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APRIL 2013

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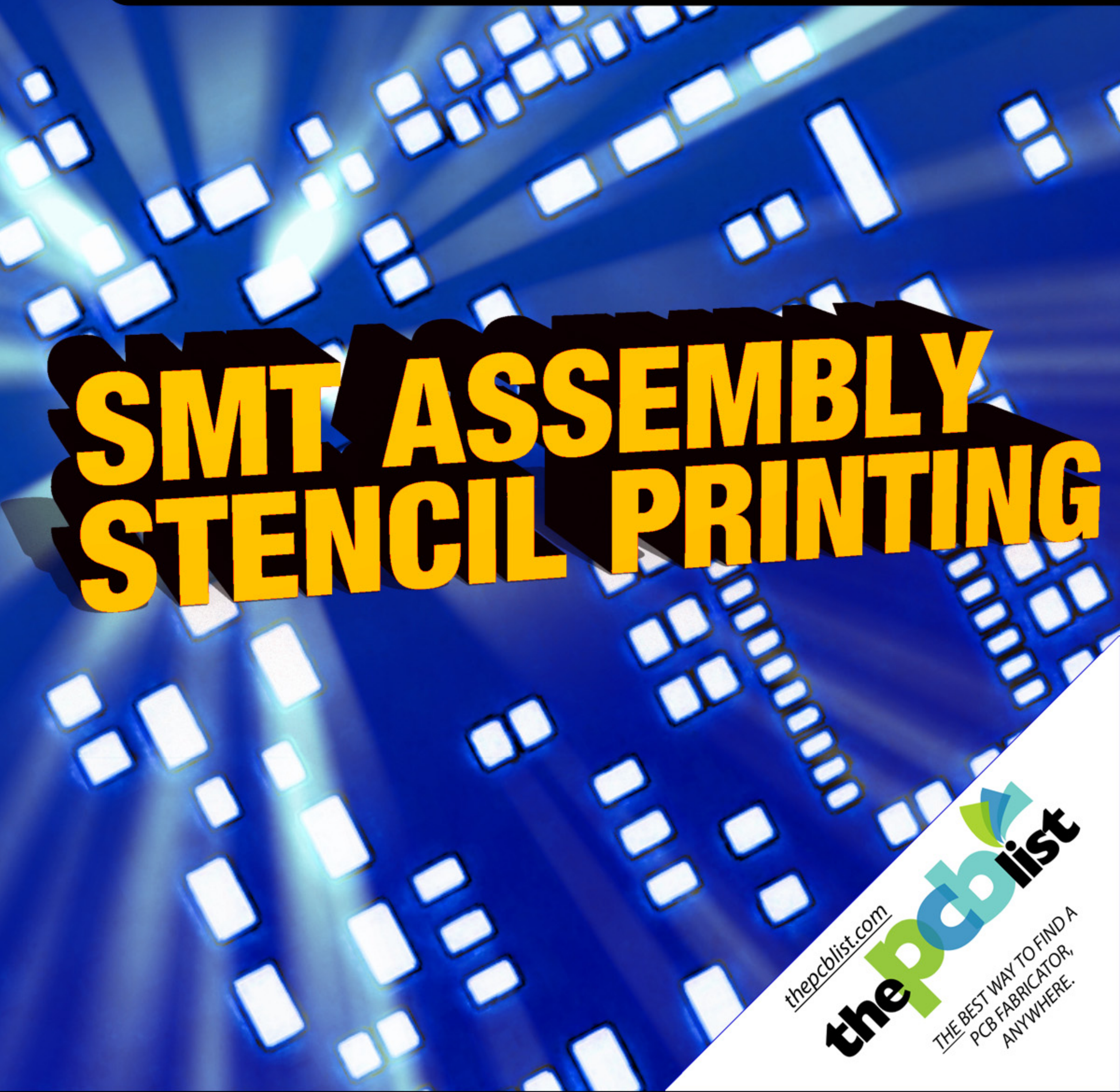
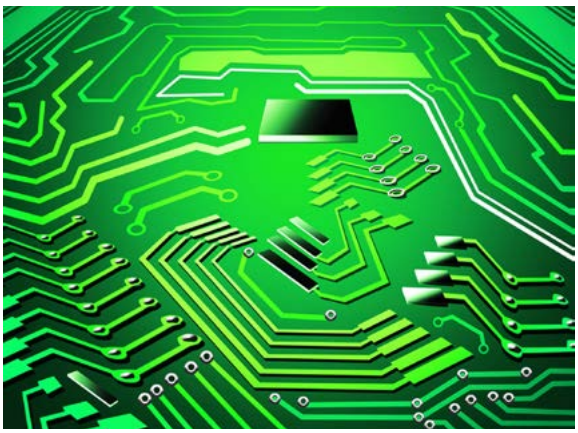
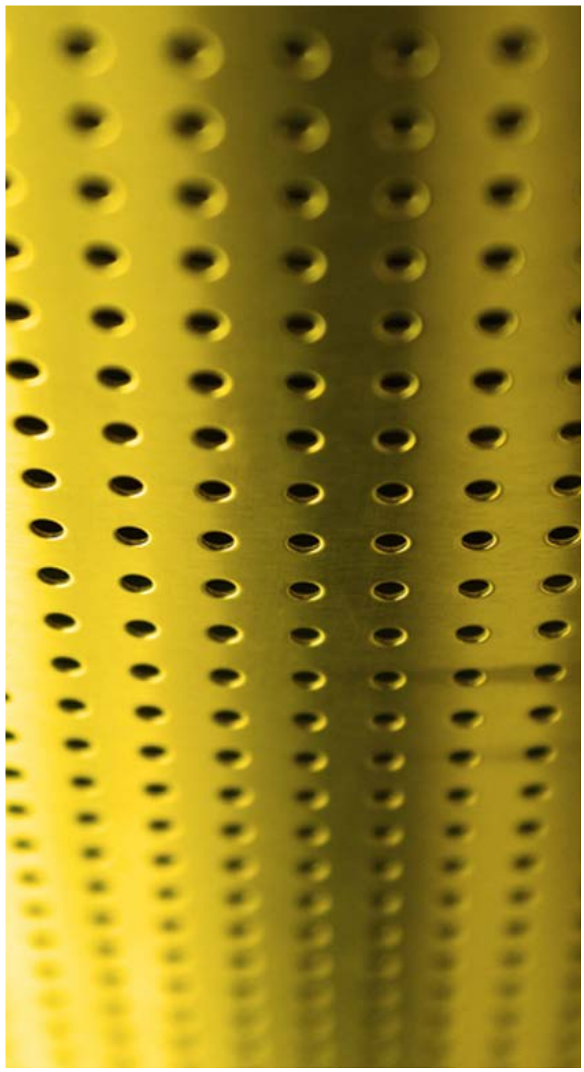


April 2013 Featured Content

SMT ASSEMBLY PROCESSES PART I

The April issue of *SMT Magazine* addresses SMT assembly processes, including stencils, paste printing/dispensing, component handling, ESD control, component placement, and odd-form placement. The issue features 3M's James T. Adams, explaining how to find the perfect cover tape; Dr. Bill Coleman, vice president of technology at Photo Stencil, addressing the stencil printing of small apertures; Ricky Bennett and Eric Hanson covering low surface energy coatings; and many more articles and columns from industry experts, including Eric Klaver, Karla Osorno, and Michael Ford.





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What I Learned at IPC APEX EXPO

by Ray Rasmussen
I-CONNECT007

SUMMARY: This year's IPC APEX EXPO was filled with exciting new products, promising market news, and a wealth of information supplied by the very best in the industry. Ray Rasmussen supplies his list of note-worthy happenings and events.

The Market

The market is getting better. Of course, no one is being blown out of the water, but forecasts for the industry are solid for the next couple years. Walt Custer is forecasting 4% growth in 2013 and 6% in 2014. I'd much prefer a steady, year-over-year rise as opposed to a boom, which is always followed by a bust. The growth Custer is talking about will manifest in the second half of the year so be patient, but get ready.

One caveat is the dreaded "sequester" which Congress has failed to address at the time of this writing. The good news from the show floor was that just about everyone is investigating equipment and materials for a near-term purchase or they were at the show to buy. Technical capability seemed to be the main driver—lots of pent-up demand.

New Technology

If you're an exhibitor, it's a good thing to come to a show like IPC APEX EXPO with something new to talk about. This year a plethora of new products dazzled those hungry for the latest and greatest piece of new technology. IPC compiled a list of the 43 companies exhibiting 80 new products at this year's show.

Where the IPC is Headed

As many of you know, I've felt that IPC has been under-serving the industry for decades, always playing catch-up to new regulations, trade issues, and technical challenges, leaving the industry (its member companies) to fend for themselves, mostly. This isn't a Denny McGuirk issue, but an issue with the board of directors, most of which were satisfied with the status quo. Well, that's all changed. Not sure why it took McGuirk's departure to get the board fired up, but they seem to have finally figured out what IPC is all about (member satisfaction) and where it needs to travel (toward becoming a truly global organization).

IPC Board member Mike Carano sat down with IPC President John Mitchell to discuss this new focus for the organization. Although some might have heard Mitchell talk about this charter in other interviews, it's worth repeating for those who missed it. Mitchell and Carano do a good job of laying out the Board's expectations going forward in this video interview.

145 Videos Produced

I was quite proud of our effort this year to produce our video coverage in partnership with IPC. Real Time with... (RTW) does a great job of extending to many the upfront and behind-the-scenes activities and events at the show. People around the world have told us how much they've enjoyed our coverage. Even though they

WHAT I LEARNED AT IPC APEX EXPO *continues*

weren't able to attend, watching this extensive coverage keeps them up-to-date on the latest technology, events, and programs. The choreography needed to pull off this dance is getting more and more refined each year. It's no easy task to line up the interviewees and match them with a guest editor, conduct a pre-interview, shoot, edit, render, upload to the Internet, and post on the show RTW site—not to mention this is all done usually within an hour. It's an amazing team effort.

Now, if you haven't been to the site, visit Real Time with...IPC and click on a tab to sort through the list. You can also perform a keyword search if you want to narrow the selection further. There, you'll find technical product discussions, market forecasts, industry progress reports, interviews with some of the industry's biggest personalities, and more. If it happened at IPC APEX EXPO, we have it here. Enjoy!

13 Panel Discussions

Following last year's inaugural introduction of panel discussions as part of our RTW program, Lisa Lucke, managing editor for The PCB Magazine, led our effort again this year, organizing 13 in-depth discussions from some of the industry's biggest names. Topics ranged from technology roadmaps to nearshoring to assembly cleaning practices, impact of lead-free, embedding components, and much more. Visit Real Time with...IPC and click on the "Panel Discussions" tab.

Mostly Assembly

It's an assembly show for sure. What started out as The PCB EXPO, a show dedicated to the PCB fabrication industry, IPC APEX EXPO has morphed into a show that reflects the current nature and composition of the industry. I certainly wish the PCB component of the show was more substantial, but that's the way it is, for now. Still, having fabricators, assemblers, and designers all at the same event makes a lot of sense.

San Diego: Not Always Warm and Sunny

What I'm sure was disappointing for most attendees coming from outside California was the weather and how it didn't live up to its reputation. Cool, cloudy, and sometimes rainy weather kept many focused on the show, a good thing for the show organizers and exhibitors. The I-Connnect007 team stayed in town on Friday to wrap up the final pieces from the show, and wouldn't you know, it was the type of day most would have expected for their week in San Diego—both sunny and warm. For those lucky enough to have extended their trip for the weekend, they likely got their money's worth.

ODB++ Celebrates a Birthday

Was Chuck Feingold right? In the fight between IPC GenCam over a decade ago, Valor and IPC were at loggerheads as to which was the best information standard for the industry. IPC wanted an open (available to all) standard like GenCam, which Dieter Bergman and company would not let go of, while Valor wanted the industry to adopt what it claimed was a better format; however, they didn't want to give control of the software to IPC and possibly their competitors.

All these years later we still see ODB++ going strong. I was invited (sort of...I actually crashed the party) to attend a celebration by Mentor, who purchased Valor a few years back. Congrats to all the Valor folks and to Chuck Feingold, especially (Chuck sold his interest in the company years ago and is probably living on his private island somewhere in the Caribbean).

A Death

I found out some sad news after the show. Marty Georgia, owner of Electronic Circuit Supplies in New Jersey, died unexpectedly in his hotel room during the week of the show. We published an obituary on our site. Marty worked selling PCB materials to the industry for over 20 years.

Next Year: Las Vegas

Everybody has an opinion on this. Some like Las Vegas and some don't. In any case, that's where we'll be next year and the year after. There's a growing list of pros and cons, with one of the cons being that it's way too far to walk. As in years past, the show will be located at the Mandalay Bay Convention Center, which is located at the back of the casino. If you're staying at Mandalay Bay, it's not too bad, but still about a half-mile walk from your room to the show floor. If you're like us, looking for the "best deal" (read: cheapest) in Vegas hotels, then it's at least a mile from the room, to the tram, from the tram, to the show floor. It's fairly good exercise, except for the walk through the smoke-filled casino. We try to walk outside as much as possible.

Another con is the distance from the market in Los Angeles or, more accurately, Orange County. The thought is that the show isn't close enough for people to drive down for the day like the trip to San Diego, so you potentially lose quite a bit of floor traffic. Also, Las Vegas is a huge distraction for most of us, pulling us away from company-sponsored events to attend a Cirque du Soleil show or some other spectacular magic show. I get that.

On the "pros" side, Las Vegas is a truly international destination, which draws more high-level folks and tends to encourage show and conference attendees to hang around longer. Not sure if the show is cheaper for exhibitors, but the overall cost could be a bit cheaper and offer lots of hotel choices.

I like Vegas for the shows and the vibe and I like San Diego for that SoCal (Southern California) feel. Either place works for me. It's a nice change every couple years. It's all good. If you missed IPC APEX EXPO this year, you missed a good show. I expect that with the market heading north, the show in Vegas will meet or exceed expectations.

See you there! **SMT**

Ray Rasmussen is the publisher and chief editor for I-Connect007 publications. He has worked in the industry since 1978 and is the former publisher and chief editor of CircuiTree Magazine. Contact Rasmussen here.

Package-under-Package: A 2D Option with 3D Benefits

by Joe Fjelstad
VERDANT ELECTRONICS

SUMMARY: How many ways can you stack chips? Your options are many, but package-under-package (PuP) assembly is one solution that offers the unique potential to build unusual interconnection substrates.

