues that have plagued our industry as it had been forced to underwrite the cost of closing the ever-widening gap between academic preparation and industry need.

As civilization has developed, the role of education for the individual has changed in its objectives—from the elitist position that the education of the masses is dangerous to the civil order, to the need to create an environment of total academic freedom, to education being recognized as a key element necessary to safeguard the freedom of a republic's citizenry. The current state of higher education has been morphed into a restrictive, politically correct environment where free speech is protected as long as it is the correct free speech—free of micro-aggressions and political incorrectness.

Education is life itself (John Dewey). As early as the 1920s and 30s the philosopher/educator John Dewey proposed rethinking what he saw as a restrictive education system. He suggested that learning should be a process based on students experiencing the challenges associated with the real world.

Challenge everything Jefferson said: Question with boldness even the existence of a god; because, if there be one, he must more approve of the homage of reason, than that of blind-folded fear. (Source: 1787 Letter from Thomas Jefferson to his Nephew Peter Carr.)

The Socratic method suggests that truth is arrived at by asking questions.

It is essential that in democratic-based governments individuals come to their own conclusions about what people they should permit to lead them. In addition, deciding what they will allow those leaders to do. This was a primary goal of education.

So at least in theory, an objective of academia consistent with the freedom of speech clause of the first amendment of the federal constitution, is the need to protect the academic freedom that comes with creating an educational environment that encourages questioning. Tenure for academic faculty members was established to guard against any action that could be taken against them if they said something that was not politically correct. Having an academic community that is protected from scrutiny and is separated from the industry for which they are preparing students has not worked.

"The Socratic method suggests that truth is arrived at by asking questions."

Let's test the theory.

I have questioned and challenged the traditional framework that academia has used to prepare students for a career in high tech electronic product assembly. The complexity and rapid rate of change in this industry has not permitted the academic community to properly educate the student.

Many in the academic community say, "This is essentially a vocational field. The details needed for an individual to be successful should be taught in a vocational school—not an engineering school. They should be taught like we teach welding or auto mechanics." In the U.S., we continue to lose manufacturing jobs to low labor rate regions of the world. Most sources estimate five million manufacturing jobs have been lost since the year 2000.

Other *Jumping off the Bandwagon* columns have addressed the ostensible reasons given for this. All of these reasons miss the real causes: (1) the skill sets provided to the entry-level workforce by the academic community are incomplete, not real world based, and improperly taught; (2) the proclivity of management to staff factories with the lowest wage workers possible; and (3) an organizational structure that has very high indirect and overhead costs that must be absorbed. This causes labor sell rates to be greatly inflated with non-value added costs.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No one likes to have his or her worldview challenged. This personal interpretation of what our existence is all about and how one should interact with the world we perceive through our senses is shaped through our genes and experiences. It develops as a person grows from childhood through adolescence and into adulthood. Usually, the older a person is, the more entrenched this worldview becomes. We are exposed to more and more of the world and embrace some ideas and discard others. We gravitate to ideas that support and reinforce our emerging view. Finally, many of us shut down and reject out of hand those ideas that threaten our personal view.

This progression holds true for organizations, communities and disciplines as well. It is one of the reasons the academic community is intractable when it comes to recognizing the need for real change in certain areas of study.

For many of us the individual path that defines this journey begins with our parents. Unfortunately, for others it begins with Pokémon Go—and stays with video games and smart phone apps. For many, Maslow's Hierarchy of Needs should be modified; the need for self and instant gratification feeding a narcissistic attitude of entitlement should be inserted between the need for breathing, food, water, etc., and security of employment, body, morality, etc. In other words, what becomes of supreme importance is access to Grand Theft Auto V, and

> **"For many of us the individual path that defines this journey begins with our parents."**

I'll throw in one's telling the world what they had for breakfast this morning through social media.

People preoccupied with these activities become ripe for government picking. Remember: bread and circuses! Maybe, things haven't changed so much from the days of the Roman Coliseum!

Our species has the unique advantage of storing and sharing information outside of ourselves. This ability permits us to fast-track the journey to worldview as other people's experiences are accessible to us through books and other media.

The body politic is a metaphor, but the body part is closer to reality than we sometimes realize. Taking a short view, the activities each us undertake appear as self- contained and random, usually with self-interest as the driving force. If we look at an individual ant in a colony its movements often seem without purpose. As we pull back and look at the same ant in the context of the entire colony what emerges is meaning and purpose to an individual ant's activity. As David Hofstadter suggests, it is what seems to transform an anthill into Aunt Hillary[5] (no political connection implied).

At the primary, secondary and post-secondary levels, the United States educational system is currently ranked 14th out of the 39 countries in the Global Index of Cognitive skills and attainment[6]. What does this mean? The ranking depends on the organization doing the rating and the criteria used in the evaluation. This may have relevance at primary and secondary levels because reading, math and science knowledge are fairly easy to test… but, at a college level?

Relegating the goodness of a post-secondary school to a top-40 list is like judging the quality of a new song by the appearance of the artists performing it.

What are some of the criteria that go into some typical rating systems? Using the number of books in a campus library as a criterion for rating the school's excellence? The age of the university as a factor in the school's ranking? Are you kidding?

The arrogance alone in suggesting that meaningful results can be determined by plugging numbers into a model, speaks volumes about the people doing the rating.

What a bureaucratic waste of time, resources and money. Predictive evaluations, like those of a new record release, are subjective at best: "It's got a good beat and it's easy to dance to!"

The real value of an institution of higher learning is manifested in the results their graduates achieve. These results are a measure of the per student intellectual property that they generate and the economic output they add to the companies for whom they work.

As important, the value of a post-secondary education to an individual is measured by:

1. The enthusiasm and inquisitiveness developed for lifelong
2. General skills acquired, like problem solving and critical thinking
3. Specific learning for earning skills attained

To rate a college's performance based on these criteria, one must track the graduates when they are working in the real world.

In addition, there should be a gap analysis done between the student entering the school and the student when they graduate. The Graduate Record Exam (GRE) is an attempt to measure the latter. The SAT is an attempt to measure the former. There is little attention paid to measuring the student's college achievement as a function of their starting point.

What is the solution to an educational system that has become unresponsive to the needs and best interests of their customers—the students? A system, that for all the money spent per student at the compulsory stage of the pipeline, grades 1–12, and an elective, post-secondary part of the pipeline that burdens the graduate with debt as far as the eye can see. A system that produces graduates that trail other competing countries in basic reading, math and science skills, countries that spend far less per student and provide better learning for earning skills needed in the real world.

Is the solution STEM?

Is the solution a government provided free college education?

Is the solution a government that throws more money into the system?

Is the solution continuing to dumb down the curriculum to attract more students and keep the college classrooms filled?

Is the solution for the government to make more loans available that many students have little or no chance in paying back, but permit schools to continue to raise tuition since the student (and/or, parent) simply need to sign on the bottom line? We'll worry about repayment later, i.e., "I will gladly pay you Tuesday for a hamburger today." (Source: Wimpy, 1960, From Popeye and the Giant.)

I can't and won't speak to the entire educational system. I am not qualified. However, I think I can speak to the part of the system that is responsible for preparing students to go into our industry—the high tech electronic product assembly business.

> **"Is the solution continuing to dumb down the curriculum to attract more students and keep the college classrooms filled?"**

The strategic goal is to create a system that must serve an industry that changes at light speed—an industry that has to have built into it an automatic, natural change mechanism. That change mechanism: the student. What? The student? How can that be?

In the 1802 poem, "My Heart Leaps Up When I Behold," English romantic poet William Wordsworth wrote, "the Child is father of the Man," a plea that if he ever stops feeling the unbounded childhood joy of the world's natural beauty, he wishes to die. The Who's Pete Townshend expressed a similar desired outcome a little more directly and a lot more cynically in the song, "My Generation" with the lyric, "…hope I die before I get old."

Our post-secondary educational system must change from being reactive to our industry's needs (and, as we have discussed, it's not been very good at that) to being proactive. They cannot continue to produce entry-level personnel that require two- to three-year learning curves to become fully productive. Instead, students that graduate need to be father to the companies for whom they go to work. They should act as change agents, challenging a company's status quo by bringing the latest design, production equipment and process techniques to their new employers from their academic experience.

Employers too easily become captive in doing things a certain way. Why? Because we've always done them that way. Having been educated in a leading edge, world class environment, recent graduates could act as a counterweight to this natural company inertia.

So, if that's our strategic objective, what is a tactical plan that provides a path to achieve that strategic goal?

Here are the critical elements I would suggest need to be part of that tactical plan:

1. Our industry requires a highly educated, direct labor, engineering workforce—not a minimum wage labor force with a sprinkling of engineering support.

2. Each engineer in the workforce must be multifunctional. The days of specialization are over. It costs too much. Each skilled engineer must be fluent in all technical and "soft" disciplines from chemistry to motion control to team dynamics to physics to conflict resolution.

3. These super engineers must be self-managed.

4. The traditional hierarchal organizational model build on collecting employees of common skills into separately managed departments (i.e., M.E.s, E.E.s, I.E.s, procurement, program management, etc.) must be replaced by just two groups: product teams and a leadership group. The leadership group acts as a check and balance to the product team, and serves as the enabling support function, ensuring the product team has the resources needed to be successful.

5. Engineering students need to be educated in a real world, world class, for-profit environment, for a full four-year undergraduate program, experiencing and learning every aspect of leading edge technical and business practices.

6. For educating students going into the high tech electronic product assembly industry, this environment should be provided by wrapping a college around a for-profit contract manufacturing (EMS) operation. The EMS being an essential part of the student's classroom for all four years.

In summary, for industries characterized by rapid change that are faced with ever increasing global competition, the solution calls for a radical departure from a traditional post-secondary education. Educating in one community (academia) and sending the "educated" to work in another community (the real world) has not, and will not work. To be competitive in high labor rate regions, industry needs to focus on reducing assembly labor content and maximizing assembly yields. In addition, a new industry organizational model must be adopted that minimizes indirect and overhead costs.

The current post-secondary educational approach has created a gap between academic preparation and industry need—a gap that continues to widen. What is needed to close this gap and prevent it from forming in the future is Concurrent Education—educating the student in a world-class, real-world business environment for a full four-year undergraduate program.[7]

Hey, what do YOU say? I'd like to hear your thoughts. **SMT**

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Tom Borkes is the founder of The Jefferson Project and the forthcoming Jefferson Institute of Technology. To reach Borkes, click here.

Electronics Industry News
Market Highlights

China Further Fortifies Its Semiconductor Sector with Formation of High-End Chip Alliance

With the government's backing, key enterprises in China's semiconductor sector have just established a "high-end chip alliance" that fosters the formation of a vertically integrated industry ecosystem on a national scale.

Bit Supply Growth Led to Small Sequential Increase of 6.3% in Global DRAM Revenue for Q2

Compared with the prior quarter, the global average sales price of DRAM for all applications fell by more than 5% in the second quarter, amid continued market oversupply, according to DRAMeXchange, a division of TrendForce.

Smart Weapons Market Worth $15.64 Billion by 2021

The smart weapons market is estimated to reach $15.64 billion by 2021, at a CAGR of 6.3% between 2016 and 2021, mainly due to increasing incidences of armed conflicts, war, and terrorism, which are driving the demand for smart weapons globally, according to MarketsandMarkets.

Military Satellites Market to Reach $14.37B in 2016

The military satellites market is set to be worth $14.37 billion in 2016, resulting from several major contracts in the United States, Israel and Russia and continuing satellite fleet modernization in China and India, according to a new report by visiongain.

Chip-on-Board LED Market in APAC to Grow 34.79% by 2020

The chip-on-board LED market in Asia-Pacific (APAC) is forecast to grow at a CAGR of 34.79% during the period 2016-2020, mainly driven by the expansion of manufacturing capacity in China given the subsidies for LED manufacturers offered by the government.

2.5 Billion Wireless Sensor Network Chipset Shipments in 2021

The Internet of Things (IoT) charges ahead with billions of wireless sensors in use worldwide and annual shipments of wireless sensor network (WSN) chipsets on track to reach 1 billion within the next two years, according to global technology research firm ON World.

Global Smartphone Production Volume Hits 315 Million Units in Q2

Worldwide smartphone production volume totaled around 315 million units in the second quarter, representing an 8.9% increase over the previous quarter and a marginal year-on-year increase of 3.2%, according to TrendForce.

Led by Macroeconomic Factors, Power Semiconductor Market Revenues Declined in 2015

The global market for power semiconductors fell 2.6% to $34 billion in 2015, due primarily to macroeconomic factors and application-specific issues, according to a new report from IHS Markit.

Micro-LED Displays to Enter Mass Production in 2018 Due to Heavy Investments from Sony and Apple

Following LCD and AMOLED, micro-LED has emerged as the next-generation display technology that is expected to be deployed widely in various applications. Increasing interests from electronics giants Apple and Sony have encouraged further investments in micro-LED and accelerated the timetable for its commercialization.

Global Semiconductor Market Posts Sequential Sales Increase in Q2

Worldwide sales of semiconductors reached $79.1 billion during the second quarter of 2016, an increase of 1% over the previous quarter and a decrease of 5.8% compared to the second quarter of 2015, according to the Semiconductor Industry Association (SIA).

FEATURE

IPC-1782 Standard for Traceability Supporting Counterfeit Component Detection

by Michael Ford
MENTOR GRAPHICS

Abstract

Traceability has grown from being a specialized need for certain safety critical segments of the industry, to now being a recognized value-add tool for the industry as a whole. The perception of traceability data collection however persists as being a burden that may provide value only when the most rare and disastrous of events take place. Disparate standards have evolved in the industry, mainly dictated by large OEM companies in the market create confusion, as a multitude of requirements and definitions proliferate.

The intent of the IPC-1782 project is to bring the whole principle and perception of traceability up to date. Traceability, as defined in this standard will represent the most effective quality tool available, becoming an intrinsic part of best practice operations, with the encouragement of automated data collection from existing manufacturing systems, integrating quality, reliability, predictive (routine, preventative, and corrective) maintenance, throughput, manufacturing, engineering and supply-chain data, reducing cost of ownership as well as ensuring timeliness and accuracy all the way from a finished product back through to the initial materials and granular attributes about the processes along the way.

Having the proper level of traceability will also help ensure counterfeit components do not end up in a product. Through effective policing in the use of any and all components, any material found to be counterfeit will be immediately traceable to source, and hence responsibility is assigned. IPC 1782 will work hand in glove with the U.S. Department of Defense's current counterfeit component effort.

The goal of this project is to create a single flexible data structure that can be adopted for all levels of traceability that are required across

the industry. The scope includes support for the most demanding instances for detail and integrity such as those required by critical safety systems, all the way through to situations where only basic traceability, such as for simple consumer products. A key driver for the adoption of the standard is the ability to find a relevant and achievable level of traceability that exactly meets the requirement following risk assessment of the business.

The wealth of data accessible from traceability for analysis can yield information that can raise expectations of very significant quality and performance improvements, as well as providing the necessary protection against the costs of issues in the market. Taking a graduated approach will enable this standard to succeed where other efforts have failed.

Scope of Standard

This standard establishes the requirements across different scenarios for supply chain traceability based on perceived risk as defined by the Purchaser and Supplier (AABUS). The standard will apply to all critical products, processes, assemblies, parts, components and items as defined by the Purchaser and Supplier of equipment used in the manufacture of printed wiring assemblies, as well as mechanical assemblies.

Traceability is defined as an unbroken record of documentation of materials, parts, assemblies, processes, measurements and associated uncertainties.

Minimum requirements are based on four levels of traceability for materials and processes. These levels correlate to the IPC Product Classification System (Class 1, Class 2, Class 3) and/or another set of categories of compliance (e.g., IPC-2610 Grades A, B and C) based on the business model/economic needs of the end-use market for the final product (telecom, aerospace, automotive, medical device, and/or consumer electronics) or a subassembly within that product.

Purpose of Standard

This traceability information is expected to improve operational efficiency and productivity, quality and reliability as well as enable activities such as predictive maintenance in the manufacturing environment. Current implementations of traceability have typically followed a hazy set of requirements often driven directly between customer and manufacturer for example in an EMS scenario. Requirements are based on quality expectations, limitation of responsibility, and management standards such as those defined by ISO. As such, the current definition of traceability differs from sector to sector, company to company, customer to customer and even from order to order.

When negotiating the levels of traceability that is required, the key concern is the cost and accuracy of the traceability data collection. When it comes to the need to use the traceability data, the concern is the completeness and accuracy of the data. On many occasions, the data that is needed is found to be omitted from the agreed specification on cost grounds. The feeling for traceability then is a double negative, in that there is cost and effort the collect the data which may end up being useless. The lack of a uniform component traceability standard has caused an unnecessary consumption of resources (e.g., time, people, money, etc.) to track down and remedy any quality, reliability, etc., issue and has made it difficult to uniformly create and appropriately enforce the necessary contracts. IPC-1782 identifies criteria for tracking components on or in a specific assembly and creates a means to specify different levels of traceability to accommodate different economic and business models/needs.

The purpose of the IPC-1782 standard then is two-fold. It sets out the definitive standard to control what data should be collected, and through the standardisation opens up the capability to introduce the automated collection of traceability data from processes that can support it. In so doing, it drives down the cost overhead. With this achievement in place, traceability can then be applied in a broader sense throughout the industry, for example, the application of traceability to counterfeit components in an organization's supply chain.

This standard helps organizations more easily ensure end-users/consumers will receive products and services that meet or exceed their expectations and in the timeliest and economically viable method.

Application of Standard

This standard defines a template which can be used for, but not limited to:

- SMT components (including discrete components) and through-hole components
- PCBAs, PCBs, and base materials (laminate, glass, resin, etc.)
- Connectors and switches
- Cables
- Mechanical assemblies and covers
- Acoustic and RF components (including antennas, power amplifiers, etc.)
- Software

Levels are defined in the standard that describe up to 16 different levels that can be applied to different sectors in order that there is an appropriate balance between the detail of data collected and the cost/effort/values in doing so. The standard can therefore be applied in sectors as diverse as:

- Mil/Aero
- Consumer electronics
- Medical
- Automotive
- Industrial
- Telecom

Getting Started

The flow diagram in Figure 1 shows a simple process used by the user to determine the appropriate levels of traceability required, both in terms of materials and process traceability, based on risk assessment.

Approaches to risk analysis can vary between industries and geographies. Traceability has grown from being a specialized need for safety-critical segments of industry to now being a recognized value-add tool for industry as a whole. What constitutes a risk can be quite different say between the failure of a satellite circuit in space, the failure of a missile to differentiate a target, or the protection of the brand associated with a consumer electronics product. Traceability, as defined in IPC-1782, represents the most effective quality tool available, which can become an intrinsic part of best-practice operations. This is accomplished with the encouragement of automated data collection from systems already integrating quality, manufacturing, engineering and supply-chain; reducing cost of ownership and ensuring timeliness and accuracy. This can greatly influence the cost versus risk assessment. The wealth of data accessible from traceability for analysis can yield information that can raise expectations of very significant quality and performance improvements, as well as providing the necessary protection against the costs of issues in the market.

Levels of Traceability

IPC-1782 creates a flexible data architecture that can be adopted to represent all levels of traceability that are required across industry. This includes support for the most de-

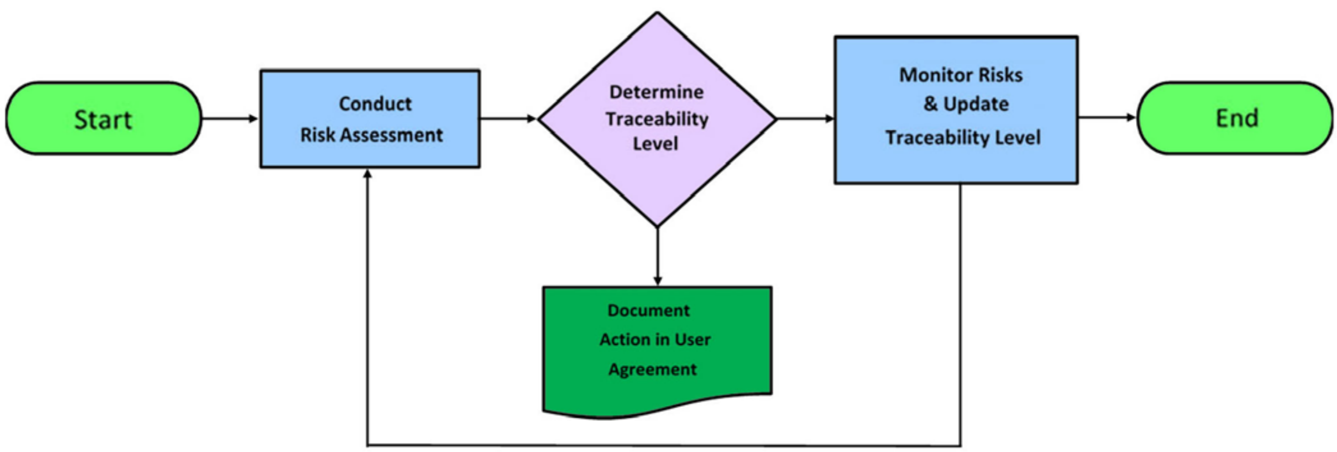

Figure 1: Determination of traceability level.

manding instances for detail and integrity such as those required by critical-safety systems, all the way through to situations where only basic traceability may be needed, such as for simple consumer products. This standard presents a cellular-based structure so as to provide required flexibility and to create an efficient format in which unnecessary duplication of data is avoided. The format also allows data to be added after the completion of production, allowing further detail to be added as it becomes available.

Throughout the design of this standard, different key usage models of traceability were considered. It is written to explain how access to critical data, when needed to identify the exact scope of any market issues, can be ensured, while also being capable of providing "live" access to detailed product build records for advanced quality analysis. This standard also demonstrates the benefits of best-practice data collection through automated means. This is reflected in the definitions of the different levels of traceability.

To suit the many different sets of requirements for traceability across the various sectors of the electronics manufacturing industry, four levels each have been defined of material (M1 through M4) and process (P1 through P4) traceability (Table 5-1). These levels may be combined in any way, such as to create requirements which can be agreed upon by user and supplier (i.e., the two parties agree to traceability of M3 with P1).

	Level 1: "Basic"	Level 2: "Standard"	Level 3: "Advanced"	Level 4: "Comprehensive"
Material Traceability	**M1:** Listed to work-order by part number and incoming order	**M2:** Listed to batch/work-order by unique material ID (where applicable)	**M3:** Listed as loaded, by PCB-A, by unique material ID (subject to the constraints of the processes)	**M4:** Exact materials used on each PCB-A
Process Traceability	**P1:** Significant process exceptions against batch record/traveller	**P2:** Capture common key process characteristics, exceptions and test and inspection records to serialized PCB-A	**P3:** Capture all key process characteristics, exceptions and test and inspection records to serialized PCB-A	**P4:** Capture all available metrics: complete test results and process data
Data Integrity (in the range of)	3 Sigma	4 Sigma	6 Sigma	9 Sigma
Data Collection / Storage Automation	90% Manual	70% Automation	>90% Automation	Fully Automated
Reporting Lead Time	48 hours	24 hours	1 shift	Live Access
Data Retention Time	Life of product plus 1 year	Life of product plus 3 years	Life of product plus 5 years	Life of product plus 7 years

Figure 2: Overview and summary of traceability levels.

Levels are roughly defined as follows:

• **Level 1 "Basic"** traceability can be considered an entry level of traceability. This is the minimum level expected for responsible manufacturing where any degree of traceability is required. It shows the materials used for a work-order of products. Requirements at this level are set such that adoption should not be significantly challenging for a properly managed operation, thereby representing a low operational cost and a low cost of any change being required. Individual PCBs and materials are not serialized. Assemblies are grouped and identified under production lot/date code/work order/batch code, while materials are identified using their part number and incoming order information. As data collection is predominantly manual, it is expected that rare omissions of data will occur.

Together with the lack of use of unique IDs for materials or PCBs means the value from this Level 1 Traceability is limited in terms of the ability to identify the scope of an issue or to ensure conformance to operational standards. The storage of traceability data at Level 1 Traceability may comprise a mix of computerized records and manual record keeping, across different locations/sites. As such, the time required for the use of traceability data for analysis of any issue is high.

• **Level 2 "Standard"** traceability builds on level 1 traceability by adding the unique identification of both materials and assemblies. This allows the ability to show the materials that were available for use during the period each sub-assembly was/is being processed. Materials should gain a unique material ID as early as possible upon entry to the manufacturing site.

Typically, each individual carrier of materials obtains a unique ID, such that each individual carrier of materials can then be tracked. For process traceability, the PCB should also receive a unique ID as early in the production process as possible. Starting with each final product, all key sub-assemblies, such as PCBs, all the way back through to initial assemblies consisting of all raw materials, should have a unique ID assigned, such that a hierarchy of traceability identified by the final serial number of the shipped product can relate to each of the sub-assemblies within the product. In order to manage the flow of serialized assemblies, a work-order structure should be adopted to define the processes through which sub-assemblies will pass. A selection of key process data is then captured for each product at each process.

It is expected that there is an increase in the level of automation of data capture with level 2 traceability, as computerized systems will typically be required to provide the serialization process, manage the database of individual material and product elements and provide the work-order management required. This reduces additional effort of manual data management as well as increases the accuracy and timeliness of data capture. In situations in which data capture is built into the operating procedure, increased assurance of compliance with procedures can also be achieved, thereby making cost of ownership of level 2 traceability to be balanced with operational benefits. The ability of level 2 traceability to limit the scope of product recall and rework is significantly superior to level 1 traceability.

• **Level 3 "Advanced"** traceability is a tightened specification of level 2 traceability, in which more detailed information about processes and materials are defined and retrained. Level 3 traceability also promotes a higher degree of data gathering automation, with an associated decrease in degree of errors and an increase in the speed of use. As such, this level 3 traceability brings significant additional value from the quality and assurance perspective to the operation.

• **Level 4 "Comprehensive"** traceability is the highest level of traceability, representing an achievable goal that demonstrates maximum value of traceability in terms of the precise definition of the complete production build record of any product and assembly. In level 4 traceability, data for both materials and traceability are collected in precise detail. Material data are precise, with no doubts of where materials are exchanged or replenished during the execution of placement, for example. In level 4 traceability, process data collects results in a comprehensive set of data. In all cases, the intent is that

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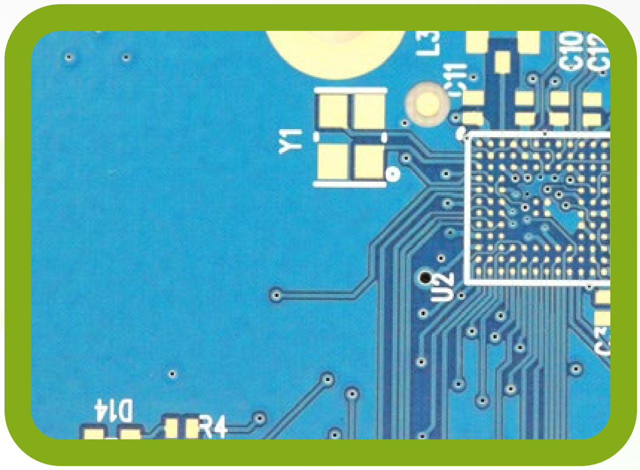

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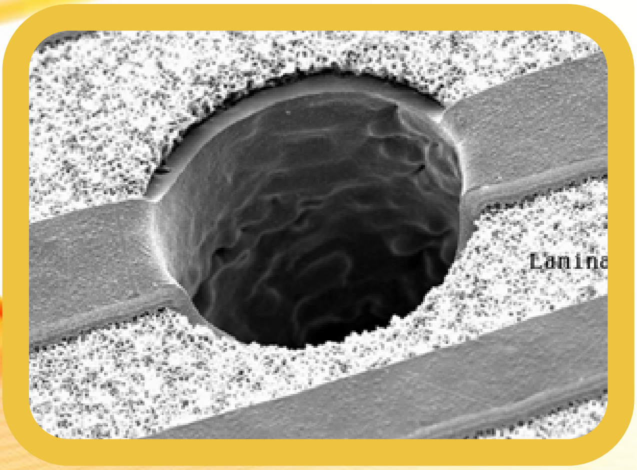

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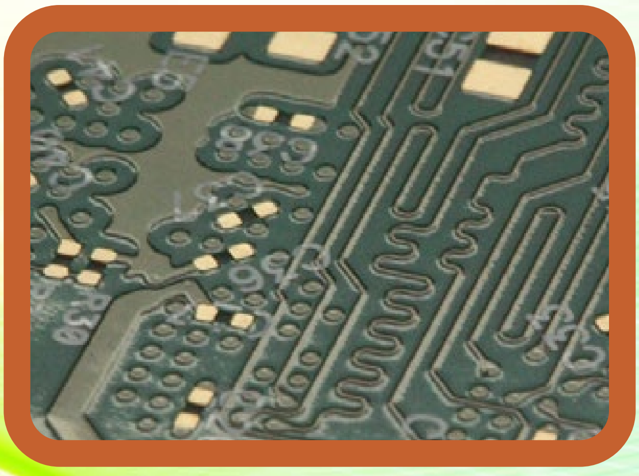

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Process / Material Level	M1	M2	M3	M4
P1	Class 1	Class 1 & Class 2		
P2	Class 1 & Class 2	Class 2	Class 2	
P3		Class 2	Class 2 & Class 3	Class 2 & Class 3
P4			Class 2 & Class 3	Class 3

Figure 3: Traceability level to product classification system matrix.

data are captured automatically by way of integration or interfacing with operational and supporting systems, ensuring no data are lost or delayed. The use of level 4 traceability data, therefore, is compatible with updates and maintenance of live dashboards showing various key performance indicators (KPIs).

Figure 3 provides recommendations for mapping IPC-1782 levels of traceability to the IPC Product Classification System. The classification and the final choice of traceability levels shall be AABUS.

Hierarchy of Traceability Data

The adoption of a hierarchy allows a complete tree of traceability data to be constructed, linking together different "cells" of data that describe different elements of the traceability data. The uppermost head of the traceability data is likely to the completed shipped product. This product will contain sub-assemblies and component materials, each of which may have their own tree of traceability data cells linked. In this way, critical components can be traced all the way back to the fundamental manufacturing processes where the need exists. Figure 4 provides a visual representation for the cell structures belonging to a defined assembly, showing how sub-assemblies are related, each of which is the head of another traceability cell structure.

Traceability Data Cells

The tree is made up of different cells of data, each type of which are populated according to the designated level of traceability, either material or process. Cells link together so as avoid unnecessary duplication of data. For example, a reel of materials may be used on an SMT placement machine where many PCBs are populated. The traceability record for each PCB will contain the ID of the material used, which refers to another cell that holds the actual traceability data of the reel. All PCBs made using that reel can therefore link to the same instance of traceability data, rather than containing duplicate copies. This very much ensures that the traceability data is consistent and concise. While this paper seeks to summarize the defined content, the full detail can be found in the draft working document of the IPC-1782 standard. The cells currently defined are as follows:

Assembly Cell:

- The Assembly Cell is the head of the traceability structure. For a complete product, the Assembly Cell refers to the final product, by serial number if it exists.
- The Assembly cell also represents sub-assemblies which themselves have a tree of traceability cells linked to them.
- The associated data within the Assembly Cell is as follows:

- Production Bill of Materials (BOM): Components and sub-assemblies
  - Where possible, components should be referenced using an individual unique reference designator.
  - Components without a unique specific reference designators should be called with a standard descriptive name (such as screws, M3, 5mm)

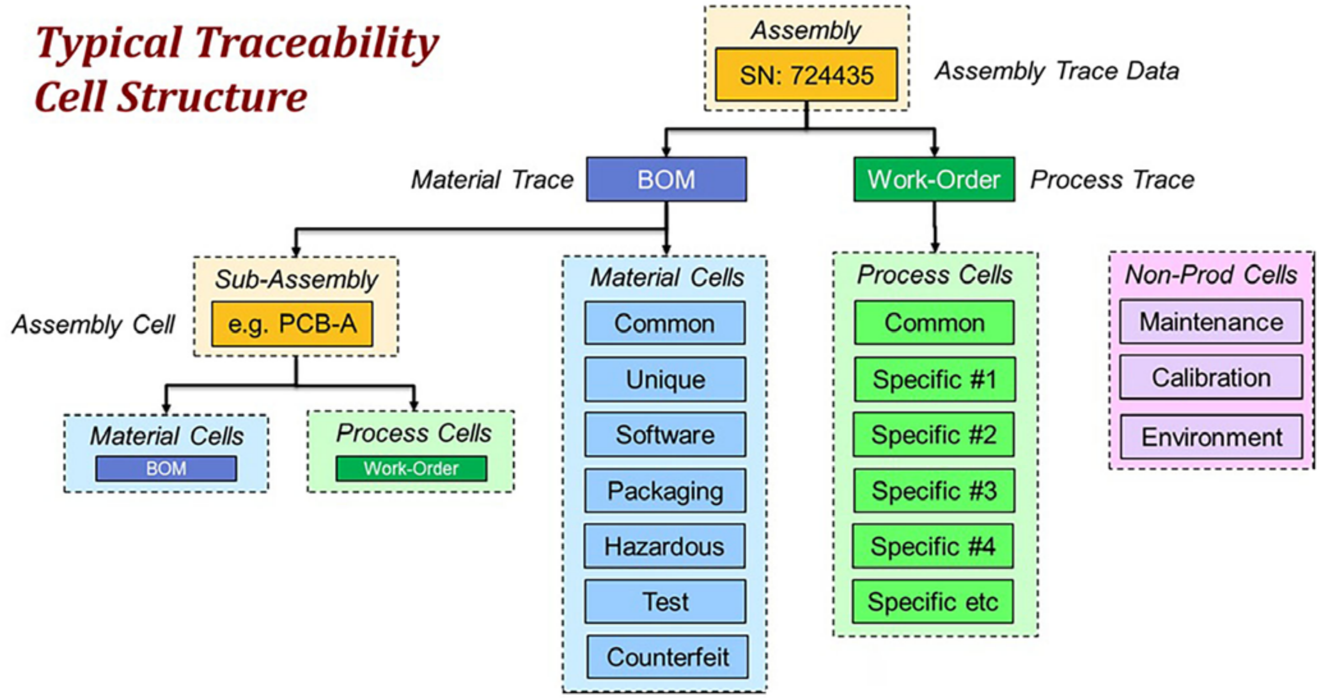


Figure 4: Traceability cell structure.