The three-dimensional interconnection of electronic devices continues to hold sway over the minds and imaginations of electronic product developers around the globe. Its growing attraction stems from the fact that 3D assembly offers a means for addressing the challenge presented by the electronic industry's desire to pack more function in to the same, or lesser, amount of space. Looking back, it is nothing short of amazing to see how electronic packaging and interconnection engineering teams around the globe have continued to deliver on the industry mantra of "smaller, faster, better, lighter, and cheaper" and increasing interconnection density has been a centerpiece of the effort. The fact is, 3D assembly is not all that new and was actually first proposed in the earliest days of the electronics industry, but it has definitely become the latest "go-to" technology to continue the tradition of getting more "stuff" into less space.

Some might be nonplussed by the interest in 3D, asking, "How many ways can you stack a few chips?" under the impression that it's a fairly straightforward proposition. However, the truth is that the list of prospective 3D solutions presently in play is fairly extensive given the relatively limited number of technological options available to execute designs. Figure 1 was generated more than a dozen years ago in

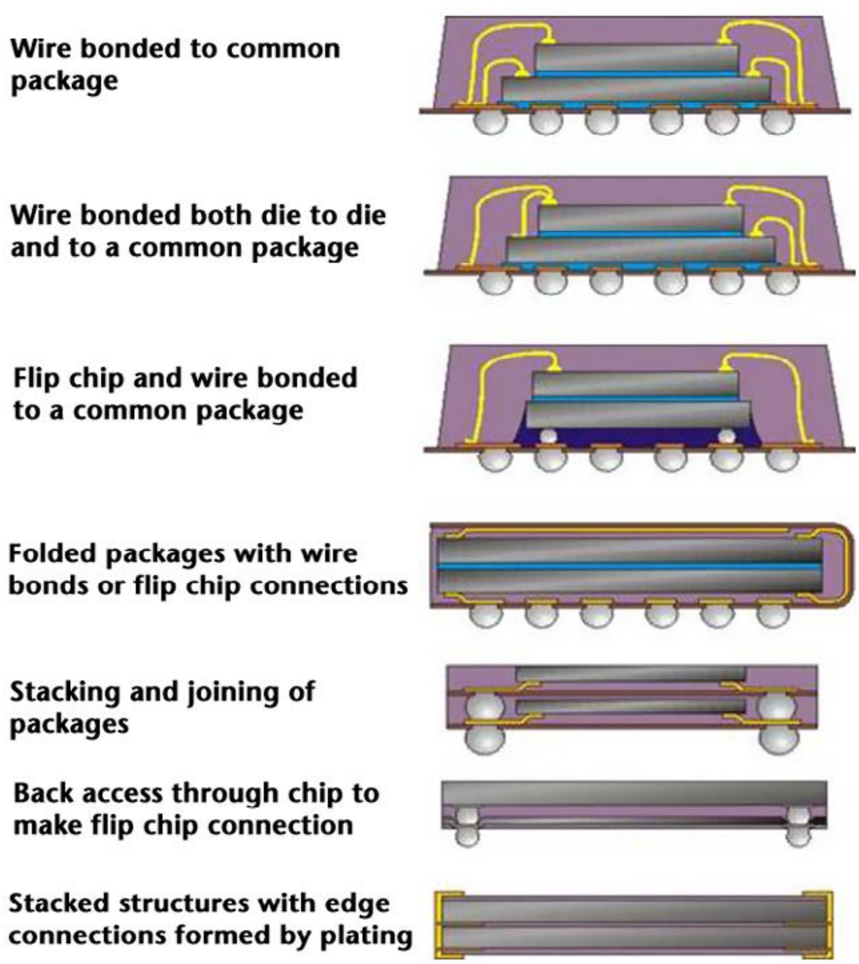

Figure 1: A fundamental and short list of options for stacking semiconductor devices.

anticipation of what might be possible in the realm of chip stacking and it generally circumscribes most of what we see in use today, though there have been some very interesting twists introduced over time which have improved the scope of opportunity in 3D. A recent example that comes to mind is the so-called 2.5D interposers whose function (which is, for all intents and purposes, 3D) is fundamentally to space transform the very fine I/O pitch chip to an I/O pitch more manageable for normal IC production assembly by means of a silicon or glass redistribution element having plated through vias.

Examining 3D Options

The present recipe book of options embraces all items illustrated in the Figure 1 chip-on-chip, package-on-package, folded assemblies, and combinations thereof. There are, for example, many chip-on-chip solutions involving chips which are interconnected by conventional wires and solder balls, as well as not so conventional conductive adhesives and inks with the devices connected to both each other and to their common substrate, which is most often and IC packaging substrate.

Much has been written in recent years on the use of TSV technology for making stacks of wafers using a mix of front end of line (FEOL) and back end of line (BEOL) manufacturing to produce vias first and vias last, which enable such applications as the stacking of memory devices and the integration of mixed technologies into a multilayer semiconductor device. Some developers have also turned to the use of packages within package assemblies to create high-performance products. These are the so-called package-in-package (PiP) 3D solutions which beneficially rely, in many cases, on wafer-level packages rather than bare chips.

Beyond the 3D solutions within the package are 3D solutions which reside at the next level of interconnection: Package-on-package (PoP). Again, PoP solutions have roots which reach far back into the history of the electronics industry. They were arguably first implemented using the iconic DIP devices (which the general public still commonly hold in their mind's eye as an image of what a chip is). The DIP was and is well suited to stacking. Trim the leads and stack one device on the shoulders of another using a slightly higher temperature solder and the task is done. Alternatively, one could also assemble the board with DIPs and subsequently use a pin-in-paste technique with a lower melting temperature solder to accomplish the same objective. More recent solutions involve packages where copper posts are used in lieu of solder balls and where packages have molded-in cavities with exposed lead terminations which accept the solder balls of the package mounted on top.

"While much attention has been given to 3D predicated on the considerable benefits it both promises and delivers, 2D may still have a few tricks up its sleeve and cards left to play if one is open-minded about the unconventional."

2D Plus

While much attention has been given to 3D predicated on the considerable benefits it both promises and delivers, 2D may still have a few tricks up its sleeve and cards left to play if one is open-minded about the unconventional. What is being referenced is the notion of placing packages and devices under other packages rather than on them with an eye to having both interconnect to a common substrate. This is not impossible, but it does require a bit of rethinking relative to what we know and believe about SMT assembly. It will also require some effort, diligence, and forethought to assure that missteps or misapplication of the concept are avoided. Limitations exist, but having another tool in the designer's tool chest relative to what might be possible is a good thing in the

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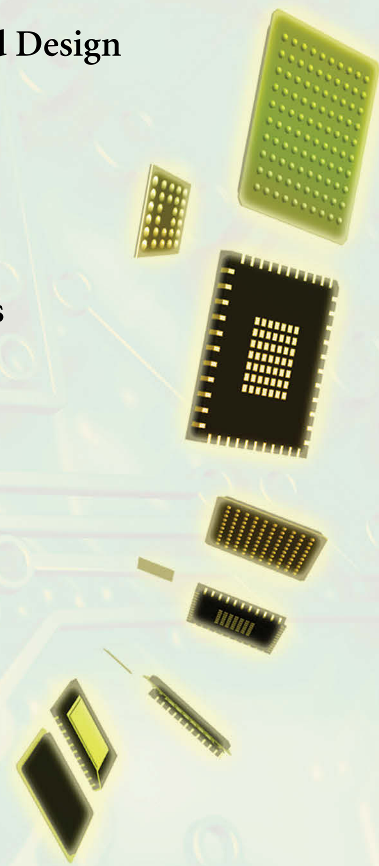

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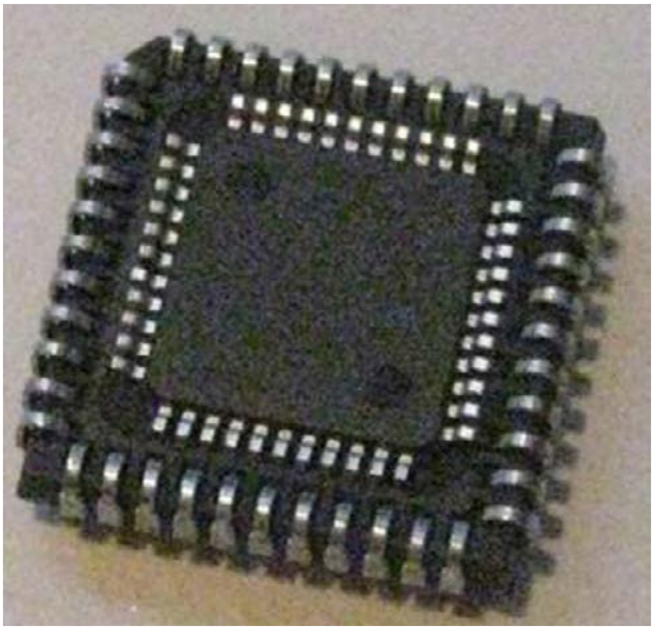

Figure 2: A 44-lead QFN fits comfortably in the cavity formed by the leads of 44 I/O J-leaded component. The adhesively mated pair of devices could be placed and soldered as a unit if desired.

effort to sustain the march of progress in electronics manufacturing.

Discrete devices can be a challenge to the electronic assembly process, especially when they have been reduced to the size of pepper specks. As they are often lower in profile that solder balls, what if they were to be placed in the shadow of a larger BGA or QFN? Discrete devices are often attached to higher performing microprocessor packages so it might be possible to take advantage of the space beneath the package. Along the same line of thinking, some legacy devices have a significant standoff height compared to many current and former generation devices and the lower height devices could sit comfortably beneath them (Figure 2). These are soldering solutions that may or may not strike fear into the hearts of manufacturing engineers, but they are conceptually feasible provided some other concerns, such as watt density, are not exceeded.

A SAFE Option

Taking the thought a bit further, into the realm of solderless assembly for electronics (SAFE) and approaches such as those embraced by the Occam Process where solder interconnections are eschewed in favor of copper-plated interconnections because of the known weaknesses and limitations of solder, the concept looks even more attractive. Figure 3 provides an example of what such an assembly might look like after manufacture using an aluminum base. Again, provided no cardinal design rules are broken, the approach could return appreciable amounts of real estate back to the designer to help meet goals and objectives. Moreover, when thermal management becomes a concern, the process allows for the use of aluminum as the substrate which can possibly ameliorate the problem in many applications.

Figure 3: Package-under-package (PuP) assembly is possible and offers unique potential to build unusual interconnection substrates. Moreover, the use of a low-cost and highly-thermally-conductive aluminum as a base is possible when solder is not employed to make package and device interconnections. Note that while only a single-sided assembly is illustrated, two-sided assemblies are possible. It is also possible to stack assemble the completed assemblies to create even higher density structures with the dimensionally stable aluminum bases potentially serving as ground and/or power layers.

Summary

The second dimension has not yet been fully exploited. The concept of package-under-package (PuP) is an extension of 2D which has the potential to deliver improved performance and space savings in certain instances without resorting to stacking of packages, yet staying within the existing solder assembly paradigm. While it may not solve every problem and address every need, it appears to have the potential to solve or address many challenges facing product developers. With respect to the possibilities in solderless applications of PuP, one challenge will be in getting component suppliers to deliver packages which have not had to endure the attachment of high-temperature solder balls or plating with precious metals. It should be less expensive due to the reduction of materials and process steps (even the solder mask on the bottoms of organic laminate package substrates is not required), but the non-standard nature of the need will likely result in an initial premium being applied until there is a predictable demand for less expensive IC package options and lower cost and more reliable electronic interconnection solutions. **SMT**

Verdant Electronics Founder and President Joseph (Joe) Fjelstad is a four-decade veteran of the electronics industry and an international authority and innovator in the field of electronic interconnection and packaging technologies. Fjelstad has more than 300 U.S. and international patents issued or pending and is the author of Flexible Circuit Technology. To contact Fjelstad, click here.

Video Interview

Automating Solder Paste Placement, Speeding Changeover

by Real Time with... IPC APEX EXPO 2013

William Crist, Apex Factory Automation's national sales manager, joins Guest Editor Susan Mucha to discuss how his company's turnkey SMT placement line solution automates solder paste measurement, speeds changeover, and supports placement of smaller components.

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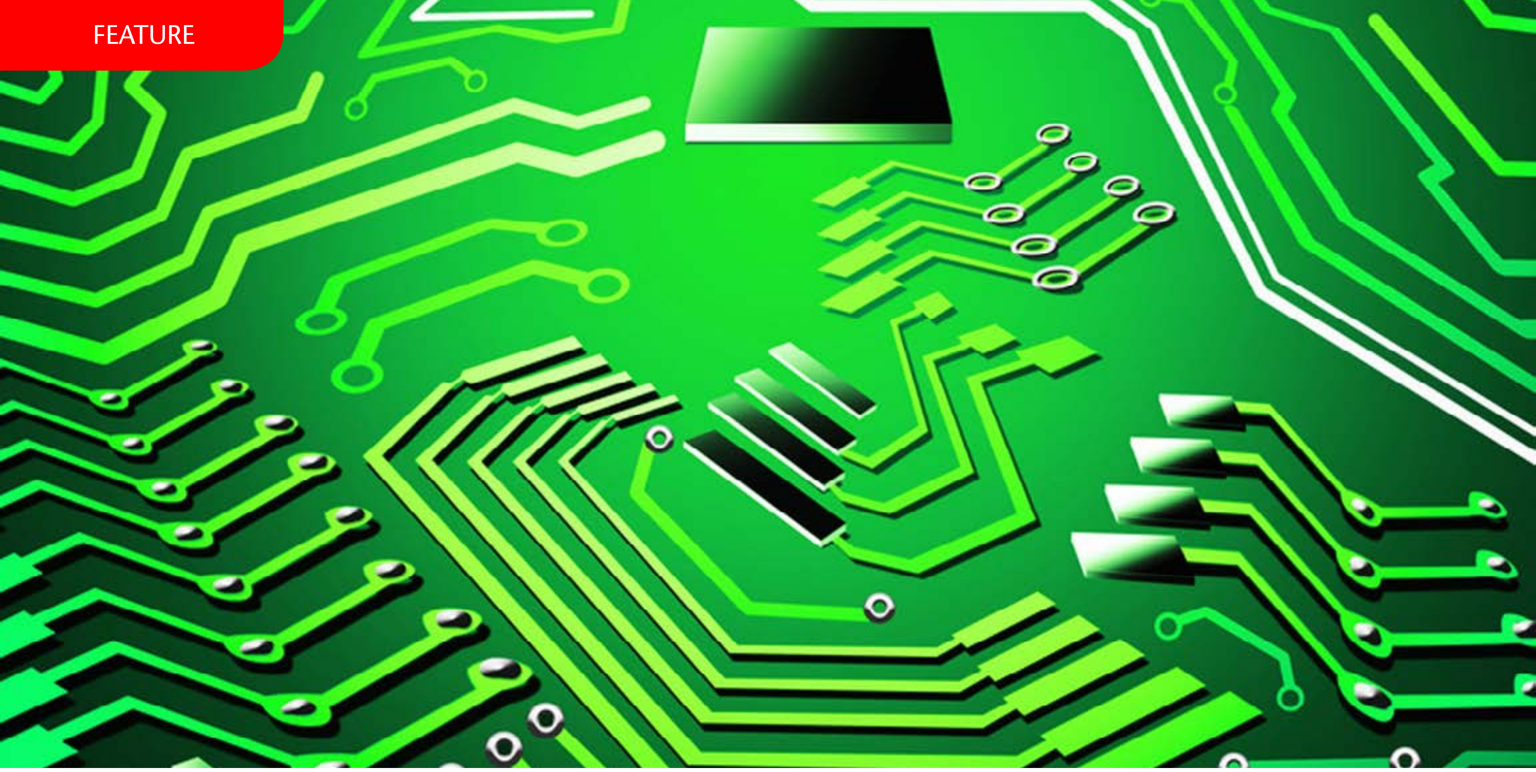

Low Surface Energy Coatings Rewrite Area Ratio Rules

by Ricky Bennett
ASSEMBLY PROCESS TECHNOLOGIES
and Eric Hanson
ACULON

SUMMARY: The need for denser and more compact devices is intensifying—a fact well known to the SMT industry. The authors of this paper focus on the relevant attributes affecting the properties of solder paste release and introduce the effects of surface free energy with respect to key elements making up the stencil printing process.