- The higher the level of material traceability adopted, the more precise the detail should be, in terms of events such as material replacement, slicing accuracy on SMT machines and in terms of certainty of exactly which material was used for each reference designator
- Each material entry in the Assembly cell links to an associated *Material Cell*
- Materials with unique ID (e.g., serialized battery) may have additional unique process information, and are described by an associated *Unique Material Cell*
- Sub-assembly traceability information is defined in the associated *Assembly Cell*
- Software traceability is defined in the associated *Software Material Cell*

• Hazardous/Prohibited Substance Content Summary is also summarized in an associated *Hazardous/Prohibited Substance Cell*
• Information about the processes that the assembly has been through is contained in an associated Process Data Cell. The items and detail of data recorded about the processes is again dependent on the level of traceability selected.

Material Cells:

• Materials may be identified by a unique ID (e.g., battery, screen/display, hard disk drive (HDD), central processing unit (CPU), have a unique ID on their material carrier (i.e., those on an SMT reel, tray or stick or any materials in a bag, pallet, box etc.) or for generic materials, be identified by part number and local. Key fields within the cell are used to define the scope of the cell as to how the materials are identified.
• Depending on the level of material traceability adopted, the cell may include such items including internal part number, receiving order name, purchase order, date of receipt, material carrier unique ID, quantity, manufacturer name and part number, batch code, place of manufacture, MSD classification, shape code, supply format, use-by date, counterfeit determination, ESD Classification, incoming inspection test record, as well as addition-

al data in more detail identified in linked cells such as a *Test Cell, Hazardous Substance Cell, Counterfeit Component Cell*
- Unique materials or sub-assemblies are identified individually by unique ID (e.g., battery, screen/display, HDD, random-access memory (RAM) module, CPU, etc.). Additional requirements are needed for these materials, such as manufacturer unique ID. Information is defined in the associated Assembly Cell if it is a sub-assembly and *Test Cell* for example.
- A software component of a product is treated in the same way as a regular material, that is, as part of the BOM, with related traceability, for example software revision checksum (CHKSUM), documentation of software processes, etc.
- Other cells exist for packing and shipping materials, and labels

Process Data Cells:
- This cell describes the process history to create the assembly
- Information about the work order is defined in the associated *Work-Order Information Cell*
- A list of actual processes, in sequence. The actual number of process sequences may exceed the number specified in the work-order (i.e., due to repair loops). Process data are required for each listed process, according to the chosen level of traceability.
- Due to the varied nature of the many possible production process, and the wide range of associated data, the process data is split into two sections. The first contains the common process traceability data, applicable to all processes equally, and the other is the process dependent section containing the unique process traceability data elements
- Common Process Traceability data includes logical process name as described in the work-order, serious process exception, such as breakdown event, unique process ID, date and time in / out of the process, operational documentation, program / setup data (name / revision / date), process operator, date of last PM / calibration, completion certification and environment data.
- Unique Process Traceability Data is defined for each type of process, including:
  - *Unique PCB Marking:* the marking of the PCB and or individual boards with a unique ID that can be scanned to identify the specific board.
  - *Product Routing Station:* including PCB flip / turn, storage / stock / waiting area, etc.
  - *Screen Printer:* including stencil ID (unique ID or part number), duration that the paste had been opened, number of cycles performed by the stencil since maintenance, age of squeegee/syringe, total cycle count, etc.
  - *Automated Paste Inspection:* including pass/fail result, inspection/ test record detail or even retained images
  - *Glue Dispenser:* including stencil and squeegee ID if applicable, number of cycles since last maintenance, programmed speed/pressure, Duration since glue removed from cold storage, etc.
  - *SMT Placement:* including material exchange events, verification events, pass / fail of visual inspection, manually recovered pick-up error cycles, automated material exchange event, automated splicing detection, fiducial read-error event, panel location error, MSD-remaining exposure time for each MSD component, automatically recovered pick-up error cycles, instances of safety stop and other machine stops or exceptions, actual nozzle used per each reference designator, etc.
  - *Pin Through-Hole Insertion:* Including material verification, manual material exchange event, splice (joining the tape), manually recovered pickup error cycles, material exchange event fiducial read error, panel location error, instances of safety stop and other machine stops or exceptions.
  - *Manual PCB Assembly:* Including

manual material verification and exchange events, key tools, including gloves, guides, etc.
- *Reflow:* Including profile ID or name actual parameters (e.g., temperature, speed, etc.) recorded, indication of how the profile was developed, cooling profile beyond machine down to ambient condition
- *Wave Solder/Selective Solder:* including profile, fixture ID, actual temperature/speed readings, chemical composition of solder pot, etc.
- *Manual Visual Inspection:* including actions taken, pass/fail, specific defects, acceptance criteria, magnification used, etc.
- *Automated Optical Inspection (AOI) and X-Ray Inspection:* including pass/fail, specific defects, full test result capture, false reject rate, acceptance criteria, retained images, etc.
- *In-Circuit Test:* including fixture ID and revision, pass/fail, full parametric test result capture, fixture cycle count
- *Press Fit Operations:* including manual material exchange event, tooling ID, profile name, actual insertion force or pressure, speed
- *Touch-Up:* including all rework and touch-up recorded, tooling ID, tip size/shape, iron temperature, mass reflows cycles
- *Encapsulation:* including speed, cure time and temperature, vibration settings
- *System Assembly (Final Assembly):* including tooling ID, torque measurement, last calibration/verification
- *Mechanical Assembly Operations (includes robots):* including manual material exchange event, tooling and fixture IDs, torques driver ID, critical parameters for hold times, pressures, cure times, etc., for adhesives, conformal coatings, under-fill, heat sink pressure pads, etc.
- *Software/Firmware Programming:* including pass/fail, checksum recorded
- *Quality Assurance Check/Test/Inspection:* including pass/fail, defects recorded
- *Repair/Rework Station:* including tooling IDs, settings and recipes, tooling details and configurations, repair method—preparation (for example cleaning), testing during/after repair
- *Functional Test:* including definition of test, pass/fail, details of test parameters, results capture
- *Burn-In/Extended Test:* including pass/fail, static/dynamic, temperature/time profile, parametric test results
- *Shipping/End User/Post Manufacturing Environment Test:* including drop-test, shipping profile test, humidity & temperature & pressure, pass/fail, test profile, parametric test results
- *Packing and Shipping:* including quantity, weight, carrier, serial numbers, shipping destination, specific material configuration, shock monitor ID & setting (limit values)

• Process Deviations: These are deviations for a range of products which have been planned in advance, deviation number (incident number), customer approval
• Labelling: Unique label information, image of applied key label(s)
• Exceptions: These are unplanned deviations (i.e., smoke, dust, high-temperature conditions or any other environment issues) which have affected one or more products which caused mitigating action to be taken. Details can include exceptions encountered, such as wiped PCB due to misprint, hand placed part normally machine placed, work-order processed with known shortage, process step performed out of sequence
• Non-conforming items: Identify and document the nonconformance condition of affected items. Records include the inspection results, evidence of performance of required test or inspection, extent of nonconformance, disposition of nonconforming items, and responsibility for corrective action. The items shall be positively identified to permit recall in

the event of nonconformity to specified requirements.

Work-Order Information Cell:

- Information that describes the work-order used to produce the assembly, including unique work-order name, product reference, planned quantity, process list, theoretical processing times, scheduled start/end time, actual start/end time

Hazardous Substance Cell:

- A list of key elements that make up a material or assembly which can be used to represent the hazardous content of a material/assembly/finished product, reducing taxation and recycle costs
- List of substance codes and amounts (g, mg, pico grams, etc.)

Counterfeit Component Traceability Cell:

- The result of visual inspection or automated determination of genuine components/assemblies. Includes the test or inspection statement, a flag to state whether the determination statement was derived manually or through an automated process and detailed result of visual inspection

Material Test Cell:

- A list of tests and results for the material or assembly including functional testing which can extend across a broad area of unique tests and associated result patterns. Information can include pass or fail, single, sample or bulk test, test equipment calibration statement, single, sample or bulk test, test name and measurement details upper and lower limits as well as measured value

Process Maintenance Cell:

- Process maintenance events and tasks can have significant effect on the quality of production. Planned maintenance events usually take place between work-orders, so they cannot be tied to a specific production work-order or product unit. Using the timing of these events relative to work-order execution, however, can aid root cause analysis. Unplanned maintenance is usually a breakdown of a process in terms of it not being able to work within defined parameters. These cases usually happen during production, resulting in a high risk of effect to the product unit being manufactured, as well as affecting a change between the conditions of the process before and after the maintenance event. Information includes process, date and time for the start and end, planned (scheduled) or unplanned (breakdown) flag, maintenance job code/description the responsible person, parts replaced, repaired or adjusted, etc.

Standard Going Forward

The draft document created by the committee is currently going through reviews that include a widening circle of interested parties. It is encouraged for anyone with an interest in traceability to obtain a copy of the draft document, to read through it and feed comments back to the committee.

The committee looks forward to the time, currently estimated as the end of 2016, when the IPC-1782 can start to be used by different companies, creating the opportunity for enhanced quality, conformance and control of manufacturing, while at the same time acting to reduce the costs of traceability data collection, and bringing value to the manufacturing organisation itself. **SMT**

Michael Ford is senior marketing development manager with Mentor Graphics Corporation Valor division.

How to Specify a Custom Machine

by Robert Voigt
DDM NOVASTAR INC.

Let's say you have an unusual product configuration, a unique space requirement, an unorthodox handling system, or an application totally unrelated to the PCB or SMT assembly business, and you can't find a standard machine provider that can handle your requirements. What then?

Time for a custom machine!

There are a handful (a very small handful, actually) of true manufacturers of assembly equipment that serve the low- to mid-range volume users. If you want a standard stencil printer, pick and place machine, reflow oven, wave or selective soldering machine, etc., you have dozens of firms to choose from. Most of them, however, are actually importers and/or resellers and have serious limitations on the kind of customization they can do.

To begin, what kinds of challenges do companies run into that often require a custom solution? Here are a few I've seen in the recent past:

• A company that required a reflow oven with a very long dwell time in the chamber, which would normally require a 40-foot tunnel, but needed to fit it into a footprint only six feet long. The solution was to design and build a serpentine conveyor within the length of a short tunnel that achieved the dwell time dictated by the process and footprint.

• A user looking for a totally integrated inline component placement process from a reel of blank substrate at the beginning to a fully populated reel at the end. The customer got a self-contained system that accurately attaches miniature medical devices onto a strip for seamless downstream processing.

• A custom pick and place application that selects a component, dips it into one or more

Figure 1: In-line paste-place-reflow system to mount parts from reel to reel.

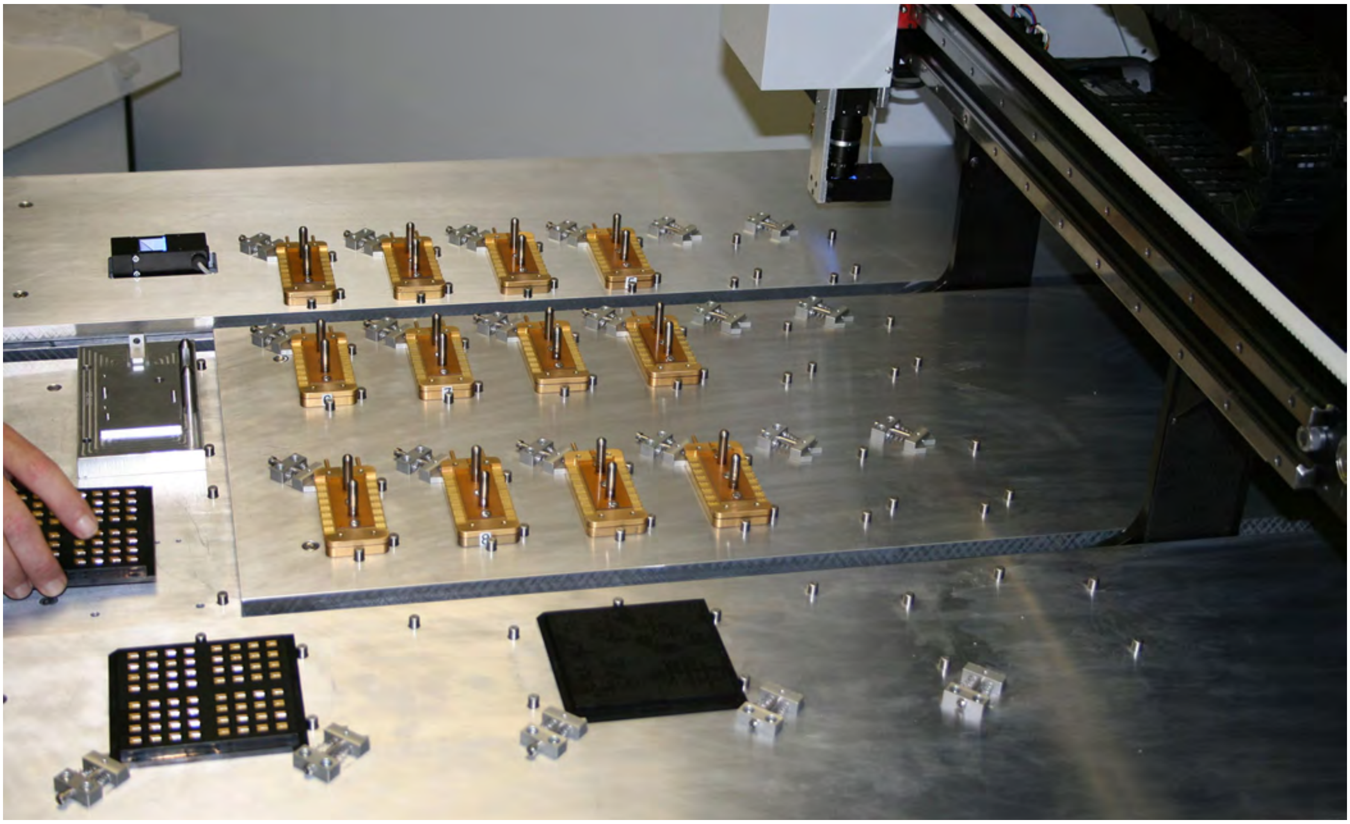


Figure 2: Custom pick-and-place system.

materials at different stations, such as paste or epoxy, then accurately centers and mounts it on a substrate. An off-the-shelf pick and place machine was modified for this application with custom jaws and positioning software. This example also required two different reservoirs for a "double-dip" function.

• A process to place multiple micro-chip lasers onto a block to aggregate a high intensity beam into a single point for a steel laser cutting tool. Due to the accuracy required for this project, the pattern layout was critical. A machine was custom-engineered which included unique LED lighting configured to handle special gold plating.

• Unique sequencing operations and processes for assembly machines conducting operations on multiple stations that require custom software programming. In addition to putting an inline system together, one needs to make sure the programming can be customized also. An example of this was an assembly line that needed to dispense paste, inspect, accurately place the components, index through a cutter assembly, provide a feed control system over to an accumulation loop, input that feed into the reflow oven process with vision inspection of finished assembly.

• Material handling systems with special line functionality, such as reverse feeding or a capability to manage large or odd-shaped parts. One customer already had an inline system, that required their new reflow oven to move right to left, in reverse of the norm.

There are some worthwhile goals that might drive you to consider going to the trouble and expense of a non-standard machine, such as reducing labor and improving predictable quality by integrating multiple processes together and reducing dependence on non-skilled labor. While the upfront investment will be considerably higher than that of a standard machine, the ROI—depending on the application and volume—could be short and significant.

So, how do you look for a custom machine manufacturer that has sufficient experience in

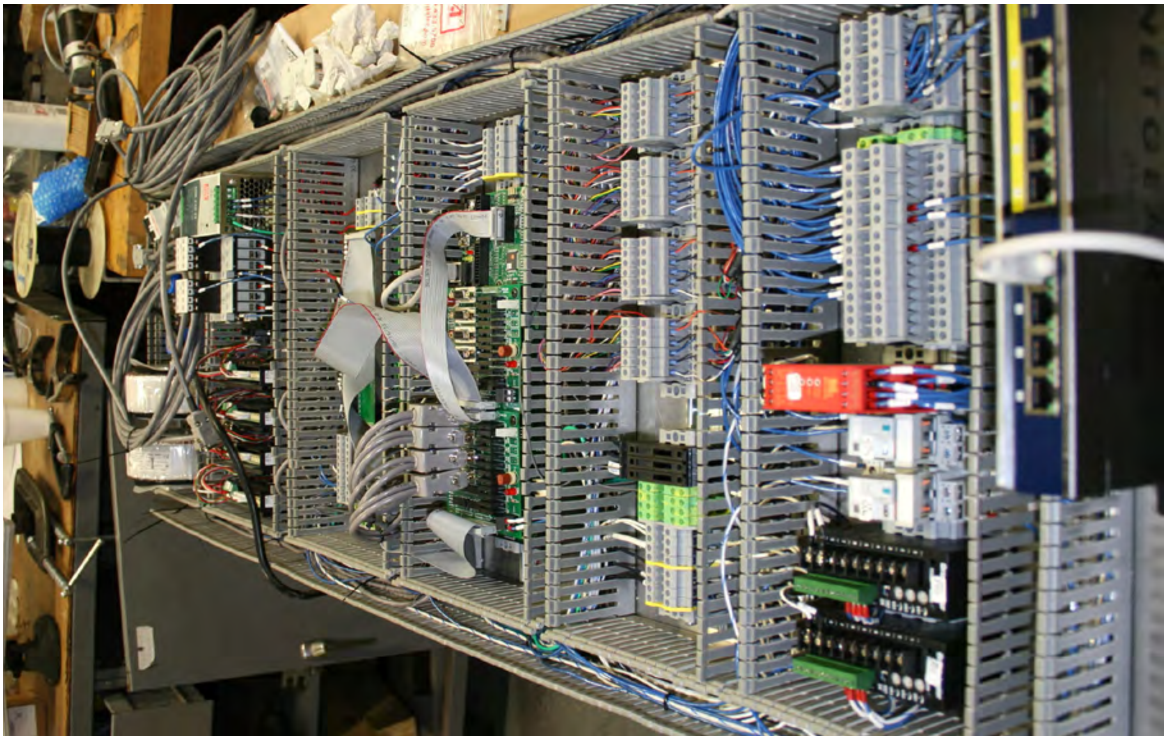


Figure 3: Custom control panel during assembly.

the PCB/SMT assembly world that you can trust with your project?

Start by asking the sellers of equipment what—if any—customization they can do. If they can, then describe your objectives and constraints, but don't tell them how to do it; let them get back to you with a recommended solution. If you attempt to dictate how to build a machine rather than describe its functional purpose, you could be liable for taking delivery of something that does what you've asked, but fails to live up to your performance expectations.

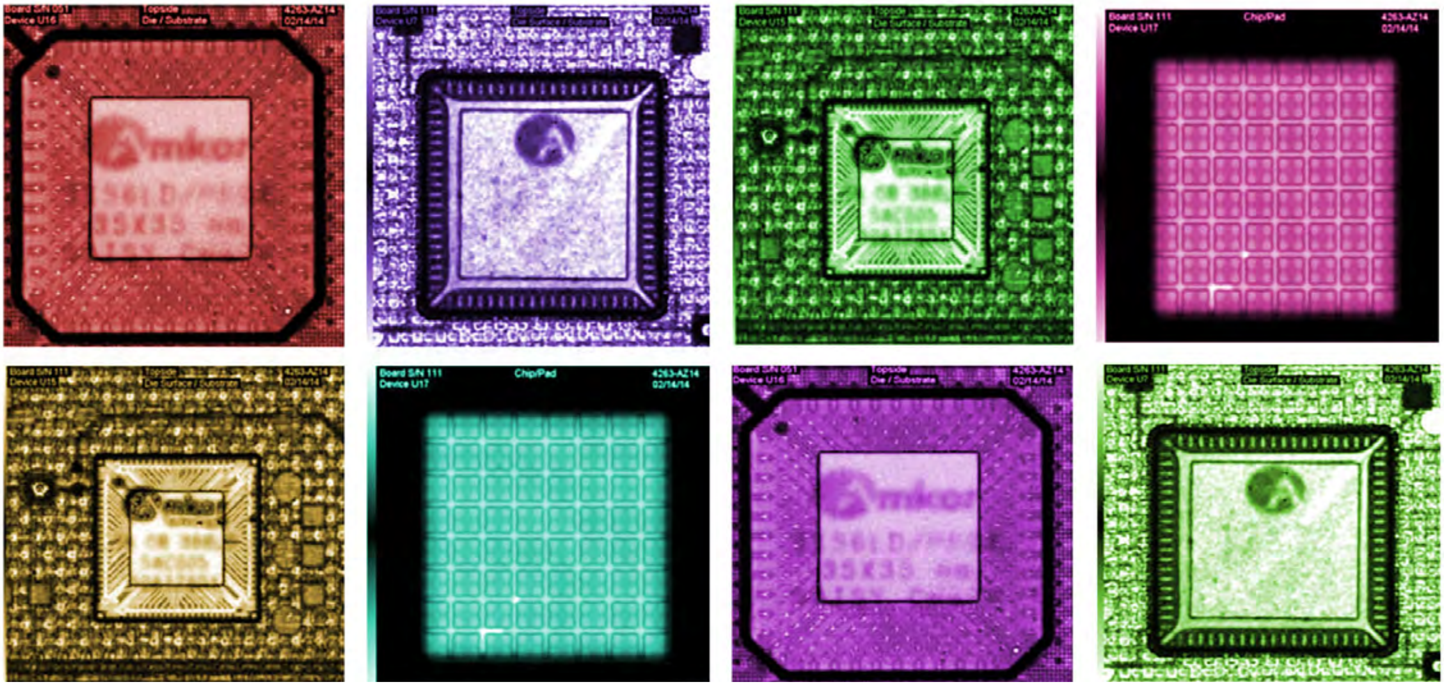
Companies that do custom assembly work should be equipped with these capabilities:

1. In-house design for both mechanical and software integration
2. Quality processes and practical engineering to deliver optimal performance with minimal maintenance
3. Capability to create prototype parts and/or entire machines
4. Machining, electrical design/assembly, circuit board assembly
5. Sheet metal fabrication, welding and assembly
6. Inspection and testing, including procedures for validating design and studying potential failure points in a custom machine
7. Ability to design and make any special tooling required to manufacture small table-top machines to large assembly/process equipment.

Check References

Remember to consult a variety of machine providers, talk to the manufacturers themselves, and get references to contact before making a purchase. An important consideration for a complex machine such as a custom assembly system and associated options is factory support, specifically training, software, upgrades and spare parts. **SMT**

Robert Voigt is VP of global sales at DDM Novastar Inc. To reach Voigt, click here.



Defect Features Detected by Acoustic Emission for Flip-Chip CGA/FCBGA/PBGA/FPBGA Packages and Assemblies

by Reza Ghaffarian, Ph.D.
JET PROPULSION LABORATORY,
CALIFORNIA INSTITUTE OF TECHNOLOGY

Abstract

C-mode scanning acoustic microscopy (C-SAM) is a non-destructive inspection technique showing the internal features of a specimen by ultrasound. The C-SAM is the preferred method for finding "air gaps" such as delamination, cracks, voids, and porosity. This paper presents evaluations performed on various advanced packages/assemblies especially flip-chip die version of ball grid array/column grid array (BGA/CGA) using C-SAM equipment. For comparison, representative X-ray images of the assemblies were also gathered to show key defect detection features of the two non-destructive techniques.

Below are some of the highlights of the study:

- Compare the images of 2D X-ray and C-SAM for a plastic LGA assembly showing features that could be detected by either NDE technique. For this specific case, X-ray was a clear winner.
- Evaluate flip-chip CGA and FCBGA assemblies with and without heat sink by C-SAM. Evaluation was to evaluation defect condition of underfill and bump quality. Cross-sectional microscopy performed to compare defect features detected by C-SAM.
- Analyze a number of fine pitch PBGA assemblies by C-SAM to detect the internal features of the package assemblies and solder joint failure at either package or board levels.

Twenty times touch up by solder iron having 700°F, each with 5–7seconds and induced defects were analyzed by C-SAM images.

Acoustic Emission Technology

Electronic Packaging Trend

Previous generations of microelectronic packaging technology aimed mostly at meeting the needs of high-reliability applications, such as the ceramic leaded quad flat package (CQFP). Nondestructive wire bond pull at the package level and subsequent visual inspection for solder joint integrity at the board level were adequate for ensuring the quality of CQFPs. Consumer electronics are now driving miniaturiza-

tion trends for electronic packaging and assembly; they introduce a vast number of area array packages. The array packages initially only had hidden solder joints under the bottom area of the package; now the flip-chip die within package also have hidden joints.

The hidden joints—both at package and assembly levels—added significant challenges to the inspectability and certainty of assuring integrity at the various microelectronics hierarchy levels. Another added complexity is the transition to using only Pb-free solder alloys. Suppliers of electronics packages either have or will soon transition to using Pb-free alloys in order to enforce restrictions on hazardous substances (ROHS) for electronic systems. The solder joint appearance for the Pb-free solder alloys is dull rather than shiny, as it is for the tin-lead eutectic solder, which will add confusion even if visual inspection is used inadvertently as a criterion for the quality of joint acceptance or rejection of a Pb-free solder joint.

Inspection of ball grid array (BGA) and column grid array (CGA) package/assembly, especially their flip-chip versions is challenging[1, 2, 3, 4, 5]. Nondestructive X-ray inspection became a new approach for ensuring the quality of area array packages and assemblies. Even though X-ray can detect the level of voids and bridges of solder joints hidden under packages, it become of less value for detecting solder attachment and underfill integrity of higher I/O (>1000 I/Os) packages with flip-chip die technology (such as FCBGA and FC-CGA; Figure 1). Ceramic substrates considered for high-reliability applications are heavier and less penetrable to X-ray radiation than plastic, making them even more difficult to inspect for this category of packages and assemblies.

Acoustic Micro-imaging, C-SAM, and X-ray

Acoustic microscopes emit ultrasounds ranging from 5 MHz to more than 400 MHz, so that micrometer size resolution can be

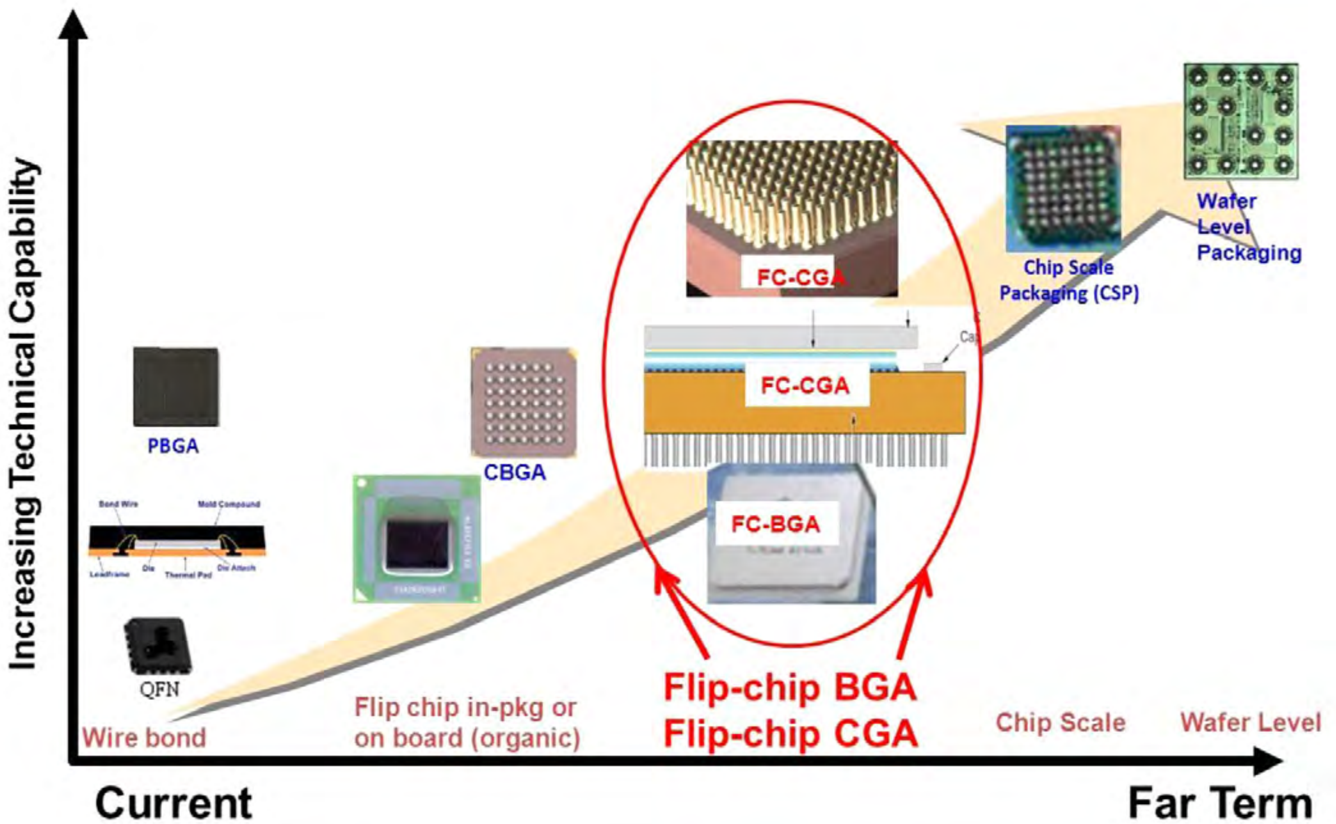


Figure 1: Microelectronic trends for single packaging technologies including flip-chip BGA and CGA.

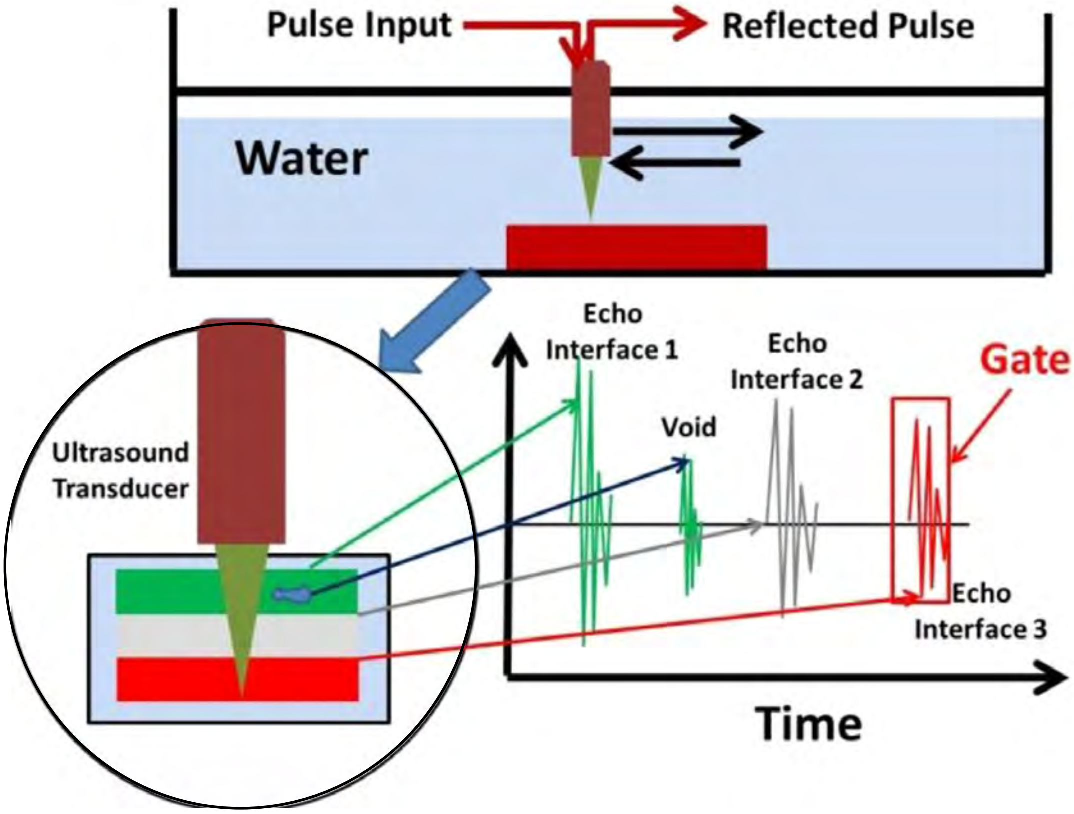


Figure 2: Key features of C-SAM operation and detection of defects including voids and delamination.

achieved[6]. Ultrasound that penetrates a sample may be scattered, absorbed or reflected by the internal features of the material itself. These actions are analogous to the behavior of light. Ultrasound that is reflected from an internal feature has traveled through the entire thickness of the sample, and is used to make acoustic images. At least three basic types of acoustic microscope have been developed. These are the scanning acoustic microscope (SAM), scanning laser acoustic microscope (SLAM), and C-mode scanning acoustic microscope (C-SAM).