Editor's Note: This paper was originally published in the Proceedings of IPC APEX EXPO, Las Vegas, Nevada, February 28-March 1, 2012.

Abstract

Paste release characteristics are driven by the area ratio formula, which is based upon conventional stencil foil materials such as a variety of stainless steel alloys, nickel, etc. The surface energy or "phobic" characteristics of these materials are significantly greater than the newer chemistries used to coat stencils and effectively limit the conventional area ratio formula in its ability to predict transfer efficiency in ultra-fine-pitch devices.

Introduction

With today's consumer technologies driving the need for denser and more compact devices, the assembly process for surface-mounted devices has become increasingly more difficult. With the mixture of components requiring a broader range of print deposition volume, various techniques are used in an attempt to ensure consistent and appropriate paste volume is achieved.

These techniques include step etching a stencil locally on a targeted device, promoting electroformed smooth-wall nickel stencils, and laser cutting newer grade stencil materials. This paper focuses on the relevant attributes affecting the properties of solder paste release and introduces the effects of surface free energy with respect to key elements making up the stencil printing process.

Area Ratio

Increasingly, today's stencil aperture designs typically utilize the area ratio as a guideline, which is specified in IPC 7525B. A value of > 0.66 is the threshold established to ensure a high consistent release of the solder paste from the stencil, known as transfer efficiency. This is the percentage of solder paste released from the stencil aperture compared to the theoretical (not actual) aperture size.

The area ratio formula is stated as: Aperture area/Aperture wall surface.

The transfer efficiency has been generally accepted in the industry to be 80% or greater as the threshold for "good" effective solder paste deposition. We have researched available literature extensively and have been unable to establish the origin of this figure. Almost all data has been captured since the early 1990s and would have been experimented with the materials of the day, including aperture filling with unique/novel squeegee designs; paste deposition using electroform stencils with their "unique" cusps; and trapezoidal apertures due to the inherent nature of the lasers of the day.

As can be seen by the discussion that follows, there is more to this simplistic formula that affects the transfer efficiency and, therefore, a more complex formula is required to accurately determine the transfer efficiency threshold for each individual process.

Aperture Filling

The area ratio formula assumes a 100% aperture fill. Aperture fill is achieved by a combination of squeegee type (angle of attack, blade flex, etc.), print speeds, and the makeup of the solder paste being printed. Many papers on effective aperture filling have been published; however, verifying that the aperture is 100% filled prior to being released from the stencil has not been typically established.

Studies such as squeegee angle of attack, squeegee material type, edge treatments, and ultrasonic/vibrating squeegees have been tested, claiming to enhance the paste deposition/transfer efficiency. It would stand to reason that packing more material into a cavity may lead to other problems associated with the release characteristics. Forced aperture fill and/or poor gasketing with non-mask defined pads, will create a small amount of leaking of flux around the perimeter of the aperture on the contact side of the stencil. With the newer surface chemistries, the flux build up can transfer to the pad with more ease and reduce the flux build up on the stencil surface. This, in turn, will lead to less stencil cleaning wipes.

SMDP and NSMDP

Recent work has also been uncovering the effects of transfer efficiency on both solder mask defined pad (SMDP) and non-solder masked defined pad (NSMDP). From our perspective, the effects of transfer efficiency can be related to the additional surface energy derived by the SMDP versus the lack of additional surfaces by the use of NSMDP.

Surface Related Properties

The printing of solder paste via stencils onto PCB surfaces from the standpoint of surface/interface chemistry is extremely complex. Successful printing of solder paste through stencil apertures is a function of multiple different phenomena, some of which can be considered issues of surface/interface chemistry rather than bulk material properties. The following is a list of surface-related properties that can potentially have an impact on solder paste printing and adhesion to surfaces:

1. Surface chemistry of the stencil surface(s), especially the side of the stencil facing the PCB and the sidewalls of the stencil aperture.
2. Surface chemistry of the surface being printed.
3. Surface chemistry of the flux mixture.
4. Surface chemistry of the solder balls (can usually be ignored unless the particle size is <1 micron).
5. Surface tension of the flux mixture.
6. Presence of surface-active agents in the flux (reducing agents, surfactants, etc.).
7. Total contact area of the stencil surfaces with the solder paste.
8. Total contact area of the solder paste with the surface being printed.
9. Surface topography/roughness.
10. Gravity.

We should mention that when we (and others) use the term "surface free energy" to describe a particular material's surface, what we really are speaking of is its surface chemistry. Molecules and atoms interact with each other in many different ways, including covalent, ionic, hydrogen, and van der Waals-type bonding mechanisms and it is these interactions which define not only the bulk properties of materials, but also their surface properties. Attraction/repulsion of complex materials like solder paste to surfaces can be considered consequences of the relative strengths of these forces. In other words, these basic forces are also responsible for determining the surface and bulk chemical interactions of materials in general. To assist the reader in understanding how variances in surface/interface chemistry relate to printing of solder paste on PCBs, we will attempt to explain each issue separately then bring them all back together again to provide a more general guide to assist in selection of materials.

Points 1-6: Surface Chemistry

When a liquid (or semisolid) material is brought in contact with a solid surface, the interaction between these two phases will be controlled by the forces listed above; we will focus on the important considerations of these forces toward governing the interaction(s) between solder paste and various materials. An excellent guide to wetting of liquids on surfaces has been written by Gao and McCarthy [1]. Figure 1 is a schematic illustrating a basic example of solder paste being printed onto a PCB surface. As you can see, multiple forces control how solder paste behaves when being printed.

The first things to consider are the surface free energies of all the components in the system. We have used a copper pad as an example to illustrate. Estimated surface free energies of the various components in this system compared to a few low surface energy substrates are found in Table 1. An important thing to notice is that the surface free energies of both copper and stainless steel are lower than one might expect. Metal oxides typically possess surface free energies of at least 70 dyn/cm^2, however almost all surfaces exposed to a typical laboratory environment will rapidly be contaminated and the surface energy lowered as a result [2].

Metals that have been exposed to processing with organic materials—cutting fluids, etching chemicals, fluxes, fingerprints, and even plasticizers from plastic shipping containers or tape—will have even more surface contaminants present that can be difficult to remove. Most metal surfaces that have not been specially prepared will behave like a hydrocarbon as far as wetting phenomena due to the presence of these contaminants.

Since organic-based fluxes are mainly hydrocarbon-based they will readily spread out on all surfaces except those with extremely low surface free energies such as fluorocarbon-based materials. This is due to the fact that hydrocarbon-based molecules interact via weak van der

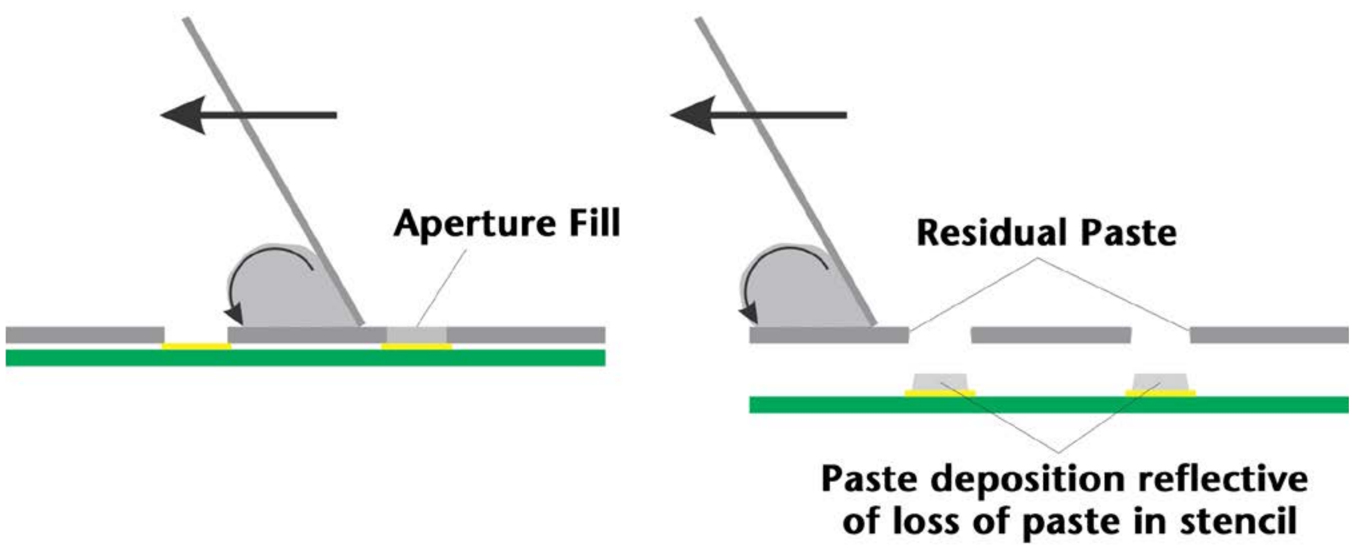

Figure 1: Illustration of solder paste being printed onto a PCB.

Substrate	Surface energy
Stainless steel (clean)	>70 dyn/cm^2
Stainless steel (contaminated*)	30-40 dyn/cm^2
Copper (clean)	>70 dyn/cm^2
Copper (contaminated*)	30-40 dyn/cm^2
Nickel (clean)	>70 dyn/cm^2
Nickel (contaminated*)	30-40 dyn/cm^2
Amine-cured epoxy	40-50 dyn/cm^2
Polypropylene	~30 dyn/cm^2
Teflon	18-24 dyn/cm^2
Fluorocarbon self-assembled monolayers	14-20 dyn/cm^2

*surface energy of contaminated surfaces depends on the nature of the contaminant(s)

Table 1: Estimated surface free energies of various components in this system compared to low-surface energy substrates.

Waals forces and are not strongly attracted to each other. Hexadecane (a decent surrogate for organic fluxes) has a surface tension of ~27 dyn/cm and will have contact angles of <10 degrees (extremely wetting) on everything from metal oxides to polypropylene. Furthermore, fluids with low surface tensions are likely to separate into droplets more readily than high surface tension fluids when force is applied to them.

Comparing the surface energies of the materials in Table 1, it can be estimated that solder paste will likely transfer to each surface similarly. While a small amount of surface transfer to the stencil apertures is not much of a problem for large openings, it becomes a significant issue when area aspect ratios drop to <0.66. So far, fluorocarbon films are the only materials on which liquid hydrocarbons will not spontaneously spread. The ability of fluorocarbons to repel other molecules rests in their extreme nonpolar behavior at the molecular scale. While the high electronegativity of fluorine compared with the relatively low electronegativity of carbon does result in a dense distribution of electron density away from the center of mass of each CF_2 segment, in perfluorocarbons (-$[CF_2]_n$-) all of the local dipoles tend to cancel out across a molecule, resulting in no net dipole [3]. Also, due to the extreme difference in electronegativity between carbon and fluorine, there tends to be a bit more resistance to creation of transitory dipolar attraction of neighboring molecules. In addition, while solder paste is far more viscous and less liquid than a simple organic solvent it should still be repelled more readily from fluorinated surfaces in comparison to untreated surfaces.

However, it is dangerous to simply use surface free energy to determine the degree of repellency of a particular surface treatment. It must be taken into consideration the nature of what materials are contacting the surface and any potential they have to chemically react or form surfactant-like layers at interfaces. Solder paste typically contains reducing agents that are used to remove surface oxides during soldering so that intermetallic contact can be made between the solder metal alloy and the PCB trace [4]. Although these reducing agents are usually formulated to react at higher temperatures they

will still react with the metal oxides at lower temperatures, albeit at lower rates. If a fluorinated surface treatment is present on the stencil surfaces, it must be stable to continuously contact with the flux's reducing agent(s) for an acceptable time; otherwise it will be etched away from the surface. This also means that in the case of a thin treatment (<1 um) the underlying metal oxides should be stable toward chemical attack by the reducing agents, as there will inevitably be pinholes present in very thin films (or molecular diffusion through the layer itself).

In some cases, surfactants are used to lower the surface tension and surface free energy of solder pastes to achieve more uniform wetting on surfaces [5]. These pose a particularly difficult problem, as surfactants can essentially defeat even fluorinated films by lowering surface energy/tension too far. Fluorinated surfactants are almost guaranteed to achieve good wetting of formulations on fluorinated surfaces. We would suggest that formulators looking to make solder pastes that print at high fidelity with surface-treated stencils may need to avoid the use of surfactants for the reasons stated above. They may also want to avoid aggressively-reducing formulations to avoid damage to the underlying metal oxide on the stencil surface.