C-SAM uses the same transducer to pulse ultrasound and receive the return echoes, meaning that the acoustic image can easily be constrained to a depth of interest. It has the ability to create images by generating a pulse of ultrasound focused to a pinpoint spot. The pulse is sent into a sample and reflected off of interfaces (Figure 2). The frequency of the pulse and design of the lens are chosen to optimize spot size resolution and depth penetration for each application. In the reflection mode of operation, the same transducer is used to send and receive the ultrasonic pulse. Return echoes arrive at different times based upon the depth of the reflecting feature and the velocity of sound in the materials. The operator positions an electronic gate to capture the depth of interest. The amount of ultrasound reflected at the interface is based on the differences in the materials at the interface. The more different the materials the more ultrasound reflected.

Similar to X-ray, acoustic microscopy is a non-destructive technique for visualization of defects, widely used in the production of electronic components and assemblies for quality control, reliability and failure analysis. Usually the interest is in finding and analyzing internal defects such as delaminations, cracks and voids, although an acoustic microscope may also be used simply to verify (by material characterization or imaging, or both) that a given part or a given material meets specifications or, in some instances, is not counterfeit. Acoustic microscopes are also used to image printed circuit boards and other assemblies.

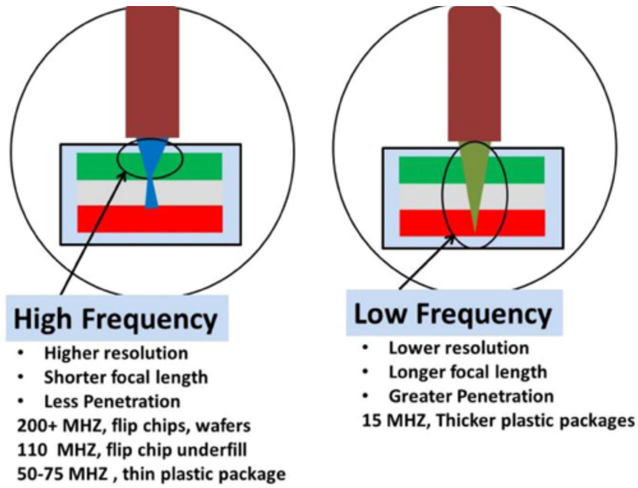


Figure 3: Selection of appropriate transducers is key in optimizing penetration and resolution for the flip-chip BGA and CGA.

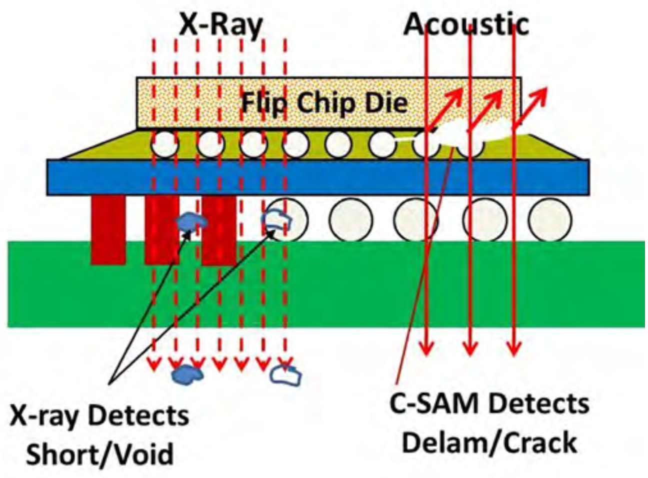


Figure 4: Key features of defect detectability by X-ray and C-SAM for flip-chip BGA/CGA.

The ultrasonic frequencies pulsed into samples by the transducers of acoustic microscopes range from a low of 10 MHz (rarely, 5 MHz) to a high of 400 MHz or more. Across this spectrum of frequencies there is a trade-off of penetration and resolution. Ultrasound at low frequencies (such as 10 MHz) penetrates deeper into materials than ultrasound at higher frequencies (see Figure 4), but the spatial resolution of the acoustic image is less. On the other hand, ultrasound at very high frequencies does not penetrate deeply, but provides acoustic images having very high resolution. The frequency chosen to image a particular sample will depend on the geometry of the part and on the types of materials.

Figure 4 schematically compares a few features of flip chip CGA/BGA detectable by AMI and X-ray. X-ray uses high-energy electromagnetic radiation with shorter wavelengths than ultraviolet light to detect inner features. They are highly penetrable depending on the X-ray's energy, which increases with frequency. As frequency and thus penetration increase, the type of X-ray moves from "soft" to "hard." The reflective nature of AMI allows for detection of delamination, whereas the penetration of X-ray allows detection of both short and large voids. These two inspection approaches are complementary techniques that should be used to reveal different features. The X-ray technique relies on the differential attenuation of X-ray energy, whereas the AMI technique relies on material change. The practical result is that AMI is orders of magnitude more sensitive for detecting air space type defects such as voids, delaminations and cracks.

AMI for Microelectronics Inspection Applications

In a previous comprehensive study, Sandor and Agarwal[7] utilized the C-SAM nondestructive technique to evaluate commercial-off-the-shelf (COTS) plastic encapsulate microcircuit (PEM). Samples from different commercial vendors were used for detecting internal defects due to various environmental exposures. PEM failure modes reported in industry due to delamination are summarized as:

- Stress-induced passivation damage over the die surface
- Wire-bond degradation due to shear displacement
- Accelerated metal corrosion
- Die-attach adhesion
- Intermittent electrical signals at high temperature
- Popcorn cracking
- Die cracking
- Device latch-up

Figure 5 shows one of the most common failure modes (popcorning) as a result of delamination, moisture accumulation, and pressure release within a plastic package during the board assembly process. Delamination is dependent on package construction, package size, die size, lead design, number of leads, and environmental stresses, among other influences.

Sandor and Agarwal reported a number of anomalies and potential reliability defects including delamination at die attach, at leads within the mold compound, around the die within the mold compound, on top of the die, and at the backside of the die paddle. The authors analyzed the defect anomalies by C-SAM imaging to determine their impact on the reliability of PEMs. C-SAM images from the beginning of a screening flow were used as a predictor of good or poor subsequent electrical performance of devices. Images tended to correlate with changes in electrical performance. C-SAM inspection and electrical parametric shifts of devices that were subjected to convection reflow were affected less than those equivalent devices exposed to hand soldering and vapor phase reflow (two zones, preheat and reflow).

In an investigation of defect detection for a multilayer ceramic capacitor (MLCC)[8], it was found that the 50-MHz transducer is more effective in detecting defects during screening by C-SAM than a 30-MHz version. Screening at a higher frequency enabled reducing rejection that was initially discovered during the board level testing. It saved costly rework at the board level even though there was a slight cost increase due to additional MLCC rejection.

AMI has been used also to analyze flip chip underfill and interconnect bonds since early 2000 when ultra-high frequency transducers are introduced[9]. It was shown that defects such as delamination and void can be detected at each layer and, with 3V (virtual volumetric viewing), the 3D morphology and depth location of the defects can give important information as to the cause of the flaws. Transducers and imaging techniques provided focused access of the ultrasound beam to the interface of interest (chip/bump and underfill, or bump and underfill/substrate) through any thickness of silicon commonly encountered.

Kessler[10] has shown using color acoustic images, full or partial disband of solder balls and voids in the underfill in a flip-chip assembly. To show such conditions, a flip-chip package was imaged from the top side from the back of the die at the high acoustic frequency of 230 MHz

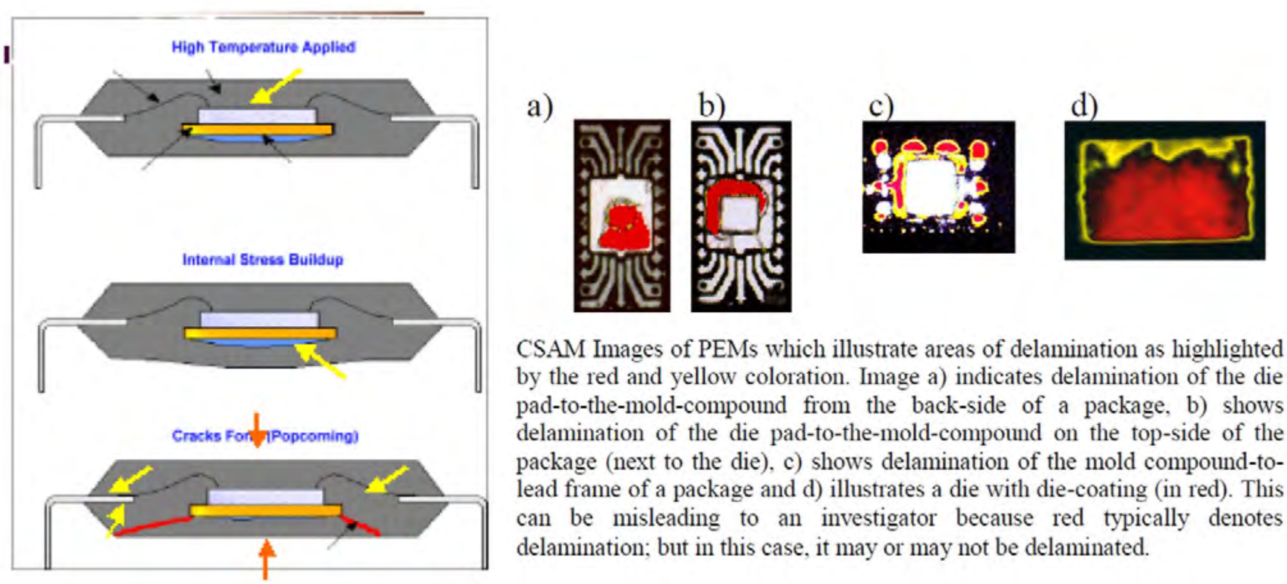


Figure 5: Examples of packages with delamination. The yellow arrows show areas where the existence of delamination can accelerate entry/collection of moisture; the red lines show where the cracks (popcorning) typically occur when the board is exposed to high temperature during assembly[7].

using a high resolution scan of 1024x960 pixels. Gating, region of set AE echo, was on the interface between the die face and the underfill material; therefore, the condition of bonding pads onto the die face was revealed. In another case, the flip-chip package was imaged from the bottom substrate side. Gating was on the interface between the cured underfill and the substrate; therefore, bonding the solder balls to their pads. This shows difficulty of implementing such condition for a real application when a large number of other package and materials interfere with acoustic signals.

Sakuma, et al.,[11] used non-destruction techniques for flip-chip improvement as well as verification for such improvement. Both C-SAM and X-ray NDE images were presented for an assembly prior to its optimization by a differential heating/cooling chip joint method. The C-SAM investigation detected fractures in the ULK layers, whereas X-ray techniques identified solder joint bridging. In a recent investigation, Phommahaxay et al.,[12, 13] stated that even though the 200 MHz transducer can detect gross defects, it does not have sufficient resolution to detect voids in a through silicon vias (TSV). Micron size defect detection required the development of a C-SAM transducer with 1 GHz capability. Such a high frequency transduced allowed good and bad TSVs to be distinguished in a number of test samples. The new SAM with resolution and depth sensitivity and defect resolution >>10 μm range enables localization and measure of defects in z-3D approach. So, new GHz SAM can be utilized as a new approach for semiconductor failure analysis in 1 μm range with potential for in line tool TSV inspection development for complete 300 mm wafer inspection.

Experimental Evaluation by C-SAM

Test Plan and Evaluation Approaches

This section covers evaluation performed by C-SAM using a number of advanced packages and assemblies before and after various environmental exposure. Representative flip-chip plastic and ceramic area array (ball/column) packages and assemblies from the previous investigations were subjected to C-SAM evaluation. It also included recently acquired land grid array packages and fine pitch assemblies. Key packages evaluated included are:

- A plastic land grid array after assembly. Because of extremely low stand-off, it was extremely difficult to visually inspect solder interconnections. It was thought that C-SAM technique may provide an insight into integrity of solder interconnections.
- A ceramic flip-chip LGA package with 1517 I/O, which were previously assembled onto PCB and then removed, was subjected to C-SAM evaluation. So, the flip-chip die was exposed to two reflow cycles. Since the flip-chip die had no heat sink attachment, its back was exposed. Also, a CGA assembly version of this LGA package, which were previously assembled onto PCB and subjected to thermal cycling, was included in the C-SAM evaluation.
- A flip-chip CGA1752 I/O package assembly was also subject to C-SAM evaluation. It was realized that this package has an extra heat sink attachment; therefore, the acoustic signal from bonding materials will be a dominant signal.
- A flip-chip BGA1704 I/O package assembly was also subjected to C-SAM evaluation. The flip-chip die of this package, similar to its ceramic CGA 1752 counterpart, also had an extra interface due to heat sink attachment. This package assembly previously was subjected to a number of thermal cycles.
- The FC-CGA 1752 I/O after its heat sink was removed was re-examined. This CGA was re-evaluated by C-SAM for integrity of the flip-chip solder joints since original package showed only integrity of heat sink bonding materials.
- A hermetically sealed CGA with 1272 columns, which had die wire bonded, was also subject to C-SAM evaluation to determine if internal integrity of wire bonds could be assessed.
- A large number of fine pitch and stack package assemblies were subjected to C-SAM to evaluate their integrity and appropriateness of C-SAM.
- The FC-CGA 1752 package with no heat sink along with a fine pitch package was subjected to cycles up to 20 times of solder iron touch to induce defects. These were re-scanned to determine the level of damage and their detectability by the C-SAM technique.

• Cross-sectional examinations were performed for the LGA 1517 I/O to correlate the C-SAM images with optical microscopy images.

To achieve the highest results with limited funding, this investigation examined only packages as individual or test vehicles built previously, either used samples "as assembled" or were already subjected to thermal cycling conditions. Ideally, new test vehicles with inducing known defects should add additional values when additional funds become available. The purpose of using such a mix of packages and assemblies was to initially determine the benefits of C-SAM and to determine its potential limitations, especially for FCBGA and FC-CGA. Detailed information on package including internal configuration, optical photomicrographs, X-ray and as well C-SAM images using a range of transducers are also presented. Two facilities one external and one internal were used for the C-SAM evaluation. The outside facility had extensive equipment capability with an experienced operator, whereas the internal C-SAM equipment had a lower capability with a less experienced operator. Results are presented.

Plastic LGA132

Figure 6 compares an optical photomicrograph image of a plastic LGA package assembly with 132 lands and their X-ray and C-SAM images. The C-SAM image was taken using a very low frequency transducer of 5 MHz in order enable deeper acoustic wave penetration into the package for comparison to its X-ray images. The C-SAM image shows a few key internal chips similar to X-ray, but several other details are missing. The X-ray shows greater details of internal package configuration, including solder on land pads and land shape (e.g., a square land on the top left). Layering image is impossible with the 2D X-ray, but it can be performed by the C-SAM technique. Figure 7 shows C-SAM layering images using a 25 MHz transducer. It clearly shows different interfaces in package assembly from the top to the bottom.

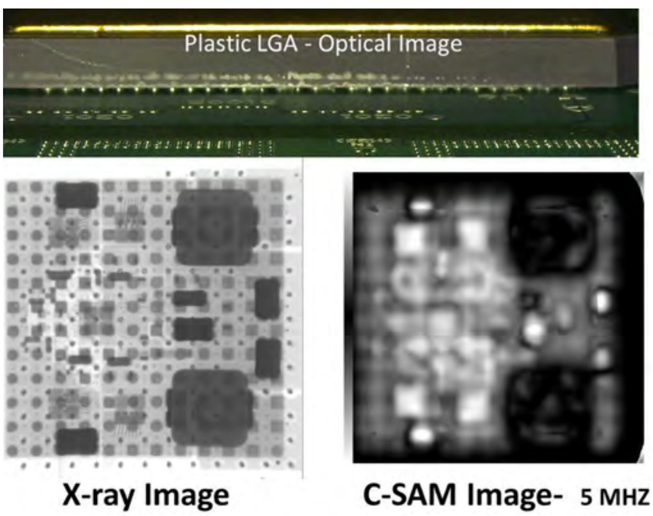


Figure 6: Comparison images by optical microscopy (top), by X-ray (bottom left) and by C-SAM from the LGA 132 I/O assembly.

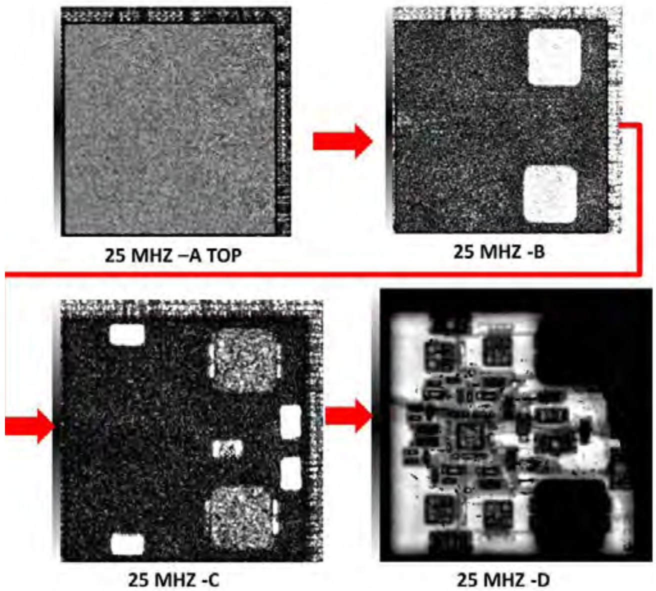


Figure 7: C-SAM layering images taken from the top to the internal LGA package assembly.

Flip-Chip BGA1704 with Heat Sink

The cross-sectional photomicrograph from a FCBGA1704, which was previously subjected to a number of thermal cycles, is shown in Figure 8. It is apparent that the back of the flip-chip die is covered by a heat sink that extended over the edge of the die, covering the flip-chip area. The only feature that could be revealed through C-SAM evaluation was the bonding condition of the thermal interface material (TIM). No in-

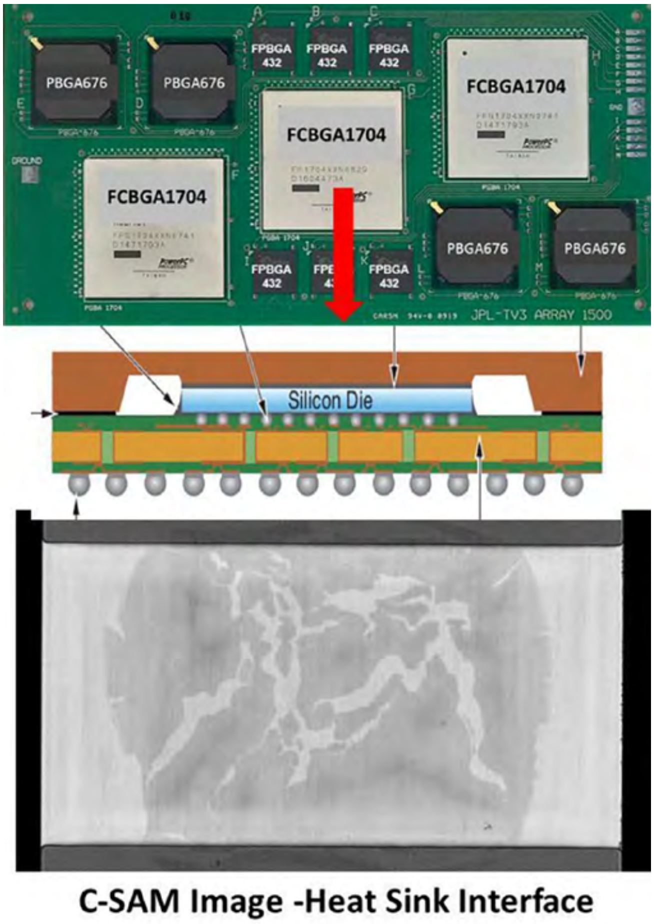


Figure 8: C-SAM image for plastic FC-BGA 1704 I/O assembly showing the heat sink interface, which hindered further penetration of signals.

formation regarding underfill or solder bump condition below the TIM could be revealed due to this interface interference with the layers of interest. Hence, the heat sink hindered C-SAM evaluation.

Flip-Chip CGA1752 with Heat Sink

The schematic drawing of FC-CGA1752 is illustrated in Figure 9. It is apparent that this package has an additonal heat sink that overshadows the flip-chip die, explaining the C-SAM signal interference with the TIM interface. Due to the TIM inteference, no layering imaging was possible. The heat sink restricted the C-SAM evaluation.

Flip-Chip LGA1517/CGA without Heat Sink

This ceramic LGA package was ideal for revealing the integrity of the flip-die, since its heat sink was yet to be attached. Two styles of LGAs with 1517 I/Os were evaluated; one as a package and the other as an assembly. Irrespective of the package being alone or in an assembly, there was no heat sink and the back of the flip-chip die was exposed. There was no C-SAM signal interference due to the TIM as it wase the case for CGA 1752 I/O. The first interface was between the die and solder bump and underfill. The second was between substrate and the land pads or solder joints of columns. Figures 10 to 12 show three C-SAM images taken with three different transducers with increasing frequencies of 25-, 100-, and 230-MHz. It is apparent that as frequecy increases the granuality of the C-SAM image increases due to increase in spatial resolution. The details of the flip-chip solder bumps became apparent at a higher frequency. There is a dark region, which is surrounding the

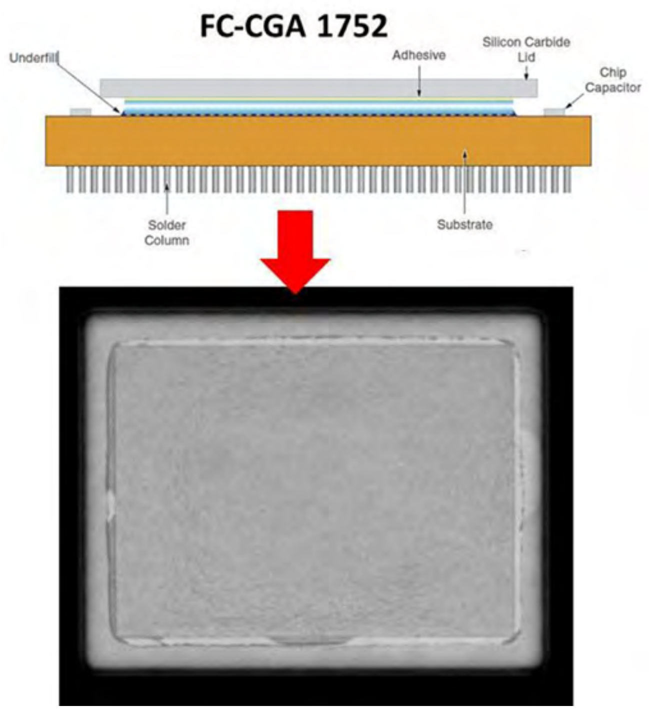


Figure 9: C-SAM image for FC-CGA 1752 I/O assembly showing heat sink interface, which hinders further penetration of singals.

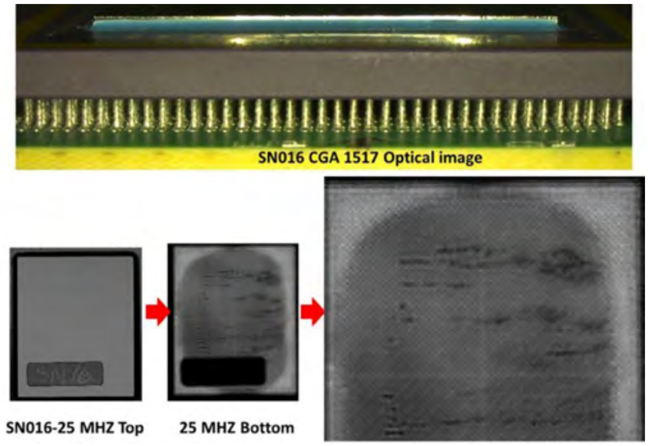


Figure 10: Optical and C-SAM (at 25 MHz) layering images for FC-CGA 1517 assembly (SN016) showing flip-chip top and flip chip bump interface. This package had no heat sink.

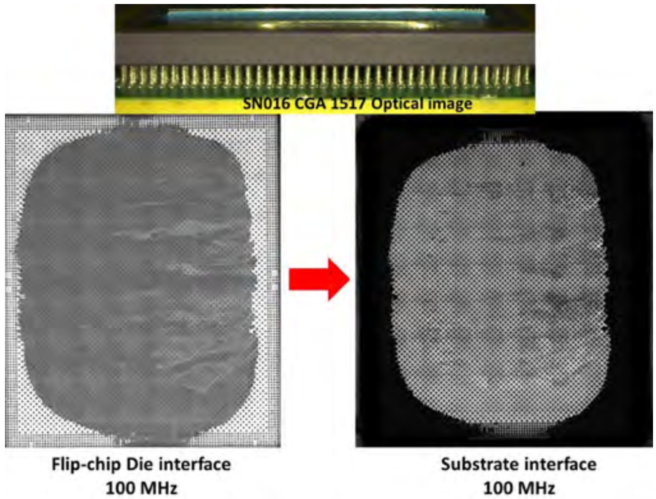


Figure 11: Optical and C-SAM (at 100 MHz) images for FC-CGA 1517 assembly (SN016) showing images for die and substrate interfaces.

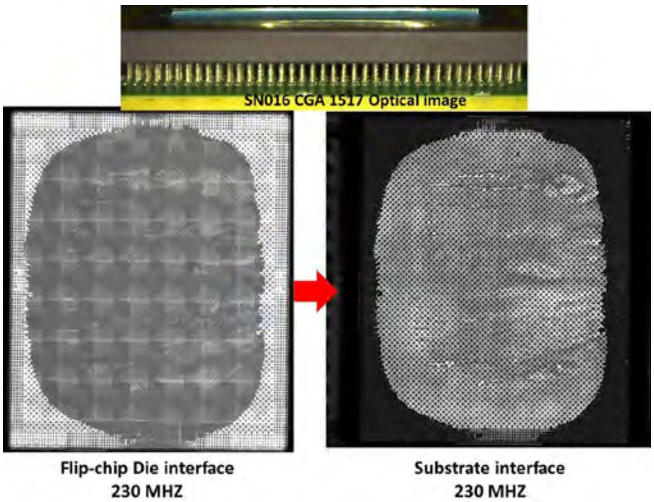


Figure 12: Optical and C-SAM (at 230 MHz) images for FC-CGA 1517 assembly (SN016) showing images for die and substrate interfaces.

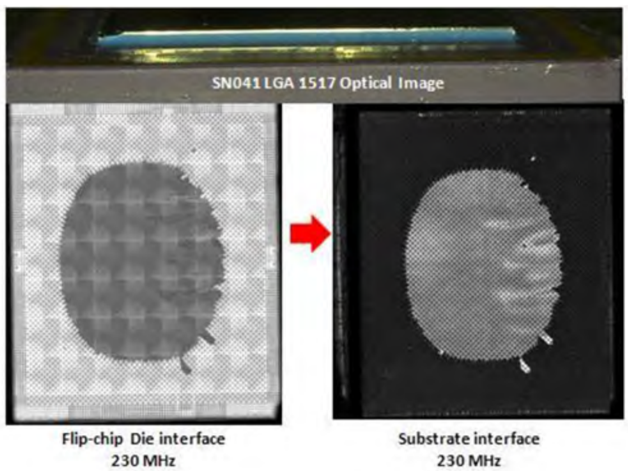


Figure 13: Optical and C-SAM (at 230 MHz) images for FC-CGA 1517 assembly (SN041) showing images for die and substrate interfaces.

central white region. The dark area is postulated to be a total separation of underfill, but needs to be verified. A similar separation condition was also observed for the other LGA 1517 I/O package assembly (SN041), as shown Figure 13.

Fine Pitch PBGAs 432 and 676 I/O

Two plastic ball grid array package assemblies, one with 432 balls and 0.4-mm pitch and the other with 676 balls and 1-mm pitch, were subjected to C-SAM evaluation. Figure 14 shows the C-SAM images for these packages as well an optical picture of the test vehicle and the package assemblies. Generally, the C-SAM method is recommended for inspection of individual packages before assembly. Prevalent delamination and "popcorn" cracking in PBGA can be detected. Nevertheless, a few features of packag-

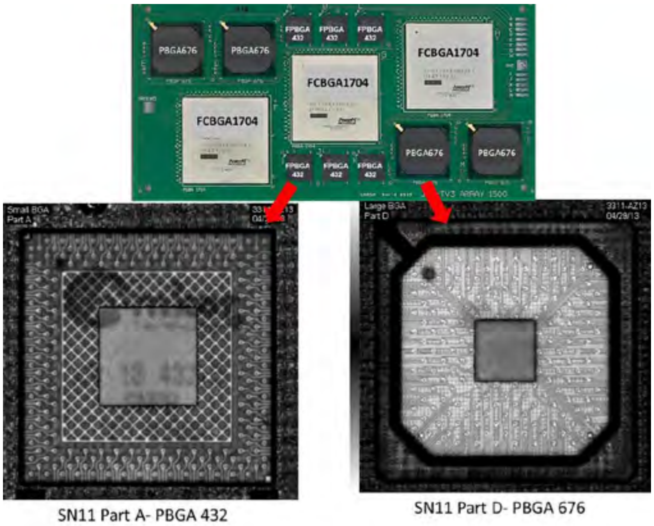


Figure 14: Optical and C-SAM images for fine pitch PBGA 432 I/O and PBGA 676 I/O.

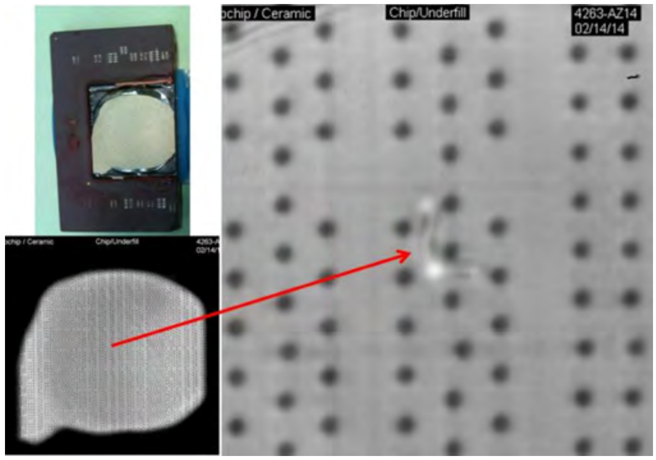


Figure 15: Optical (top left) and C-SAM images for FC-CGA 1752 I/O assembly after removal of the heat sink, showing the integrity of the flip-chip assembly and minor defect anomaly.

es such as die configuration and outline, as well as attachment condition with no signs of popcorn delamination, could be identified. However, the integrity of solder ball attachment and solder joints on the board are unidentifiable. Multiple interfaces hinder accurate C-SAM evaluation of hidden solders under the package.

C-SAM Repeat of CGA1752 after Heat Sink Removal

The initial C-SAM evaluation of FC-CGA 1752 I/O did not reveal the condition of the flip-chip die and underfill due to the package having a heat-sink interface. We successfully disbonded the heat from the die using a lap shear testing approach. The section of the flip-chip die with no heat sink was subjected to C-SAM evaluation to determine the condition of the flip-chip die and underfill. Figure 15 shows one optical and two C-SAM images of the CGA package. The condition of the flip-chip solder balls and joints appears to be acceptable. Only a small anomaly was detected in the underfill at the center of flip-chip die, as indicated by the arrow. To induce additional defects, this flip-chip CGA with no heat sink was subjected to 20 solder iron touches with a tip temperature of 700°F, each for about 5 seconds. No additional defects were detected. Other means need to be developed to induce controlled defects and evaluation by C-SAM.

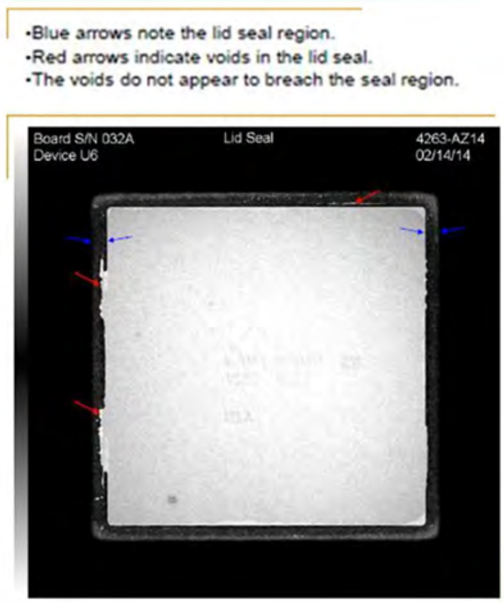


Figure 16: C-SAM images for a hermetically sealed CGA 1272 I/O assembly showing heat sink seal integrity. Blue arrows show the lid seal region and red arrows show areas with voids.

Hermetically Sealed CGA1272 with Internal Wire Bonds

Figure 16 shows a C-SAM image of a CGA1272 I/O package assembly. Only outer surfaces including the lid brazing section could be detected by C-SAM.