Points 7-10: Surface Area and Gravity

Obviously, the relative contact areas of the solder paste with the stencil surfaces compared to the PCB surface is of high importance when printing small areas. Table 2 lists the relative surface areas for various packages (data reproduced from IPC 7525-B). Even in the case of the largest average aperture device, PLCC, the stencil sidewall surface area is still quite large when compared to the surface area of the print-

Part Type	Pitch	Land Footprint Width	Land Footprint Length	Aperture Width	Aperture Length	Stencil Thickness Range	Aspect Ratio Range	Area Ratio Range	Solder Paste Type
PLCC	1.25 mm [49.2 mil]	0.65 mm [25.6 mil]	2.00 mm [78.7 mil]	0.60 mm [23.6 mil]	1.95 mm [76.8 mil]	0.15 - 0.25 mm [5.91 - 9.84 mil]	2.4 - 4.0	0.92 - 1.53	Type 3
QFP	0.65 mm [25.6 mil]	0.35 mm [13.8 mil]	1.50 mm [59.1 mil]	0.30 mm [11.8 mil]	1.45 mm [57.1 mil]	0.15 - 0.175 mm [5.91 - 6.89 mil]	1.7 - 2.0	0.71 - 0.83	Type 3
QFP	0.50 mm [19.7 mil]	0.30 mm [11.8 mil]	1.25 mm [49.2 mil]	0.25 mm [9.84 mil]	[1.20 mm] 47.2 mil	0.125 - 0.15 mm [4.92 - 5.91 mil]	1.7 - 2.0	0.69 - 0.83	Type 3
QFP	0.40 mm [15.7 mil]	0.25 mm [9.84 mil]	1.25 mm [49.2 mil]	0.20 mm [7.87 mil]	[1.20 mm] 47.2 mil	0.10 - 0.125 mm [3.94 - 4.92 mil]	1.6 - 2.0	0.69 - 0.86	Type 3
QFP	0.30 mm [11.8 mil]	0.20 mm [7.87 mil]	1.00 mm [39.4 mil]	0.15 mm [5.91 mil]	0.95 mm [37.4 mil]	0.075 - 0.125 mm [2.95 - 4.92 mil]	1.2 - 2.0	0.52 - 0.86	Type 3
0402	N/A	0.60 mm [19.7 mil]	0.65 mm [25.6 mil]	0.45 mm [17.7 mil]	0.60 mm [23.6 mil]	0.125 - 0.15 mm [4.92 - 5.91 mil]	N/A	0.86-1.03	Type 3
0201	N/A	0.4 mm [9.84 mil]	0.45 mm [15.7 mil]	0.23 mm [9.06 mil]	0.35 mm [13.8 mil]	0.075 - 0.125 mm [2.95 - 4.92 mil]	N/A	0.56 - 0.93	Type 3
01005	N/A	0.200 mm [7.87 mil]	0.300 mm [11.81 mil]	0.175 mm [6.89 mil]	0.250 mm [9.87 mil]	0.063 - 0.089 mm [2.5 - 3.5 mil]	N/A	0.58 - 0.81	Type 4
BGA	1.25 mm [49.2 mil]	CIR 0.55 mm [21.6 mil]		CIR 0.52 mm [20.45 mil]		0.15 - 0.20 mm [5.91 - 7.87 mil]	N/A	0.65 - 0.86	Type 3
Fine-pitch BGA	1.00 mm [39.4 mil]	CIR 0.45 mm [15.7 mil]		SQ 0.42 mm [13.8 mil]		0.115 - 0.135 mm [4.53 - 5.31 mil]	N/A	0.65 - 0.76	Type 3
Fine-pitch BGA	0.50 mm [19.7 mil]	CIR 0.25 mm [9.84 mil]		SQ Overprint 0.28 mm [11.0 mil]		0.075 - 0.125 mm [2.95 - 4.92 mil]	N/A	0.56 - 0.93	Type 3
Fine-pitch BGA	0.40 mm [15.7 mil]	CIR 0.20 mm [7.87 mil]		SQ Overprint 0.23 mm [9 mil]		0.075 - 0.100 mm [2.95 - 4 mil]	N/A	0.56 - 0.75	Type 4

Note 1: It is assumed that the fine-pitch BGA lands are not solder mask defined.
Note 2: N/A implies that only the area ratio should be considered.

Table 2: Relative surface areas for various packages.

ed section. This should result in a significant amount of material transferred to the sidewalls of the stencil. However, gravity and a lack of opposing attractive force on the other side of the stencil opposite the printed area results in most of the solder paste being transferred correctly. As the area ratio of printed patterns begins to drop, the amount of material transferred becomes increasingly important; the generally accepted rule is that manufacturing problems begin to arise as the area ratio drops below 0.66.

Some controversy exists as to whether or not the roughness of the stencil sidewalls plays a role in determining the amount of solder paste transferred. Some solder paste will obviously be trapped in any grooves/pores on the stencil sidewalls; whether solder balls or flux alone is trapped will depend on the size of the defects versus the solder balls' diameter. A variety of techniques have been used to minimize the amount of exposed stencil surface (electro polishing, using thinner metals, more precise cutting methods); however, attention must eventually be turned to modifying the surface chemistry of the stencil by incorporating a low surface energy treatment such as a fluorocarbon film (for the aforementioned reasons).

The choice of surface treatment type and methodology to create such a surface treatment is dependent on several factors, including:

1. Three-dimensional nature of the stencil (has an impact on coating techniques used).
2. Ability to bond to metal oxides such as nickel and chrome/iron oxides (stainless steel).
3. Stability to chemical attack and physical abrasion.
4. Additional thickness imparted to the stencil apertures by the coating.
5. Flexibility/fracture toughness of the coating.
6. Slipperiness of the surface treatment (can impact performance of the solder squeegee).
7. Surface free energy of the treatment and its relation to the chemistry of solder pastes used.
8. Surface roughness of the stencil apertures (will need to be smoothed out by the surface treatment).

Currently, surfaces can be coated and insulated from the surrounding environment in a multitude of ways, but the ways in which surfaces can be rendered oleophobic are few. In this section we will attempt to explain the most relevant methods for making stencils oleophobic and the benefits/detractions associated with them. It must be noted that while true oleophobicity is a technically valid term only when the static oil contact angle of a surface is >90°, most coatings manufacturers in this arena describe materials with oil contact angles in the 60° to 70° range as oleophobic due to the fact that most surfaces have oil contact angles of <10°, resulting in a significant change in the oil repellent properties of a treated versus untreated surface.

Three general classes of surface treatments are used to modify the oleophilicity/phobicity of surfaces, including single molecular layers of fluorocarbons bound to the surface (hereinafter simply called monolayers), multilayered or oligo/polymeric fluorocarbons, and traditional organic coatings (what one would normally describe as a paint or varnish). In the next section we will attempt to compare and contrast all three approaches in consideration of the eight factors illustrated in the preceding paragraph.

Monolayers

If solution-applied, monolayers are easy to use on complex surfaces and can be readily applied from solution and work in large-scale operations unless special chemistries are used. Monolayer-based treatments can achieve some of the lowest surface free energies due to the inherent nature of these systems to form organized structures. Abrasion resistance of these treatments on stencil materials is typically good.

Two main chemistries are used to form monolayers on metal oxide surfaces: Siloxane and phosphonates. Generally speaking, the chemical stability of silicon-oxygen-metal bonds (other than Si or Sn-based oxides) are poorer than phosphonates due the fact that

Si-O-M (M = Cr, Fe, Ni, etc.) bonds are readily hydrolysed in the presence of weak acids/bases whereas P-O-M bonds are only hydrolyzed in the presence of strong base [6]. Siloxanes typically form monodentate bonds to surfaces whereas phosphonates will form bi- or tri-dentate species with most metal oxides [7], giving them even more resistance to hydrolysis. Furthermore, the overall quality of siloxane monolayers are dependent on the amount of surface hydroxyls present; most metals are in the range of 10 to 15% M-OH functionality, meaning that true monolayers of siloxanes will be inherently limited to submonolayer packing densities[8]. Phosphonate-based treatments do not suffer from this limitation due to their capability of bonding to μ-oxo (M-O-M) groups as well as metal hydroxides. Chemical bond strength of monolayer systems to the substrate is very high compared to organic coatings, though phosphonates are significantly better than siloxanes on Ni/SS due to the aforementioned issue of hydrolytic stability.

Proper cleaning of the stencil prior to coating is of critical importance, as contaminants must be completely removed, exposing metal oxide on which the monolayers can covalently bond. In a typical application, the stencils will be cleaned with a heated caustic solution, followed by rinsing then dipping into the active solution for some period of time. Phosphonate-based systems are generally tolerant to changes in operating conditions (dip time, temperature, humidity, etc.), whereas siloxanes will need careful control of the ambient environment to avoid dimerization/polymerization of active materials.

The impact of how much water is adsorbed on the stencil surface (in the 1-10 monolayer regime) will affect the end performance of siloxane monolayers; in contrast, phosphonates will be unaffected. In addition, phosphonates do not typically need a post-curing step whereas siloxanes will need a 100 to 150°C cure for up to an hour, depending on the siloxane used. Monolayer-based treatments are an optimal choice for very low aperture sizes (they will only narrow the apertures by 2 to 5 nm) where print quality is critical yet cost per coated stencil is of some concern.

Multilayered Surface Treatments

Typically, these types of treatments are only applied via vacuum-based techniques as they are very difficult to apply homogenously on complex surfaces from solution. They are generally derived from multifunctional reactive silanes/siloxanes [9] and require control of surface water content, deposition rate, substrate temperature, etc. and therefore need tight process monitoring to be performed successfully. Flexibility can be an issue, as these systems are heavily cross-linked to achieve good surface coverage. Cost and manufacturing speed are obvious weak points when vacuum-based systems are used due to the batch-wise nature of the process and the rather expensive equipment needed. If performed correctly, they can have very low surface energy, moderate chem/abrasion durability, and a small impact on aperture narrowing (typically in the 50 nm thickness range). Adhesion of these treatments can be difficult to achieve without developing a system for priming the surface. Proper cleaning of the stencil prior to coating is extremely critical to achieving a good quality treatment for the same reasons outlined for monolayers. Overall, these may be equivalent performance to solution-based monolayer systems, but with significant added cost.

"Flexibility can be an issue, as these systems are heavily cross-linked to achieve good surface coverage. Cost and manufacturing speed are obvious weak points when vacuum-based systems are used due to the batch-wise nature of the process and the rather expensive equipment needed."

Organic (Thick) Coatings

More traditional organic (thick) coatings can be difficult to homogenously apply to complex surfaces due to the difficulty of preparing <1

um thick polymer coatings. A classic example of this type of treatment would be the Teflon® coating applied too cookware. These types of treatments typically have very good adhesion, chem/abrasion stability and flexibility. However, they will have higher surface energies than monolayers/vacuum coatings and can easily clog small apertures. Any roughness on the stencil surface should be homogenized by the thicker coating, allowing for some benefit in reducing adhesion of solder paste to stencil sidewalls that have been roughened during cutting. There are potential issues with some coating particulates flaking off into the solder paste over time as the coating ages. The use of thicker organic (polymer) treatments is probably the best choice for ultra-high throughput, medium-large aperture size (>0.66 area ratio) stencils.

In all three cases, post-analysis can be performed through contact angle goniometry, as well as more traditional coatings testing procedures (hardness, cross-hatch/tape peel, etc.), though to get a more accurate measure of the properties of the last few nanometers at the surface of a treatment it is necessary to use surface-sensitive analytical techniques such as X-ray photoelectron spectroscopy, specular reflectance infrared spectroscopy, and other similar techniques. Since contact angle goniometry is (rather unfortunately) used by many as an analytical method to give pass/fail ratings to oil and water repellent treatments, we believe it is necessary to provide readers with some advice on using such measurements to 'define' a specific surface or coating.

> ***"An instrument capable of performing X-ray photoelectron spectroscopy (one of the best surface analysis techniques) is usually $100,000+ whereas a basic contact angle goniometer can be purchased for less than $10,000. The comparatively low cost and technical skill required to perform contact angle goniometry are likely the main reasons why this technique is by far more widely used than any other technique for characterization of nanometer-scale films."***

Contact Angle Goniometry: A Brief Warning

Precious few methods exist to analyze ultrathin films on surfaces; most of the available techniques for characterization of nanometer-scale films are very expensive. An instrument capable of performing X-ray photoelectron spectroscopy (one of the best surface analysis techniques) is usually $100,000+ whereas a basic contact angle goniometer can be purchased for less than $10,000. The comparatively low cost and technical skill required to perform contact angle goniometry are likely the main reasons why this technique is by far more widely used than any other technique for characterization of nanometer-scale films.

The use of contact angle goniometry, which is characterization of a (typically) solid surface by measuring the contact angle of droplets of various fluids (predominantly water) on it can be a very useful tool to experienced practitioners, however it is also a technique that is rife with misunderstandings, poor experimental design, and misinterpreted results. We have observed time and time again that using only static water or oil contact angles to associate a specific performance metric of soil-repellent films can be problematic. We do continue to use oil and water contact angles as a method for comparing treatments or process improvements to treatments, however, only in the case where the substrates have been from the exact same piece of metal (typically we use many small pieces cut from a larger panel) and the treatment processes have been previously standardized using more careful analytics on model substrates. Otherwise, the true best method to compare different coatings or different coating methodologies is best carried out by preparing samples and testing them in their actual intended application. For more information on the topic of wetting and surfaces, we once again direct the reader to the excellent surface wetting primer by Gao and McCarthy [1].

Conclusion

The purpose of this paper is to break down the components of the stencil system and to highlight and understand the phenomenon of interacting surface free energies. Solder paste printing clearly has an intense set of complex interacting parts that does not lend itself to having one fix for all. From a stencil-specific perspective, stencil materials and surface treatments will play a vital role in successful deposition control, especially with the surface mount assemblies that have greater densities of miniaturized components.

From our perspective, as stencil aperture size decreases, the importance of addressing the issue of surface energy becomes more critical. At the moment, fluorocarbon-based surface treatments are the best method to reduce surface energy, and therefore soiling of the stencil surfaces by solder paste fluxes. Of these treatments, we believe that monolayers of phosphonate-based treatments are likely the optimal balance of performance and cost (from the considerations described above) and the fact that the innate thinness of these treatments creates very few risk factors (they do not appreciably crack or leach into paste and if they are damaged there will be no change to the aperture sizing).

The use of the area ratio formula is basic in its approach to understanding deposition capabilities. Highlighting the complexities of the various interacting surfaces and their levels of wetting/repellency to the solder paste, more studies will be needed to establish a true formula that will take into consideration the variables. **SMT**

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Ricky Bennett has been developing innovative technologies for over 30 years in aerospace and surface mount technology. He has predominantly focused on the stencil printing process and is considered the world-leading expert in this field—meeting the challenges of future demands for overall efficiency and enabling solutions for problems deemed impossible. Bennett continues to innovate and his recent product developments are changing the rules once again.

Eric Hanson is a co-inventor of Aculon's underlying science and was responsible for developing the company's Nanoclear self-assembled monolayer surface treatment for stencils. Hanson discovered the science behind many of core patents and leads his company's technology development. He has been working in the field of surface/interface chemistry for over 10 years and has a Ph.D. in Chemistry from Princeton University.

In Pursuit of the Perfect Cover Tape

by James T. Adams
3M ELECTRONIC SOLUTIONS DIVISION

SUMMARY: When it comes to tape-and-reel packaging, no flawless solution exists for sealing components into carriers. However, a newer breed of cover tape approaches perfection.

Choosing the right cover tape for tape-and-reel packaging of electronic components can present a challenge. Two types of cover tapes are commonly used with embossed carrier tapes today: Heat-activated adhesive (HAA) cover tapes and pressure-sensitive adhesive (PSA) cover tapes.

Both types have served the electronics component and PCB manufacturing industries well for decades. They still have their place, but more choices are often needed for today's smaller components.

Heat-activated adhesives may peel unevenly. With very small components, inconsistent peels may result in component migration induced by vibration as the tape is peeled back in feeders during carrier advancement at board assembly, contributing to mis-picks, assembly downtime, and yield loss. Pressure-sensitive adhesives offer a smoother peel, lessening the likelihood of mis-picks, but they tend to adhere to assembly equipment, potentially leading to machinery failures if proper maintenance is not performed on the machines.

Recent innovations in cover tape design have virtually eliminated many of the challenges associated with traditional products. A newer cover tape, called universal cover tape because it can be used with a majority of carrier tape materials and most sealing and feeder equipment, is designed to solve many of the issues associated with HAA and PSA tapes. Universal cover tape is engineered so that only the

Figure 1: Universal cover tape is engineered so that only the middle portion is removed from carrier tape during assembly.

middle portion is removed or pulled from carrier tape during assembly by a uniform peeling action. The edges, which are adhered to the carrier tape, remain in place. The result is an exceptionally smooth, consistent peel force with narrow ranges and controlled variability. Moreover, the adhesive is not exposed to assembly equipment, virtually eliminating the risk of adhesive transfer.

Traditional Cover Tape Technology

HAA cover tapes are the most widely used cover tapes in the electronic component manufacturing industry. The entire surface of one side of the tape's film backing is coated with a primer and adhesive, providing the user the choice of the seal width and location. In the taping process, a heated sealing shoe presses the tape onto the edges of the carrier tape where adhesion is desired, sealing the cover tape onto the carrier and leaving the component free of active adhesive.

HAA cover tapes can be reliable for larger components. However, the tapes' relatively wide peel force range compared to more advanced cover tapes prompted manufacturers of very small components to seek alternatives. A wide peel force range may result in inconsistent de-taping during the pick-and-place process at the assembly plant. Inconsistent de-taping may cause tiny components to pop out of the carrier tape (a phenomenon referred to as trampolining), leading to mis-picks and assembly line downtime.

Cover tapes made with pressure-sensitive adhesive appeared on the market in the 1990s. PSA tapes generally exhibit tighter peel force ranges, meaning a smoother peel off of the carrier. Therefore, they can reduce the incidence of chip migration and mis-picks due to vibration during the cover tape peeling process, particularly for very small components.

PSA adhesive is a synthetic adhesive formulated to remain tacky over a wide range of temperatures, including room temperature. Hence, PSA cover tapes do not require heat to seal them to the carrier and, with no process window to worry about, equipment setup procedures are simplified. PSA tapes will adhere to most acceptable surfaces with the application of suf-


Aqueous
Technologies
AqueousTechnologies.com
Clean
TRIDENT XLD
Example Recipe 2
Ready for New Load
START
SHUTDOWN

ficient pressure to bring the two surfaces into intimate contact.

Because the adhesive is tacky at room temperature, PSA tapes require some caution when used with pick-and-place feeders. Care must be taken not to allow the exposed adhesive to contact stationary surfaces, such as guide pins or pinch rolls, to help prevent adhesive transferring to and gumming up machinery. Using equipment coated with a low-surface-energy material and periodic cleaning with isopropyl alcohol can help prevent adhesive transfer.

A Better Solution for Shrinking Components

HAA and PSA cover tapes continue to reliably serve the electronics components industry. However, as components shrink in size, the industry is searching for new alternatives. Among the needs expressed by PCB manufacturers are:

- Tighter peel ranges with less variability.
- Elimination of adhesive transfer to sealing and feeder equipment.
- Reduced component migration during cover tape removal from carrier.
- Address future small component packaging needs.
- Improved yields associated with pick-and-place equipment operations.

Universal cover tape was developed to address such needs.

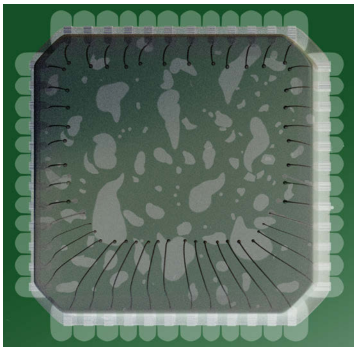
A high-performing cover tape must strike a balance between adhesion strength and smooth de-taping. The adhesive must be strong enough to prevent delamination and the minimum risk of components spilling out of the carrier. On the other hand, it must be removed easily enough to minimize vibration-induced chip mis-picks. The smoother the tape peeling operation is on a feeder, the less likely it is that components will rotate within the carrier cavity or catapult from the carrier as the tape is peeled. Smooth peeling is accomplished by narrow peel force ranges.

Universal cover tape takes the adhesive out of the peel force range equation. This marks a radical departure from HAA and PSA tapes. Universal cover tape is applied using a pressure-sensitive adhesive. However, once the cover tape is applied it does not leave the carrier, so the risk of adhesive transfer is virtually eliminated.

With HAA and PSA tapes, the entire cover tape lifts off the carrier during de-taping. With universal cover tape, only the middle portion is removed. The portion with the adhesive remains on the carrier tape edges. The tape's peel-initiation feature allows it to tear effortlessly from the carrier along a straight line. The tearing action produces an exceptionally tight peel force range, resulting in an ultra-smooth peel. A typical HAA tape exhibits a peel force range above 30 grams. The peel force range of PSA tapes generally fall below 30 grams. Universal cover tape typically exhibits a peel force range below 15 grams.

Universal cover tape combines the desirable features of HAA and PSA cover tapes and improves on them. A simplified process window makes application easy and low risk for the component manufacturer. An exceptionally smooth peel is generally considered to reduce the risk of mis-picks and assembly line failures for the PCB manufacturer. Tape-and-reel packaging users dealing in very small, thin components need a high-performing cover tape. Choosing a universal cover tape may help them achieve their goal of failure-free pick-and-place operations. **SMT**

James T. Adams joined 3M in 1979 and has more than 30 years of experience in various businesses, including magnetic media, telecommunications, and electronics. Adams specializes in establishing design criteria for packaging various surface mountable components and/or subassemblies into tape and reel, problem solving, technical marketing, and troubleshooting the complex equipment used in the electronics industry. Other areas of specialization include data transmission, contact resistance, ESD, and technical writing. He is also a member of the Electronic Industries Association/Automated Component Handling (EIA/ACH) and International Electrotechnical Commission, IEC standards committees.



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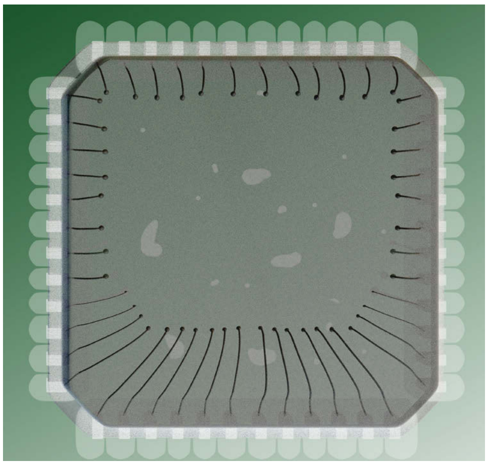

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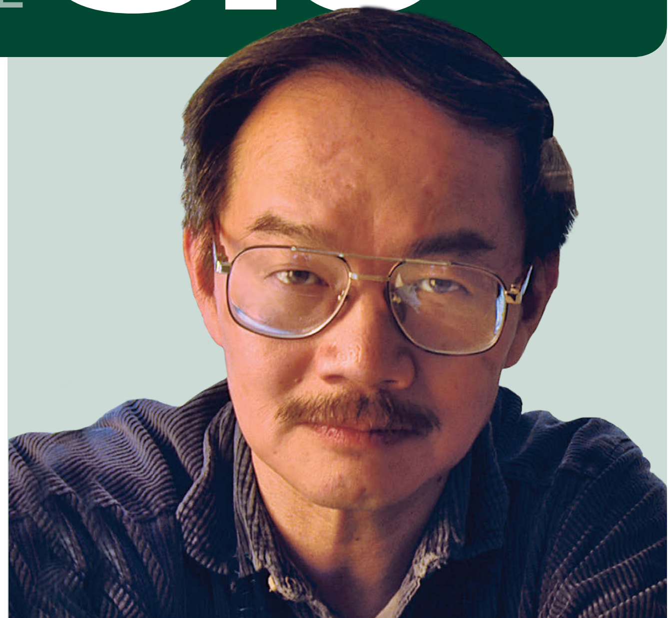

Top Ten Market News Highlights

DRAM Market Beats Seasonal Slowness in Q4

The dynamic random access memory (DRAM) market overcame seasonal slowness and returned to growth in the final quarter of 2012, helped by the strong performance of SK Hynix after the South Korean supplier expanded to its largest market share ever, according to an IHS iSuppli DRAM Dynamics brief.

Smart Grid Technology Market to Grow $73B by 2020

According to a new report from Pike Research, a part of Navigant's Energy Practice, the market for smart grid technologies will grow from $33 billion annually in 2012 to $73 billion by the end of 2020, totalling $494 billion in cumulative revenue over that period.

Qualcomm Leads Cell Phone Core IC Market

In the market for application-specific mobile handset core ICs like baseband and radio-frequency semiconductors, Qualcomm in 2012 reigned supreme with 31% market revenue share, according to the IHS iSuppli Wireless Competitive Landscape Tool from information and analytics provider IHS.

February Manufacturing ISM Report: PMI at 54.2%

Bradley J. Holcomb, chair of the Institute for Supply Management Manufacturing Business Survey Committee, states, "The PMI registered 54.2%, an increase of 1.1 percentage points from January's reading of 53.1%, indicating expansion in manufacturing for the third consecutive month. This month's reading reflects the highest PMI since June 2011."

OE Automotive Semiconductor Market Up 12% in 2012

According to the latest analysis by Semicast Research, Renesas Electronics was again the leading vendor of semiconductors to the OE automotive sector in 2012, ahead of Infineon Technologies. STMicroelectronics retained its position as third largest supplier, with Freescale fourth and NXP fifth. Semicast calculates that revenues for OE automotive semiconductors grew by 12% to $25.5 billion in 2012, while the total semiconductor industry is judged to have declined by almost 3% to $292 billion.

Global Utility Smart Grid Spending Up 48% in 2012

Spending by utilities transitioning their networks to smart grid capabilities reached $23.68 billion in 2012. Highlighting the growing momentum behind the spending, 2012's total alone represents 48% of smart grid spending to date. During the year, spending on transmission and distribution capabilities surpassed smart meter investments as utilities increasingly looked to improve their core networks and maximize the benefits of their growing Advanced Metering Infrastructure (AMI) deployments.

Global Semi Equipment Sales to Reach $36.9B in 2012

SEMI, the global industry association for companies that supply manufacturing technology and materials to the world's chip makers, has reported that worldwide sales of semiconductor manufacturing equipment totalled $36.93 billion in 2012, representing a year-over-year decrease of 15%. The data is available in the Worldwide Semiconductor Equipment Market Statistics (SEMS) Report, now available from SEMI.

Global Economy to Grow 2.6% in 2013

Although emerging markets led by the Asia-Pacific region should grow strongly this year, much of the developed world has been dragged lower by the downturn in the Eurozone. The modest growth in the U.S. economy is at risk due to automatic budget cuts implemented in early March.

A Challenging Economic Outlook Remains

The Manufacturers Alliance for Productivity and Innovation Quarterly Economic Forecast predicts that inflation-adjusted gross domestic product will expand by 1.8% in 2013 and by 2.8% in 2014, showing no change from the November 2012 report. Manufacturing production, however, is expected to show growth of 2.2% in 2013 and 3.6% in 2014.

CEOs Optimistic About Prospects in China

Despite the belief that the global economy will grow in the next two years, confidence is an issue, with 64% of respondents saying that they were "very" or "somewhat" confident that growth would return to previous high rates, a decline of 21 percentage points from the last survey in October.


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Bob Opeka, BAE Systems
ii-Feed is the newest tape feeding solution for Europlacer machines.
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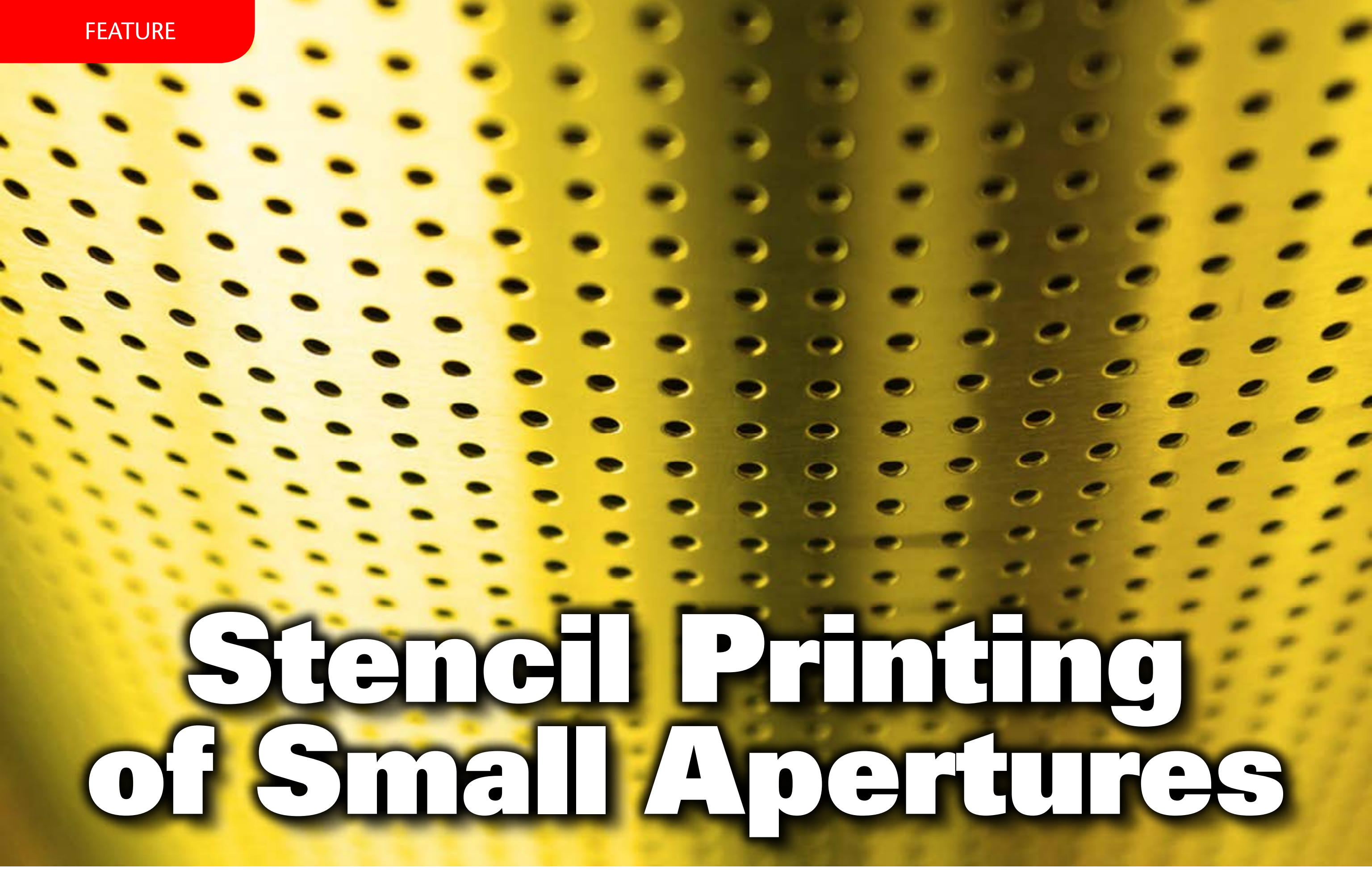

Stencil Printing of Small Apertures

by William E. Coleman Ph.D.
PHOTO STENCIL

Summary: Stencil technologies and aperture wall coatings are examined to determine how these parameters influence paste transfer for miniature devices with area ratios less than the standard recommended lower limit of 0.5.