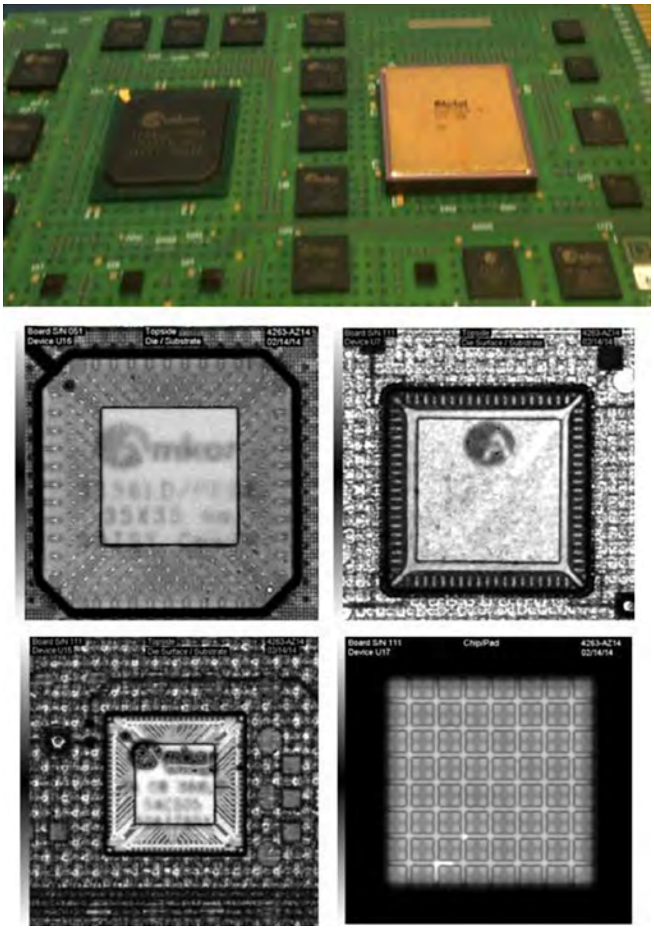


Figure 17: Optical (top) and representative C-SAM images for various PBGA and FPGA package assemblies.

Plastic LGA 1156 I/O and Fine Pitch Package Assemblies

Plastic LGA with 1156 I/O were subjected to C-SAM evaluation. Figure 17 shows images of this package. No defect anomaly was detected by C-SAM. Characterization was limited to the top section only. A number of other fine pitch plastic packages were also imaged. No defect anomaly was detected.

Effect of 20 Solder Iron Touches at 700°F

CGA 1752 I/O without heat sink and one fine pitch plastic BGA package assembly was subjected up to 20 solder iron touches at 700°F, each for about 5 seconds. C-SAM was performed at 5, 10, and 20 exposures. Figure 18 shows C-SAM images after twenty touch ups. No anomaly was detectable for either package after 20 touches.

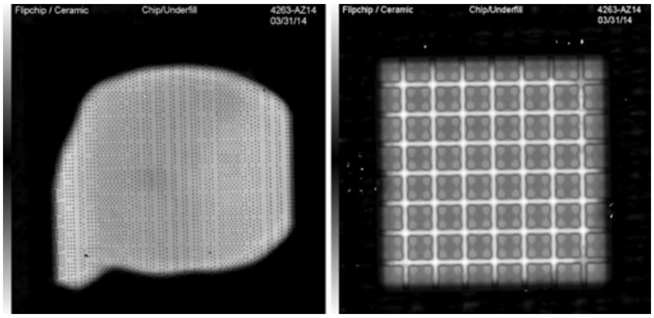


Figure 18: C-SAM images for FC-CGA 1752 I/O and FPBGA after 20 touches with a solder iron with 700°F tip temperature. No apparent changes were revealed.

Cross-sectional Characterization of LGA1517

The flip-chip ceramic LGA1517 package was cross-sectioned to verify the condition of solder bump solder joints and underfill integrity. This package was selected for X-sectioning since it clearly showed a large dark area on the periphery of the die with minor shadowing at the center of the die. Figure 19 shows the optical image of X-sectioned LGA package at lower and higher magnifications. Inspection of the X-sectioned samples did not reveal any separation in the periphery of the die, as revealed by the C-SAM images. The reason for this discrepancy is unknown.

Conclusions

The evaluations covered in this paper deal with inspection methods and comparison of inspection results performed for advanced flip-chip column grid array, flip-chip ball grid, and a number of other fine pitch ball grid array and land grid array package assemblies. Visual inspection using optical microscopy has been the traditional approach for acceptance/rejection of workmanship defects by quality assurance personnel. Inspection of hidden elements in FC-CGA and FCBGA package assemblies requires using nondestructive inspection tools such as 2D/3D X-ray and, potentially, acoustic microscopic imaging. Limitations on using acoustic

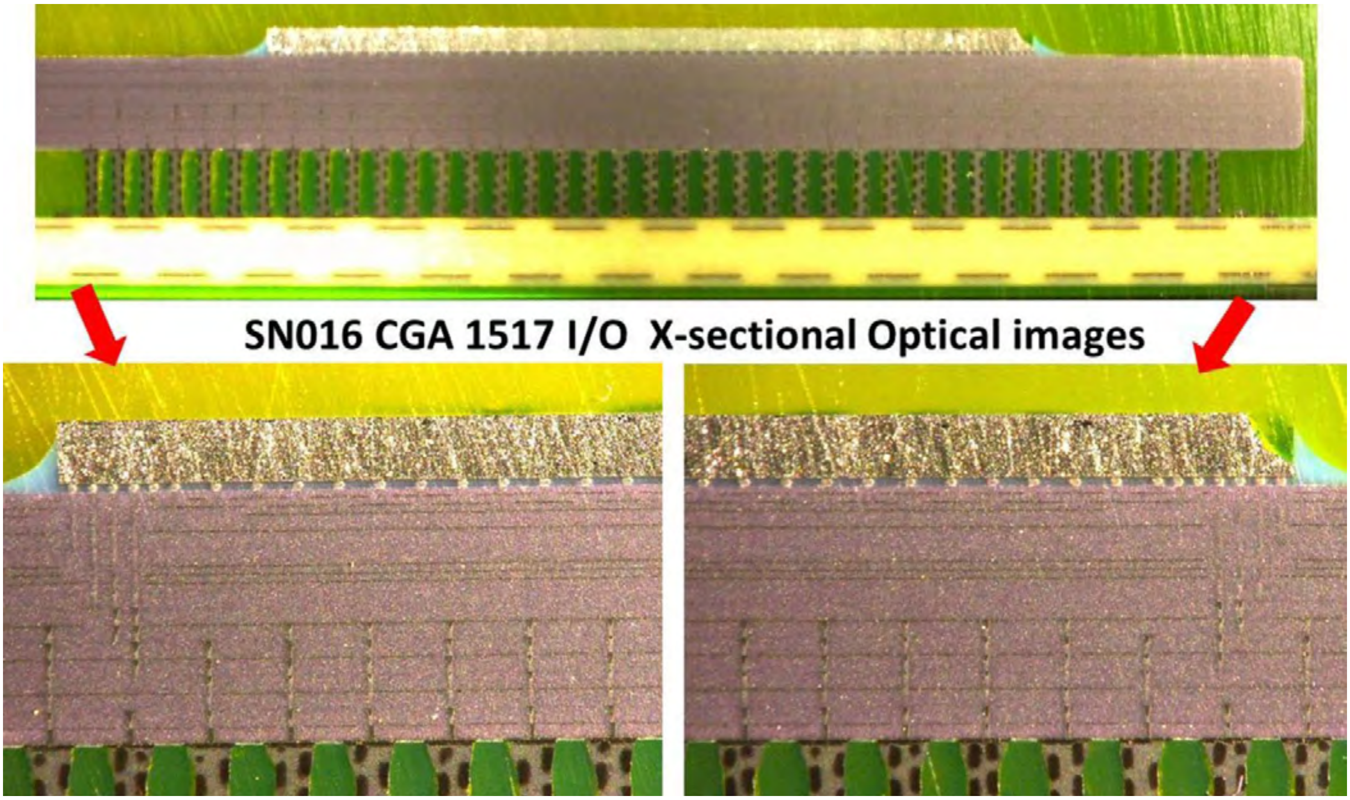


Figure 19: Optical image of a microsection of FC-CGA 1517 assembly (SN016), showing images for die and underfill.

emission for solder joint assemblies are yet to be fully established.

AE and X-ray are complementary techniques that are frequently found in the same laboratories, but they reveal different features. X-ray detects features based on differential attenuation of the X-ray energy, whereas AE detects features based on materials changes. The practical result is that AE is orders of magnitude more sensitive for detecting air-gap defects such as voids, delaminations and cracks. C-mode scanning acoustic microscopy was evaluated for advanced electronic packaging assemblies, particularly FC-CGA and FCBGA. Inspection evaluations revealed the following results.

• Visual inspection by optical microscopy is ideal for detecting exposed features such as dewetting, microcracks, cold, and disturbed solder joint.

• Visual inspection is possible for periphery columns in CGA and balls in BGA, but is difficult for joints in a plastic land grid array due to a lower gap height. A 2D X-ray revealed many internal features of the LGA package including chips and solder joints.

• Layering C-SAM using a low frequency transducer revealed many features of the plastic LGA package assembly detected by X-ray; however, the features were less clear and it did not reveal package and board interfaces or solder joint conditions.

• It was revealed that C-SAM could only show the quality of heat-sink thermal interface bonding materials of the FC-CGA 1752 I/O. Heat sink is part of the package and is attached with adhesive on top of the flip-chip die, hence, it hindered penetration by acoustic emission signal into bumps and adhesive interfaces.

• C-SAM revealed the flip-chip bumps and underfill conditions of the FC-CGA package after shearing off its heat sink.

• The C-SAM revealed an edge delamination for FC-CGA 1517 I/O assembly since it had

no heat sink on the flip-chip die. This allowed C-SAM characterization of the flip-chip bumps and underfill materials.

• Microscopic cross-sectional evaluation of FC-CGA 1517 did not support the edge-delamination revealed by the C-SAM images.

• C-SAM of a hermetically sealed LGA 1272 package revealed only the lid bonding defects. Internal features could not be detected. For plastic LGA1156, the C-SAM revealed only the die, but not the solder joint condition.

• C-SAM of a large number of other fine pitch ball grid array assemblies revealed internal die integrity and configuration, but it did not show solder ball or joint attachment integrity.

• No defect was detected by C-SAM when CGA 1752 I/O and fine pitch BGA packages with 20 repeated solder iron touches, each for about 5 seconds using a tip temperature of 700°F.

Non-destructive evaluation of microelectronic packaging and assemblies is of critical importance in assuring reliability. Understanding key features of various NDE inspection systems in detecting defects in the early stages of assembly are critical to developing approaches that will minimize future failures. Additional specific, tailored, NDE inspection approaches could enable low-risk insertion of these advanced electronic packages.

Even though C-SAM showed significantly lower versatility in defect detection compared to X-ray for packages and assemblies of FC-CGA and FCBGA, the C-SAM techniques are widely used for detection of flip-chip die attachment by package manufacturers during the early stages of the flip-chip die assembly. However, added additional interfaces (e.g., heat sink on die) limits the use of acoustic emission approach at package and assembly levels. The recently developed GHZ SAM version is shown to have potential for TSV defect detection even for complete wafer inspection.

C-SAM inspection is a non-destructive technique with a wider use for revealing hidden gap defects, including delamination and voids. It is recommended that the C-SAM characterization be used as a complement to other inspection techniques, including X-ray and traditional visual inspection by optical microscopy. It is apparent that a combination of various inspection techniques may be required in order to assure quality at part, package, and system levels. This is especially true for newly introduced miniaturized advanced electronic packages with hidden flip-chip solder bumps at the die level and solder balls at the package level with associated underfill and solder joints.

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Dr. Reza Ghaffarian is a principal engineer at NASA's Jet Propulsion Laboratory (JPL).

System Might Detect Doctored Images and Videos for the Military

Purdue University is leading part of an international effort to develop a system for the military that would detect doctored images and video and determine specifically how they were manipulated.

The project is funded over four years with a $4.4 million grant from the U.S. Defense Advanced Research Projects Agency (DARPA). The research also involves the University of Notre Dame, New York University, University of Southern California, University of Siena in Italy, Politecnico di Milano in Italy, and University of Campinas, in Brazil.

Edward Delp, Purdue's Charles William Harrison Distinguished Professor of Electrical and Computer Engineering and the director of the Video and Image Processing Laboratory, or VIPER Lab, is the team's principal investigator. The team's co-principal investigators are Walter Scheirer, Kevin W. Bowyer, and Patrick J. Flynn from the University of Notre Dame; Anderson Rocha from the University of Campinas in Brazil; C.C. Jay Kuo from the University of Southern California; Paolo Bestagini and Stefano Tubaro at Politecnico di Milano in Italy; Mauro Barni at the University of Siena in Italy; and Nasir Memon at New York University.

A huge volume of images and video of potential intelligence value are uploaded daily to the Internet. However, visual media are easily manipulated using software tools that are readily available to the public. The researchers will strive to create an "end-to-end" system capable of handling the massive volume of media uploaded regularly to the Internet, that will automatically perform processes needed to verify their authenticity. The aim is not only to verify whether a particular digital object has been tampered with, but also to learn key aspects related to its digital lineage over time, a field known as "multimedia phylogeny".

Dr. Jay Sabido

Ionics Talks Industry 4.0, Mil/Aero Opportunities, and Supply Chain

by Stephen Las Marias
I-CONNECT007

Philippine-based Ionics EMS Inc. is the first locally owned electronics manufacturing services (EMS) company in the Philippines. Founded by Larry Qua, currently the chairman and CEO of Ionics EMS and Ionics Group of Companies, the company has been around for 42 years. It started with semiconductor manufacturing services, and transitioned to EMS after less than eight years.

In an interview with SMT Magazine, Dr. Jay Sabido, president and COO of Ionics EMS Inc., discusses a wide range of topics, including Industry 4.0, automation, the challenges in electronics manufacturing, and the Philippine landscape. We also examine the challenges in the military and aerospace industry, including lead-free, counterfeit components, and traceability.

***Stephen Las Marias:** For anyone who's not familiar with your company, please give us a quick background.*

Dr. Jay Sabido: Aside from being the first local SMS—and then EMS—company in the country, there's actually a series of firsts for Ionics. From the first PCBAs to large-area LCDs when it still wasn't fashionable to have laptop or tablets, Ionics has been actually producing them already way back since 1982. We are also the first EMS company to be listed in the Philippine Stock Exchange, and be dual-listed in the Singapore Stock Exchange.

In a nutshell, that's really what Ionics is all about. It's a full, end-to-end EMS company; we offer everything from design services, to NPI, and even prototyping. Design services cover industrial design, electronic design, and embedded software. We provide complete traditional electronics manufacturing services, drop-shipping and delivery. We deliver to 162 countries and counting.

***Las Marias:** What is your company's "sweet spot"?*

Dr. Sabido: We're really big on advanced manufacturing technologies. That's what makes us

stand out from the other EMS companies. From this, it branches out into some of the things we are actually doing, such as medical electronics and telecoms, which really can be quite challenging in terms of testing and handling. We really require a lot of innovation and manufacturing technology development. That continues to be the sweet spot for Ionics, even moving forward right now.

***Las Marias:** What sort of challenges are your customers facing?*

Dr. Sabido: Globally, we all feel these. First, time-to-market is becoming shorter and shorter. And because of fierce competition globally—because there are too many players—cost is an issue. Time-to-market is very important, and of course, once again, cost.

We feel it now more than ever. But people demand more and more. For the past several years now, consumer expectations are more advanced than what companies can produce. And companies are trying to keep up with what people are expecting. Now you can actually hear the average person saying she wants this and that, and then big name companies will be saying it will take them a while to develop something like this. Before, it was just in the realm of science fiction authors. But now, anybody can dream of what they want their devices to be.

I remember when I was in grad school back in the early 90s, we were just talking about personal communication systems. Now, everybody knows what it's all about. It's very hard to imagine before that a phone or number in every hand—your unique identifier.

Going back to your question, I think it's really that the electronics being very pervasive—from something very small, such as implants to the body, all the way to something fairly big—and the challenge of that is becoming more and more difficult; and there's a lot of expectations from the public in terms of when they want it, how they want it. It's a chance for manufacturers because instead of having a high-volume, low-mix line, right now it's really low-volume, high-mix. There are too many variations; ideally, it is a market of one. And that's one of the challenges again: how to deliver that, in the same cost or even cheaper.

***Las Marias:** What forces do you see driving the industry?*

Dr. Sabido: People are talking a lot now about Industry 4.0, where manufacturing is really shifting. It's the marriage of operational technologies (OT) and information technologies (IT). It's an enabler, and at the same time, more

of a need already because it will enable us to address those challenges such as time-to-market, cost—the usual things that manufacturers face. What's shaping that, and what allows us to be able to do that is the vision of Industry 4.0. And I see more and more automation—such as robotics—in the factory floor. The use of IT, not just to do reporting but really to do more advanced stuff. It's really the guiding force in the industry right now, and it's really what's enabling us to go to the next level.

***Las Marias:** How do companies justify investments in such advanced technologies?*

Dr. Sabido: There are actually two ways of looking at it. The obvious one is that it really should make business sense. The biggest justification is that it really should make manufacturing more effective and result in cost savings. This is what we've seen in some of the things we're doing in our journey towards Industry 4.0, and I think we are leading the pack. We made an announcement last year about our tie-up with IBM and Apple for a smart factory.