Editor's Note: This paper was originally published in the Proceedings of IPC APEX EXPO, Las Vegas, Nevada, February 28-March 1, 2012.

Many of the latest SMT assemblies for handheld devices present a challenge to process and manufacturing engineers with the introduction of miniature components such as 0.3 mm CSP and uBGA devices, as well as 0201 and 01005 chip component devices. Printing these miniature devices along with more conventional SMT devices like 0.5 mm QFPs and 0603 and 0805 passives, in addition to RF shields is a challenge. Whereas a 4 mil (100 micron) or 5 mil (125 micron) thick stencil provides good paste transfer for the normal SMT devices, stencils with this thickness have very low area ratios for the miniature devices. For example, a 0.3 mm CSP with a 7.5 mil (190 micron) has a 0.47 area ratio for a 4 mil thick stencil.

This paper will examine stencil technologies (including laser and electroform) and aperture wall coatings (including nickel-Teflon coatings and nano-coatings) to determine how these parameters influence paste transfer for miniature devices with area ratios less than the standard recommended lower limit of 0.5. A matrix of print tests will be utilized to compare paste transfer and measure the effectiveness of the different stencil configurations. Area ratios ranging from 0.32 to 0.68 will be investigated.

Introduction

SMT assembly is faced with a common challenge. As components get smaller and smaller, it is difficult to print solder paste to satisfy both components. On the one hand, large components require more solder paste volume for sufficient solder fillets after reflow. If this same stencil is used to print paste for small components the apertures are so small that poor paste release is encountered (Figures 1 and 2). The print process can be divided into two processes:

The aperture fill process and the paste transfer process.

Figure 1 shows the thick stencil. Both the large and small apertures have good paste fill. The large apertures have good paste transfer, but the small apertures do not. The result is good fillets resulting in a good solder joint after reflow for the large apertures, but insufficient paste volume for the small apertures due to poor transfer, resulting in dry solder joints.

Figure 2 shows the thin stencil. As before, both small and large apertures have good paste fill and both have good paste transfer. However, there is insufficient solder paste volume for the large aperture resulting in a poor fillet and lean solder joint. On the other hand, there is sufficient solder paste volume for the small components to form good fillets and good solder joints after reflow. The area ratio plays a large part in this dilemma. The paste transfer process can be considered a tug of war. The area under the stencil aperture is trying to pull the solder paste out of the aperture, but the aperture walls are trying to hold the paste inside the aperture. The more wall area, when compared to the area under the aperture, the more difficult it is for the paste to be pulled free from the walls.

The area ratio is defined as the area of the aperture walls divided by the area beneath the aperture opening. An area ratio matrix for small components is shown in Figure 3. The acceptable area ratio for 80% paste transfer is typically 0.5 for stencils with smooth aperture walls. As seen for 01005 and 0.3 mm CSP components, the stencil thickness would need to be 62u (2.5 mils) to achieve acceptable paste transfer. This is too thin a stencil for normal SMT devices. Typically a stencil of at least 100u (4 mils) is required for boards having normal SMT components. If 01005 or 0.3 mm CSP components are populated on a SMT board with normal SMT components a 100u (4 mil) thick stencil would need to provide acceptable paste transfer at area ratios of 0.38 to 0.44.

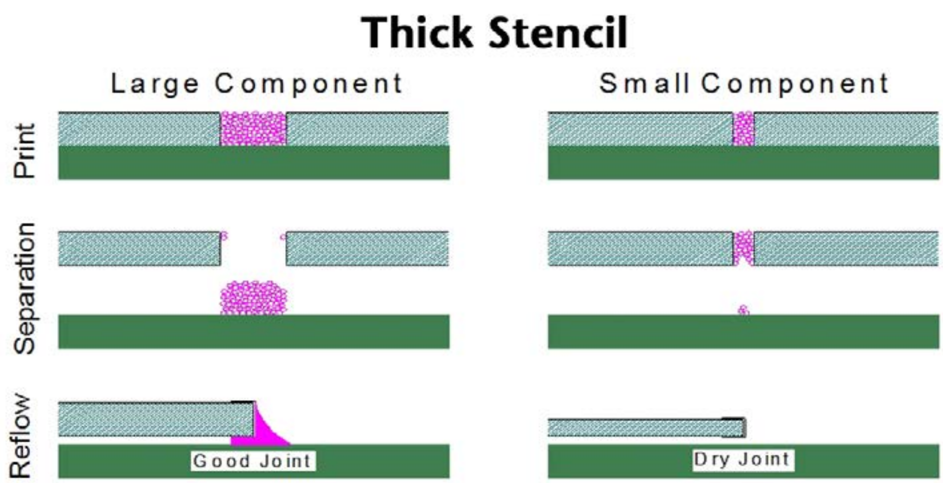

Figure 1: Both large and small apertures on the thick stencil have good paste fill.

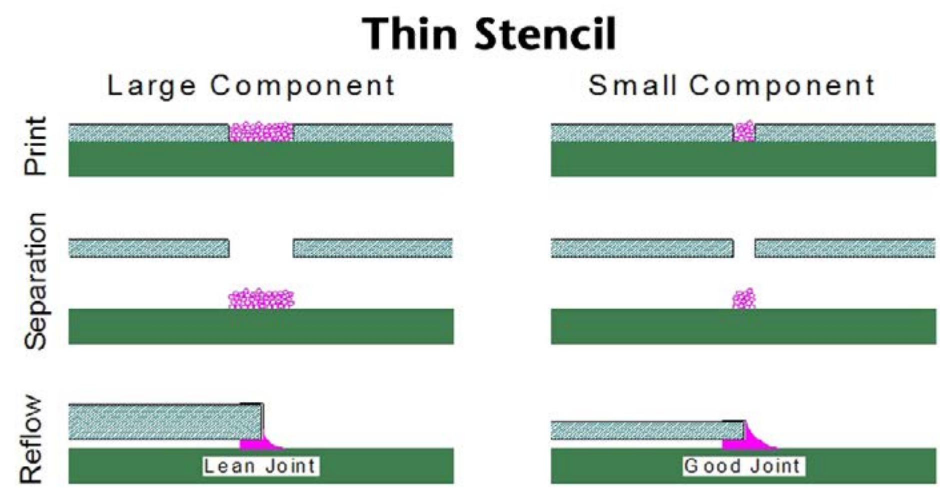

Figure 2: The thin stencil shows insufficient solder paste volume.

Background

What are the possible stencil solutions to resolve this problem? One possible solution is to

Component and typical Aperture Size ↓	Stencil Thickness →					
	2 mil 50u	2.5 mil 62u	3 mil 75u	3.5 mil 87u	4 mil 100u	5 mil 125u
01005						
6 mil (150u)	0.75	0.60	0.50	0.43	0.38	0.30
7 mil (175u)	0.88	0.70	0.58	0.50	0.44	0.35
.4mm CSP						
6 mil (150u)	0.75	0.60	0.50	0.43	0.38	0.30
7 mil (175u)	0.88	0.70	0.58	0.50	0.44	0.35
8 mil (200u)	1.00	0.80	0.67	0.57	0.50	0.40

Green = OK Orange = Warning Red = Stop

Figure 3: Area ratio matrix for small components.

use step stencils when the small device apertures are in an area where the stencil is thin and the large device apertures are in an area with a thicker stencil: A step stencil having two thicknesses [1]. According to IPC design guidelines 7525B there should be 0.89 mm (0.035") keep-out between the step down and the aperture in the step down area for every 0.025 mm (.001") of step height. Normally, sufficient spacing does not exist on many SMT assemblies having very small components and normal SMT components to allow this much keep-out.

Another possible solution is a two-print stencil process. In this process all the small component apertures are placed in a thin stencil where good paste transfer is expected. The other component apertures are placed in a thicker stencil to provide sufficient paste volume. This stencil has relief pockets etched or formed anywhere there is a first print stencil aperture. The print sequence is a two-print sequence; print with the thin stencil and while the paste is still tacky print with the second stencil. The relief pockets prevent paste smearing of the first print. Using this technique a keep-out of 380u (0.015") was achieved without smearing of the first print [2]. In this study, the first stencil had a thickness of 50u (0.002") and the second stencil had a thickness of 125u (0.005") and a relief pocket of 75u (0.003").

Another approach to resolve the dilemma of printing small and large devices is to improve the printing process by improving the paste transfer for low area ratios. The measure of improvement is to be able to achieve acceptable paste transfer volumes and minimum paste volume variations for area ratios less than 0.5. Many processes are involved in the paste printing process: Squeegee blades, squeegee speed, squeegee angle, separation speed, vibration while the paste is separating, vibrating the squeegee blade during the print stroke, positive air pressure applied while paste is separating, solder paste, and, finally, the stencil. Several recent publications have addressed the issue of improving the print performance at lower area ratios [3-7]. The present study will address the stencil only.

Scope of Study

Five stencils were included in this study:

A – electroformed stencil;
B – electroformed stencil with nano-coat;
C – laser-cut stencil;
D – high-precision chem-etch stencil with nickel-Teflon plating; and
E – electroformed stencil with nickel-Teflon plating.

All stencils were 100u (0.004") thick and all had same apertures ranging from circles 100u (0.004") up to 500u (0.020") in size. The area ratios ranged from 0.375 up to 1.250. The electroform and laser stencils were made with a normal stencil manufacturing process. The chem-etch

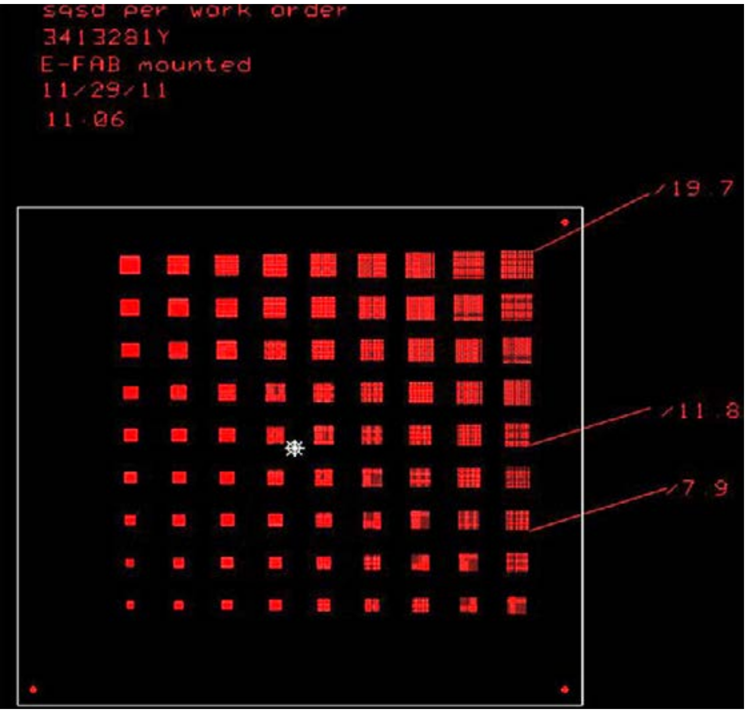

Figure 4: Stencil layout for this study.

stencil was made with a special high-precision etching process [8]. The nano-coat was a standard coating applied to contact side and inside aperture walls, but not on the squeegee side. The nickel-Teflon plating was applied to the contact side and aperture wall, but not to the squeegee side. The coating is 5u (0.0002") thick and was electroplated onto the stencil. The stencil layout is shown in Figure 4. The printing was performed at Speedline using a Momentum printer. The printer set-up was as follows:

- Printer: Accela
- Speed: 50 mm/sec
- Print gap: 0
- Print sequence: 20 boards with wipe after each print
- Squeegee blade: 200 mm Speedline OEM blade
- Pressure: 7 kgm
- Paste volume: Koh Young

Solder paste volume and solder paste volume standard deviation was measured for all aperture sites on the stencil using a Koh Young solder volume measuring tool. In addition, solder paste height and area, as well as the standard deviation of each, was measured. Charts showing these measurements for five different aperture sizes: 150u (0.006"), 200u (0.008"), 250u (0.010"), 300u (0.012"), and 400u (0.015") are shown in Figures 5-9.

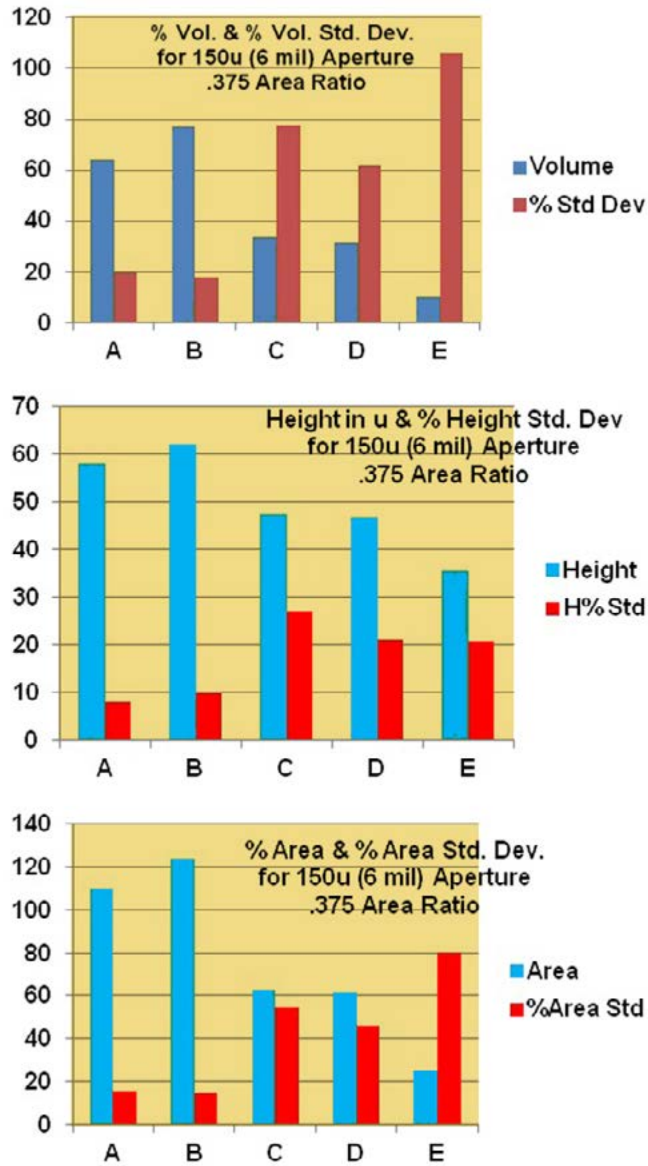

Figure 5: Results for the 150u (0.006") aperture.

Figure 5 shows the results for the 150u (0.006") aperture. Stencil B gave the highest volume and lowest standard deviation for volume, also the highest height and largest area.

Figure 6 shows the results for 200u (0.008") aperture with 0.5 area ratio. The definition of acceptable paste volume transfer and percent of

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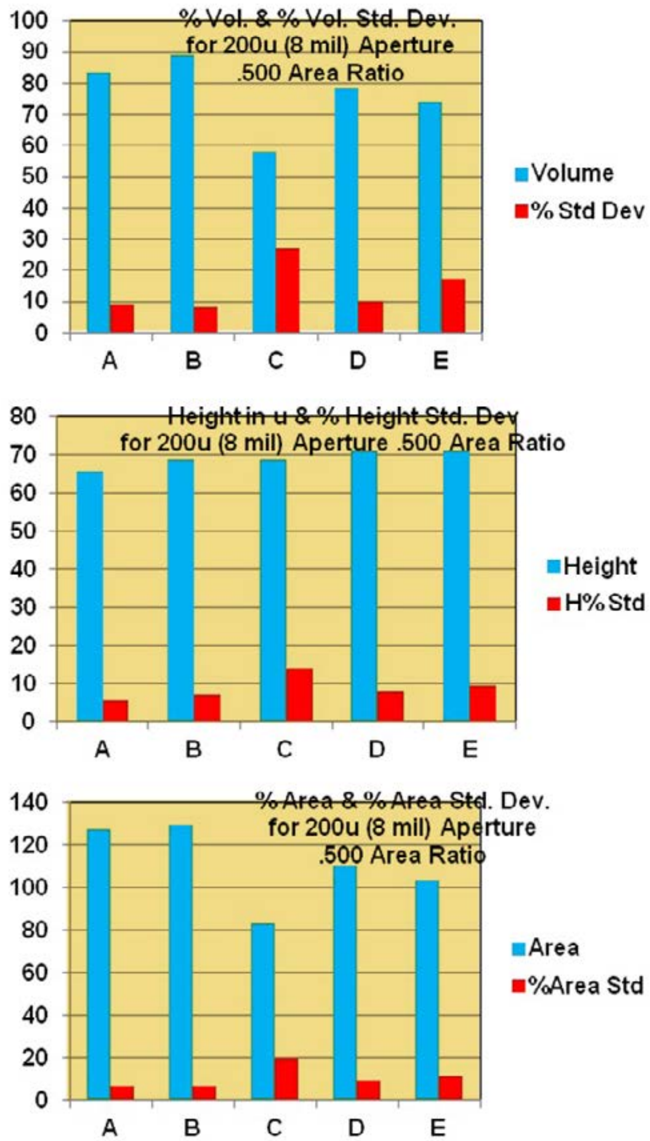

Figure 6: Results for the 200u (0.008") aperture.

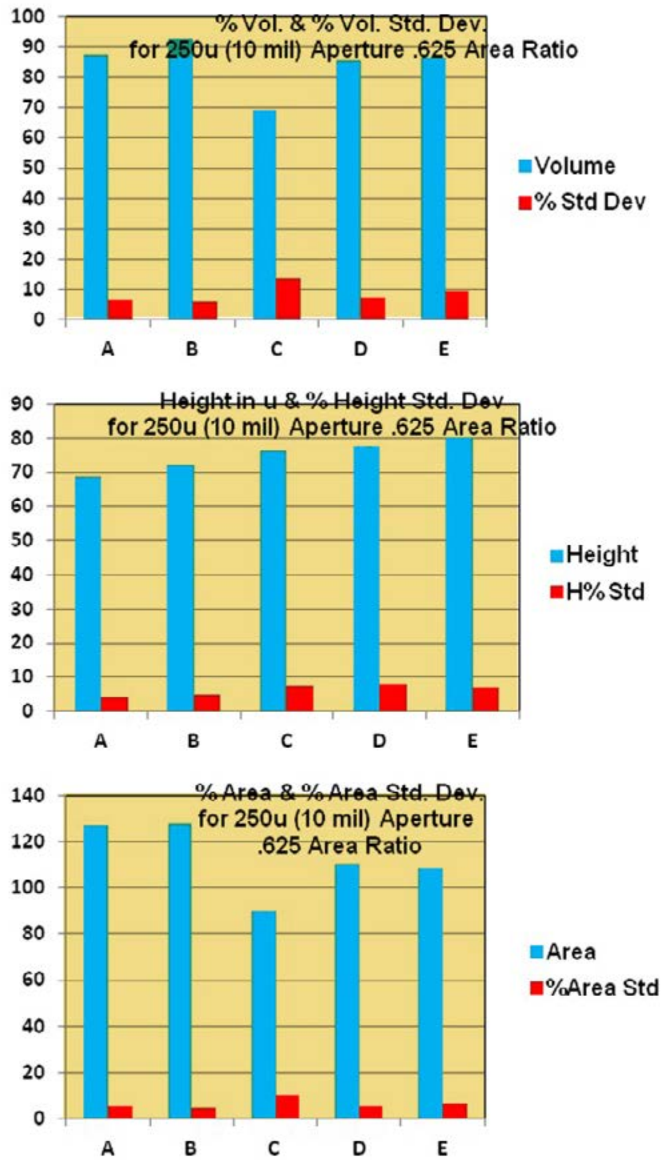

Figure 7: Results for the 250u (0.010") aperture.

volume paste standard deviation is somewhat arbitrary, but it is assumed here that the acceptable range is >80% transfer and <15% Standard Deviation. Both electroform stencils provide acceptable performance at a 0.5 area ratio. Unfortunately, there is not a test point between 0.375 and 0.500 area ratio. However, in reviewing Figure 5, it is seen that stencil B is close to having acceptable performance at an area ratio of 0.37. By extrapolation, an estimated acceptable area ratio of somewhere around 0.42 can be assumed. It is interesting to note that the paste heights are very similar, ranging from 65u to 71u.

Figure 7 shows results for a 250u (0.010") aperture with a 0.625 area ratio. Here there are an additional two stencils with acceptable paste transfer; HP chem-etch and electroform, both with nickel-Teflon coating. The laser-cut stencil still only has 68% paste transfer although the % standard deviation is below 10%.

Figure 8, with an area ratio of 0.875 shows the laser-cut stencil just slightly below the acceptable paste transfer criteria.

Figure 9 shows all five stencils with acceptable paste transfer with an area ratio of 1.000. In reviewing all five of the last figures it is of in-

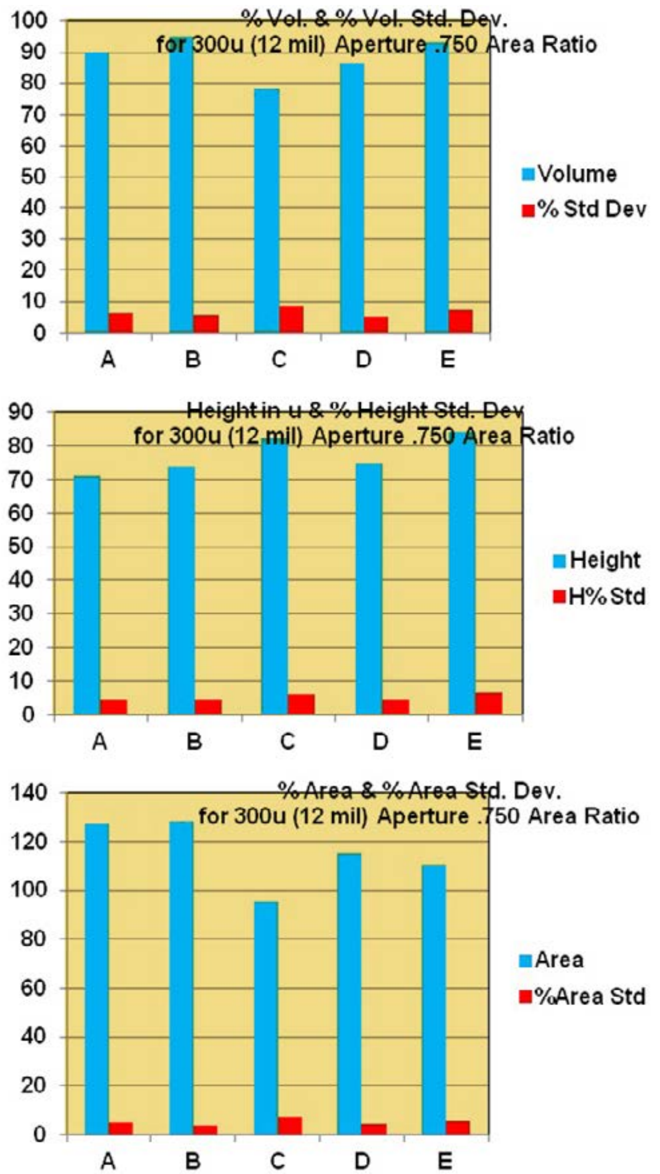

Figure 8: The laser-cut stencil just slightly below the acceptable paste transfer criteria.

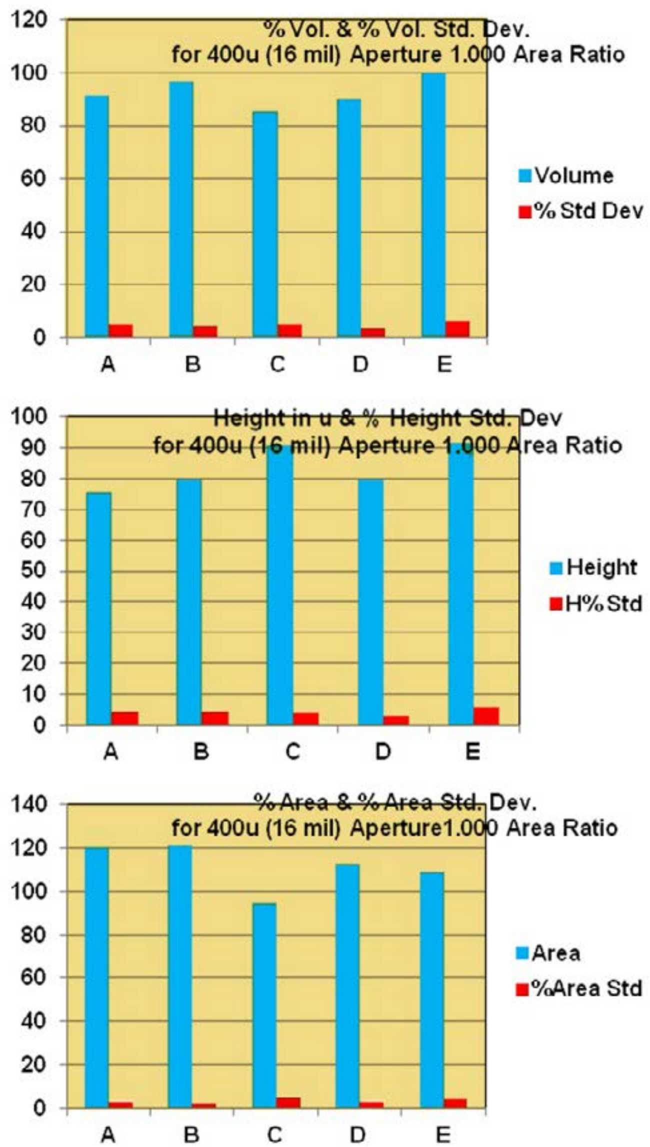

Figure 9: All five stencils with acceptable paste transfer.

terest to note that stencils A and B (electroform with and without nano-coat) have paste areas above 100% for all the area ratios, 0.375 to 1.00.

Figures 10 and 11 offer a summary of the percent of paste volume and the percent of paste volume standard deviation for all five stencils at six different aperture sizes. A chart with actual values is also shown.

Conclusions

The goal of this study was to determine if special coatings can improve paste transfer for apertures with area ratios of less than 0.5. The electroform stencil with nano-coat was the only stencil tested able to achieve this goal. This stencil is a good candidate when small (01005 and/or 0.3 mm pitch) CSP components are co-existent on the same PCB. Below is an overall summary of results:

- Electroform with nano-coat: At 0.375 area ratio this stencil was close to being acceptable, having 77% transfer and 17% standard deviation. Much better than the other four stencils.