The way we justify it is that it would make us more cost effective; granted it cannot be applied to a lot of different lines. And I think that's where the secret is—although it's not that secret. There are certain lines where it's applicable, for instance, SMT equipment really screams for automation; for IT to actually help; and to increase your OEE, to name a few.

The way you monitor your scrap—that's fairly straight forward. And that will already result in cost savings. That in itself justifies the investments we are putting in the front end, the front line, which is the SMT area. The backend is the one that's more challenging because that's where a lot of variations come in, which require a lot more creative ways of going about it. Probably, not all the lines will have that, but there are lines that justify that. For lines that really require you to have very consistent quality, very tight tolerances, I think that's where it can become effective.

For things like in automotive, wherein you really have to tightly control it, and in something where robots can actually help you, can achieve very tight tolerances; I think that's where the investments make sense. Where you actually need to produce something at very high speed, and really run operations 24/7 minimizing the downtime and changeover time, that's where robotics can get you more out of your machine and your line. That's where Industry 4.0 makes sense. And everybody is actually looking at it, including low-cost-labor countries because there are some lines or some products where that makes sense.

***Las Marias:** What challenges and opportunities do you see for your company in the upcoming year?*

Dr. Sabido: I think the most obvious is really executing our roadmap for Industry 4.0. That is something that's very important. The other one is something that the industry as a whole is facing, and it's not only for EMS companies, but every company in general: talent. At the last SEIPI show, I gave a talk on the strategies and the challenges that companies are facing right now. And my basis was the 2016 Deloitte study on global manufacturing competitiveness. They interviewed more than 500 senior executives of manufacturing companies—they do it every three years—and the number one challenge for the past six years has been talent: getting skilled people and hiring great engineers. In spite of talking about automation and the need for other advanced manufacturing technologies, they really need great people. And that's what can make or break a company. Not only in the Philippines, but globally; the manufacturing industry is experiencing the same thing.

The number one pain point and challenge will always be people. Where to get good people, how to get good people, because it's a very fierce competition right now globally for good talent. The Philippines has been experiencing that, other ASEAN countries, outside ASEAN as well, and even China and North America and Europe: it's retaining talent, acquiring them, training them, and really growing them. You really have to take care of your people, to make sure that they continue to be motivated and excited with the work that they do.

The second one is circling back to what I mentioned: advances in manufacturing technologies are really there for the picking, and

therefore execution and implementation become a challenge. They are not cheap, so it really requires good business justification for it to be created, where it can really be impactful, in your line. It doesn't have to be end-to-end, but where it makes sense, applying the technology where it makes sense and where it can really justify the business.

Those are the two greatest challenges. The third is really competition. For an EMS company, how would you differentiate yourself from others is really a big thing, and usually it has always been about cost, proximity, and relationship. And it may have worked in the past—and of course it still continues to be a traditional business—but now, we cannot be complacent, and we have to be able to differentiate ourselves and continue to really grow our business.

***Las Marias:** You've been in the industry for decades. What are some of the biggest changes you've seen?*

Dr. Sabido: A lot of my background has really been in design, in R&D. What really made Ionics attractive for me is, once again, Larry Qua's vision—the end goal of which is a Philippine product that will be well-known globally. And I share the same vision as him. That's why it's really a great opportunity to be working with Ionics.

In the industry for the past decade or so, we've looked at the different success stories of Taiwan, China, Korea, including Japan, and of course the U.S. and Europe, and Germany. The industry started off with the computing industry. It's really computers that drove a lot of the industry's growth. And then PCBAs. Locally, when Intel came into the Philippines back in the early '70s, it really gave a boost to the local manufacturing industry. That's why a lot of local companies started out as SMS—semiconductor manufacturing services. And then they transitioned into EMS companies. There are a few more that are still in SMS, but most have transitioned to EMS.

The first industry that was high volume included people open to outsourcing their production. A lot of OEMs before were manufacturing by themselves. What we've seen were EMS companies that have actually grown and more OEM companies that have become willing to outsource. It started out in the computing industry where there was a big boom in computers. But then it branched out eventually to other sectors as well—from telecom to consumer electronics, and now medical and automotive. We've seen the challenges from the computing industry, to now the stricter and stricter quality requirements of the medical and automotive industry. That's where we see the transition, wherein in terms of QMS, in terms of very high tolerances, very strict requirements, that's where we've seen the industry actually grow.

We've seen a lot of people come and go in the industry; in fact, we've seen OEMs actually give up certain market share—they are losing market share so they exited that product space. But I think what stands out—and the next normal for the electronics industry—is really how IT can actually make our operations better.

Maybe I am biased because of what I've seen in Industry 4.0, but that's where I've seen a significant change right now in the industry. The rest are business as usual, like consolidation. But more and more, it's the use of IT, starting with ERPs, putting computers on the line, and now really leveraging all that and having a complete operational picture for the whole factory.

***Las Marias:** What trends do you see as you look out at the electronics manufacturing service industry?*

Dr. Sabido: A lot of people don't talk about it, but it's really at the top of mind with Industry 4.0: analytics. The use of data, the information flow, and how you leverage that data to actually make your operations much better, to provide better service to your clients, and to improve your quality. That's the trend; but it's difficult to implement. I think that is something where, once again, the role of IT in the operations is becoming very important, not only for EMS companies but the industry as a whole. I am also still fascinated with how robots can actually make operations much better. Those two things are very important trends.

What also fascinates me is the autonomous car—I think that's actually driving a lot of developments right now. There's a lot of excitement, and maybe a lot of hype too, but it really increases more and more the code, the software that comes into a lot of products. Which reminds me, I think another trend also is the development in software. Before, when we started, it just used to be all embedded software—embedded Linux, looking at the Linux kernel, chopping it down so you can actually put in very small devices. But now, maybe we can use the Android platform. Apple is exploring the iOS platform. So there's always different choices out there that we could actually explore. That also helps leverage and improve the connectivity of the electronics to the whole complete system out there where it's actually being used.

Las Marias: Should everyone in the electronics manufacturing industry jump on the Industry 4.0 bandwagon now?

Dr. Sabido: I am actually inclined to say yes. Just like before, when SMT machines came out, people are saying they're very expensive, they don't need that, they can actually do it manually. But eventually, if you'd like to grow, if you'd like to service other industries where quality is very important, and there's a bit of higher volume, even right now, you have to evolve. So the industry has to evolve into Industry 4.0. And I think it is really just a matter of time. Right now, a lot of people are adopting a wait-and-see approach because, one, it is expensive, and the other thing is they don't know how to actually approach it. And I think that is one thing I am fairly happy and—to be honest—we really want to be the pioneer, because we see it as something that is very important for our business. If your question is whether Ionics should do it, the answer is yes. But overall, I think the answer is yes; just like in Industry 1.0, 2.0, 3.0, and now 4.0—eventually people have to do it.

Of course in a technology cycle, there are pioneers and there are laggards. We are pioneers because we see it as something that is an imperative. We have to do it for us to deliver and really delight our customers—because we want them to have visibility into what we are actually doing for them, real time, 24/7, when they need it, when they want it. We don't want to have them bother going to factories to ask about their systems, or call or email, for us to send them charts.

So, one is for our customers. The other one is for quality. Because once again, with automation, you can have tighter and tighter tolerances and better specs, because now you have better control. And then speed. With automation, you can do quick changeover. With your machine, you can make your ROI ideally become shorter and shorter, even though they are actually more expensive, because you utilize them more; the downtime is much less because you can actually do much more than preventive maintenance, through the use of analytics. That's where we see it. So for us, it is a need, and it's the only way to go.

Las Marias: Please tell us more about the smart factory.

Dr. Sabido: For us, the smart factory is something where you use data, the information flow from the start of our engagement with the client in terms of manufacturing their products, even from the parts itself, all the way to upon shipping it and arrival to their final destination. So having that full information flow at your fingertips, in your mobile device, in a tablet, in your computer, where you can actually access that information from beginning to end, and having real time access to that, is something that we envision as the simplest version of the smart factory. That's just one aspect of it—really

having an end-to-end view—where it is at, how you are doing, etc.

A lot of people think that's already what makes a smart factory. That's just an operational view. What makes it smart—and again the definition of smarter is it should be interconnected, you have IoT, and it is instrumented. But then, the current aspect of it is intelligence. For us, another name for smart factory is intelligent factory—it's not just having an operational view of what's going on, but it is being able to predict what may happen in the future. For example, how much yield you may actually get, when you can actually ship it all the way to your client, and by how much, based on this yield right now. And where you can actually do simulation, or how you can do real, intelligent preventive maintenance, wherein before it even breaks down, you can see that there's something wrong because the yield is going down little by little. Or you can actually optimize the process and make it more efficient by doing this or that. So I think, having the ability to not only view, but to simulate, and really predict, and really prescribe—I think these are the three aspects of analytics.

Analytics can be descriptive—it can describe something; it can be predictive—it can predict something; but the most powerful one is to prescribe—to prescribe a possible task, prescribe a possible way of going about it, so that you can really optimize. In manufacturing, the use of operations research, the use of prescriptive type of analytics and statistics to be able to really optimize all aspects in your factory—that, for us, is the vision of a smart factory.

***Las Marias:** What tips can you offer OEMS in selecting their EMS provider?*

Dr. Sabido: Not just to go with the lowest cost. A lot of OEMs think outsourcing is just a cost play. And they look at it from a placement cost perspective. But of course, it's not just cost, but quality. I think the message to OEMs is that you have to look at it from an end-to-end perspective—from cost, quality, and engaging with the company that can help you come up with better products. As I've mentioned, we can actually help our clients, improve their products, improve their operations, and make suggestions where we can. And I think that's what differentiates a great EMS company.

***Las Marias:** How would you describe the electronics manufacturing industry in the Philippines?*

Dr. Sabido: The Philippines' EMS industry is not as big as we would want it to be. It could actually be bigger, because, one, we have a lot of very good and creative engineers—which is why in spite of lower-cost production countries, the EMS companies in the Philippines are actually thriving and continue to be here. It shows that for others who have explored other countries and have gone to lower-cost production countries—or what they thought are lower-cost countries—a lot are actually coming back. We see a lot of Japanese clients going back to Ionics and other EMS firms here. It really leverages on a lot of our creative and talented engineers and skilled workers, and I think there's a lot more room to grow. I think there's a lot more opportunities we can tap, and we're very excited about the changes in the country.

Las Marias: ***What are the challenges for EMS companies catering to the military and aerospace industry?***

Dr. Sabido: The specs of some items, the tolerances, are much tighter today. The reliability in the field, and of course, the environmental requirements. They require different types of packaging; they require really massive testing; and the specs are much more stringent. Labor-wise, cost-wise, I think they are very high, and then for you to really be engaged in the industry really requires a lot of experience. You have to work very closely with your clients. It has to be tightly controlled also. Overall, it is challenging in all aspects. And military-grade products are expensive because they really undergo testing to death, and really have to withstand the harsh environmental conditions. Because of the very stringent requirements, it requires a different breed of EMS companies to be able to serve the market. It's a very difficult market to actually serve, but the profits and margins are really good.

Not all EMS providers can go into that and the challenges are known: it requires a lot of technical capabilities, and it's not just a business-as-usual EMS line—it requires a very stringent line, a very controlled line, and of course, for some military applications, you really have to make it a self-contained operation because of the sensitive nature of the products, for example. It requires a certain know-how, it requires a certain skill, and traceability is very important. So it is a different breed of EMS companies and the skills that you really need. But it could also be very rewarding if you succeed.

Las Marias: ***Because of the critical nature of the mil/aero industry, counterfeit components are a big issue. How do you address that challenge and how do you ensure the integrity of your component supply chain?***

Dr. Sabido: One of the things that would make or break an EMS company is supply chain management. Even the top 10 EMS companies worldwide would actually say one of the secrets to their growth and success is actually managing their supply chain. And really, tracing your components is actually very important. There are a lot of technologies you can use in terms of traceability and making sure they are not counterfeits. Our supply chain group ensures that they have that capability to actually trace the components back to their origin. That's one of our competitive advantages. That's why I keep talking about technologies such as RFID, barcoding, and really coordinating with our suppliers, and the use of IT also for monitoring the logistics flow of our supply. I think it's very important.

Las Marias: ***With respect to the mil/aero market, what tips can you give customers when it comes to selecting their EMS provider?***

Dr. Sabido: I think number one is trust. You really have to find an EMS company that you can trust. Because it is really more of a partner than a client, so the relationship is very important. My message to OEM companies is that you really have to be open to the EMS company that you are going to talk to, because of the possible sensitive nature of the application of your products. But then you also have to pick the right partner. You have to be able to trust that organization. I think that's the most important thing. The rest are the specs; you have to be able to comply with this and that. But I think trust, experience and know-how are very important.

Las Marias: ***What market drivers or trends will effect changes in the PCBA process?***

Dr. Sabido: Newer material technologies are very important. Solder, and other materials, how to make them more reliable, even the materials for the board, the materials for the flex components, the wafers, and the chips. Even the issue with multiple substrates, which is a challenge in the semiconductor industry. But really the core is OT/IT, and then materials.

Las Marias: ***Thank you very much for your time.***

Dr. Sabido: Thank you. **SMT**

Recent Highlights from SMT007

1 Kimball Electronics Acquires Aircom Manufacturing

Kimball Electronics has announced the acquisition of the assets of Aircom Manufacturing Inc., an Indianapolis-based contract manufacturing company that specializes in metal fabrication, plastic injection molding, and assembly.

2 IPC EDGE Provides the Critical Education Required to Excel in the Electronics Industry

IPC has launched a new learning management system, IPC EDGE, designed to deliver the education needed to acquire and develop the competitive skills necessary to excel in the electronics industry.

3 SMTA International Keynote Speaker Announced

The opening session at SMTA International on September 27, 2016, will feature a keynote presentation titled "How's Your Storage?" by Daniel Kuhl, Vice President of Engineering at Seagate Technology, who will provide an overview of the memory storage explosion and factors influencing global design and architecture, technology progression and infrastructure for manufacturing and validation.

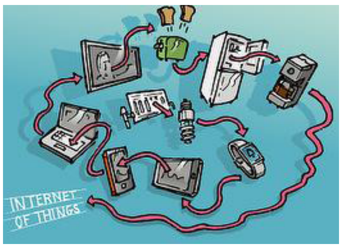
4 SMTA and IPC Cleaning and Conformal Coating Conference Program Finalized

The SMTA and IPC have finalized the program for the 2016 Cleaning and Conformal Coating Conference being held October 25-27, 2016 in Rosemont, Illinois.

5 AIS Touts Comprehensive DFM and DMS Services for IIoT

American Industrial Systems Inc., a subsidiary of Ennoconn Corp. and group member of Foxconn IPC, is offering design for manufacturability and design manufacturing services to help customers deploy new visualization, control and monitoring solutions for IoT, Industry 4.0 and IIoT.

6 PFP, Wistron and Xilinx Team to Deliver Cybersecurity for IoT



PFP Cybersecurity has teamed with Wistron and Xilinx to develop solutions that protect against cyber-attacks that threaten any IoT connected device.

7 Etratech to Make its Debut at electronica

EMS provider Etratech Inc. will make its debut at the electronica trade fair in Munich, Germany this November.

8 Saline Lectronics Invests in a Stinger Dispensing System

Saline Lectronics Inc. recently installed the Stinger on its DEK Horizon 03iX printer used on a high-volume SMT Line. The company plans to add the Stinger to its other DEK printers in the future.

9 Spectrum Assembly Reconfigures Its SMT Production Area

Spectrum Assembly Inc. has added equipment and is reconfiguring its SMT area utilizing Lean manufacturing principles to increase flexibility and throughput.

10 Vexos Appoints New SVP for Global Supply Chain

EMS firm Vexos has appointed Stephanie Martin as SVP, Global Supply Chain, wherein she will be responsible for establishing performance metrics consistent with Vexos' strategic vision, as well as take a fresh approach toward leveraging scale and optimization across the business.

Events

For IPC's Calendar of Events, click here.

For the SMTA Calendar of Events, click here.

For the iNEMI Calendar, click here.

For a complete listing, check out SMT Magazine's full events calendar here.

Medical Electronics Symposium 2016
September 14–15, 2016
Portland, Oregon, USA

24th FED Conference
September 15–16, 2016
Bonn, Germany

IPC India 2016
September 21–23, 2016
Bengaluru, India

SMTA International 2016
September 27–29, 2016
Rosemont, Illinois USA

electronicAsia
October 13–16, 2016
Hong Kong

IPC-SMTA Cleaning and Conformal Coating Conference
October 25–27, 2016
Chicago, Illinois, USA

IMPACT Europe 2016
November 1, 2016
Brussels, Belgium

PCB Carolina: Regional Trade Show
November 2, 2016
Raleigh, North Carolina, USA

electronica 2016
November 8–11, 2016
Munich, Germany

International Printed Circuit & Apex South China Fair (HKPCA)
December 7–9, 2016
Shenzhen, China

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What makes a great leader, and the changing roles of the leader in this industry

NOVEMBER:
Vias
Looking into the impact of vias in assembly