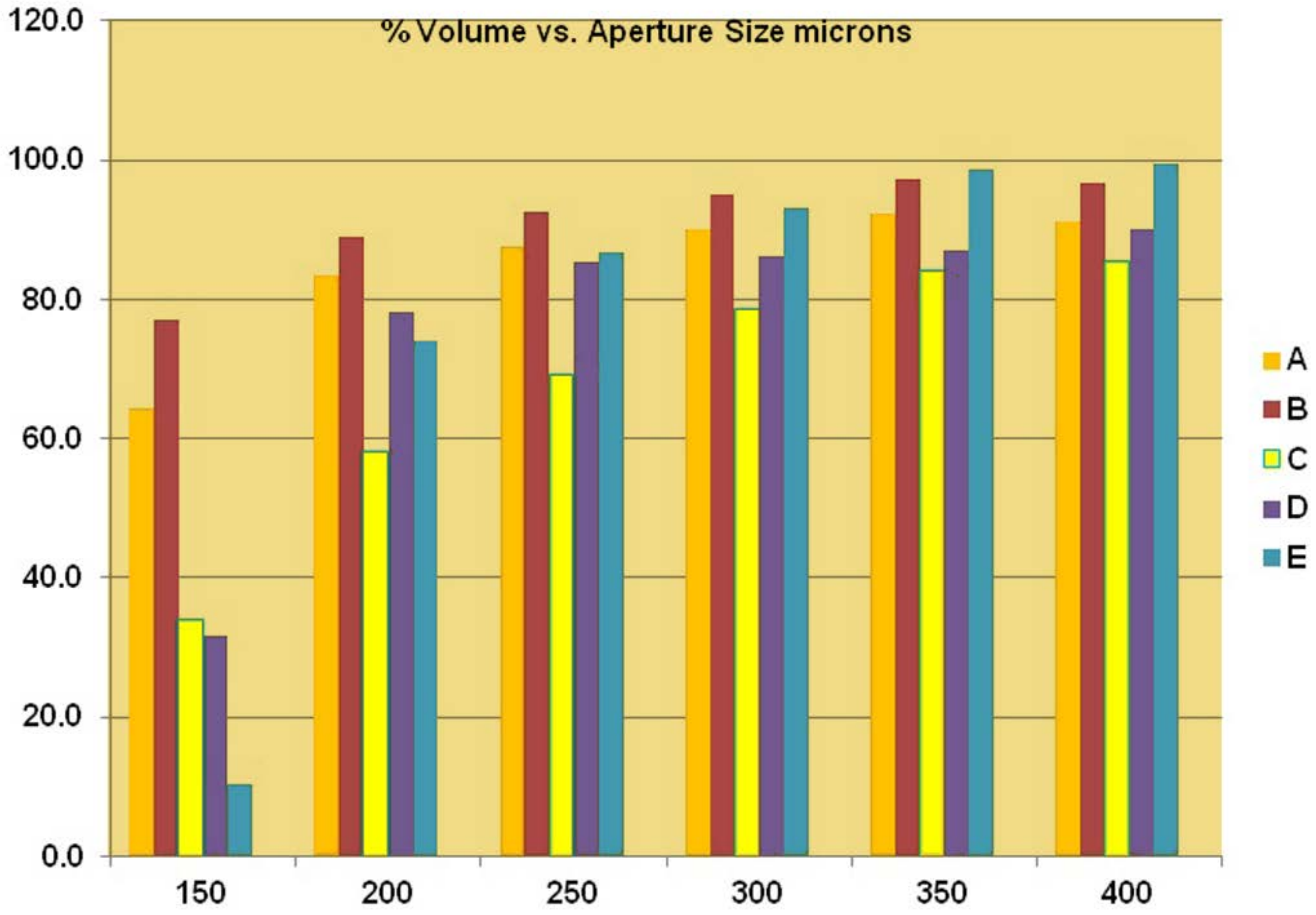

Figure 10: Volume versus aperture size.

At 0.500 area ratio an 89% transfer and 8.2% standard deviation. was achieved. Acceptable down to 0.42 area ratio.

• Electroform with no coating: At 0.500 area ratio 83.5% transfer and 8.8% standard deviation was achieved, better than the remaining three stencils. Acceptable down to 0.50 area ratio.

• Electroform and high-precision chem-etch stencils with nickel-Teflon coating performed about the same: At 0.625 area ratio both had transfer of about 86% and standard deviation of about 8%. Acceptable down to 0.60 area ratio. It was disappointing and surprising that the electroform stencil with nickel-Teflon coating gave lower paste transfer performance than electroform stencil without any coatings. It was impressive that the high-precision chem-etch stencil provided acceptable paste transfer down to a 0.60 area ratio.

Acknowledgements: Thanks to John Morini of Speedline for paste printing and volume measurements. **SMT**

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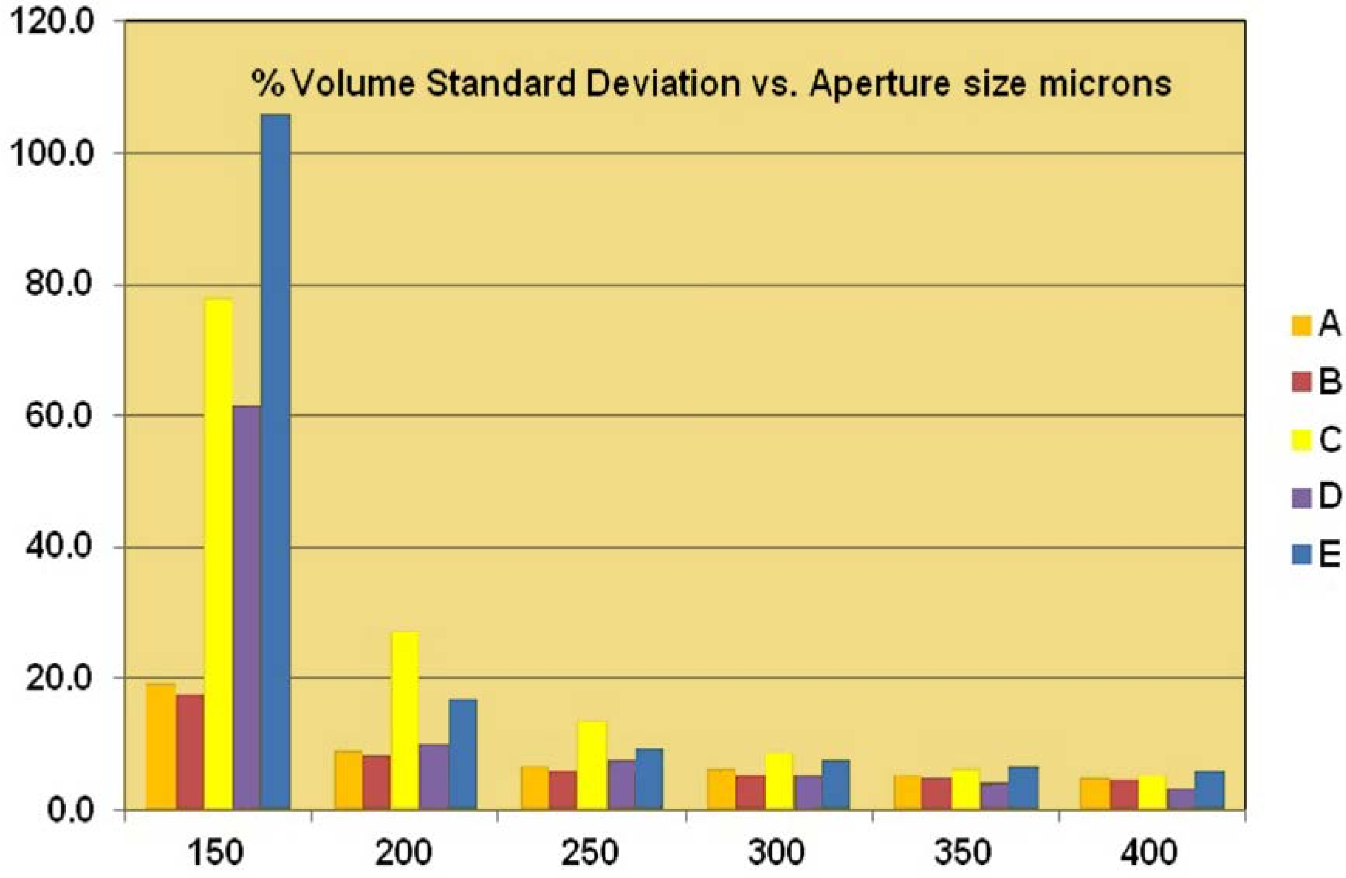

Figure 11: Standard deviation versus aperture size.

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Dr. William E. Coleman earned his Ph.D. in Physics from West Virginia University. His early career was spent with NCR developing memory and visual display devices. Dr. Coleman has spent the past 23 years at Photo Stencil as Vice President of Technology working closely with customers to understand their SMT printing requirements. At Photo Stencil he has developed several innovative solutions for these requirements. Dr. Coleman has published over 20 papers in this field and is presently Co-Chair of IPC 5-21e committee, which produced IPC 7525 "Stencil Design Guidelines." He is on the Editorial Advisory Board for SMT Magazine and the Advisory Board for West Virginia University.

SMT TRENDS & TECHNOLOGIES

Miniaturization Little by Little

by Eric Klaver
ASSEMBLÉON

SUMMARY: The push for smaller and smaller components seems to be a never-ending process. How can manufacturers deal with such devices?

When will the miniaturization trend end? Perhaps the end will come when we can no longer see the components. On one hand, ICs are squeezing more patterns into a nanometer—something that we certainly can't see; on the other, surface-mounted components are becoming smaller and smaller.

I remember when 0402 chip devices were introduced. I heard phrases like "impossible," "no way they will get smaller," and "can't be handled." Then came 0201 and the claims were repeated, and again with 01005. Are such small components actually practical? Where will it all stop?

008004 on the Scene

The miniaturization trend continues with the release of the 0201 metric (008004-inch) and I'm now wondering whether or not reading glasses might help.

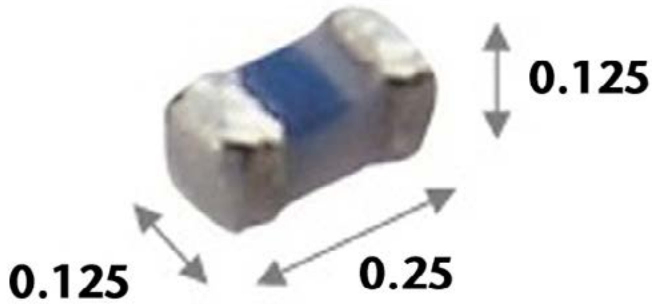


Figure 1: 0201 metric.
(Source: www.murata.com)

The self-aligning effect of components has practically vanished since the beginning of lead-free manufacturing. A small spread in placement results was once tolerable because it would correct itself during curing. This is no longer true and becomes more important with each generation of smaller and smaller components. Accurate placement is a must.

With components being so difficult to see, actions like loading tapes into feeders, prepara-

tion, and splicing are becoming more difficult. The chance of losing components rises as handling now takes more concentration and the chance of losing a component rises—mistakes are easier to make.

Small, lightweight components cannot withstand much impact, so forces must be tightly controlled and placement accuracy must be nearly perfect to ensure accurate placement. Near perfection is needed to prevent errors like tilting during curing in the oven. And, like placement, the pick process must be stable and almost perfectly centered and free of high impact forces.

The 008004 technology is, of course, nearly unstoppable and the push for smaller and smaller components won't end here. How can we deal with such devices?

Find the Right Carrier

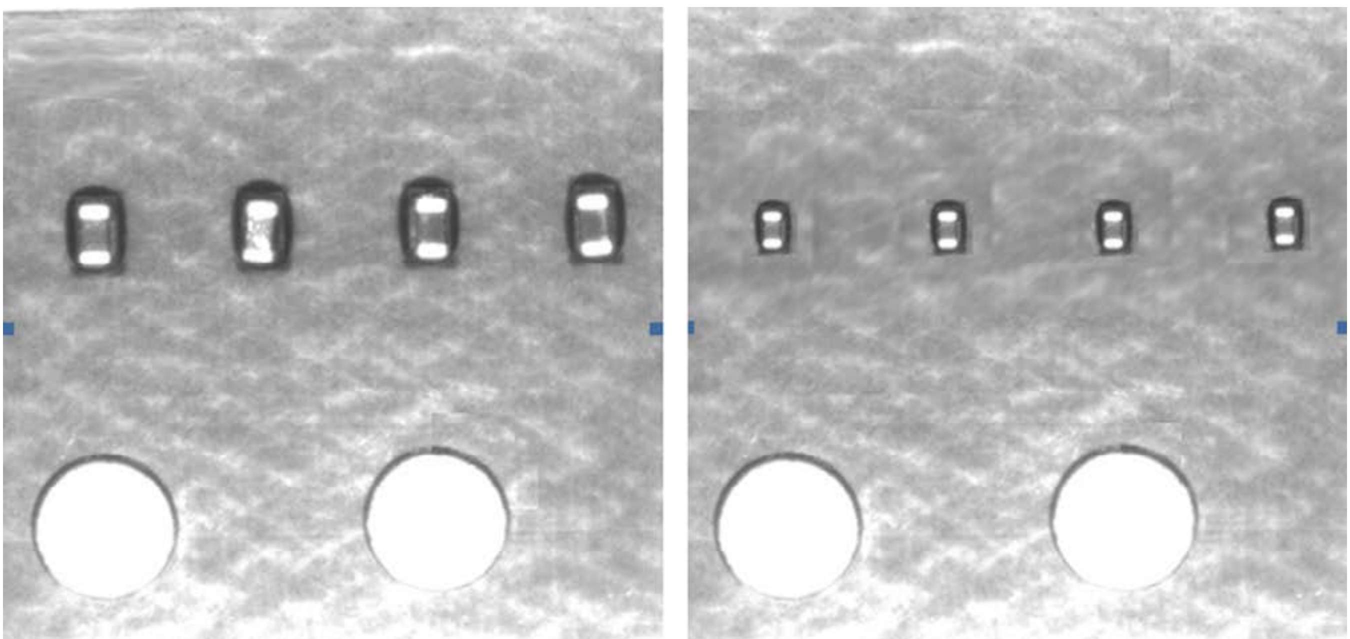
Components are subject to static electricity when the cover tape is peeled and the slightest airflow can cause devices weighing this little to fly out of the cavity. Paper tape seems out of the question. It's just not accurate enough. A good process can never be guaranteed with such tiny components in paper tape, even leaving aside the dust particles that can degrade soldering quality. How can an operator see where the parts actually start? Perhaps by marking the tape immediately in front of the first component, but, again, that's difficult when you can hardly see it.

And talking about tape, the current 8 mm wide tape is wasteful overkill for such tiny components. This is even true for the new 4 mm standard, so we perhaps even need 0.5 mm pitch—that would give plenty of space and smoother tape movement since the component-to-component distance is small enough not to need extreme tape speeds. It would also help reduce ESD when separating the tape cover, where speed of peeling is a dominant factor.

Feeder Accuracy

When it becomes difficult to see whether or not you have a component at the pick position, you may not even realize it has disappeared by the time the feeder has been placed into the system's feeder bar.

How accurate should the feeder be? Increasing accuracy is costly. A slight offset may cause a pick error (e.g., not picking, slanted pick, tombstoning). Perhaps the accuracy of the static feeder position is less important



Figures 2a and 2b: 01005 in 4 mm wide tape (left) versus 008004 in 4 mm wide tape (right).

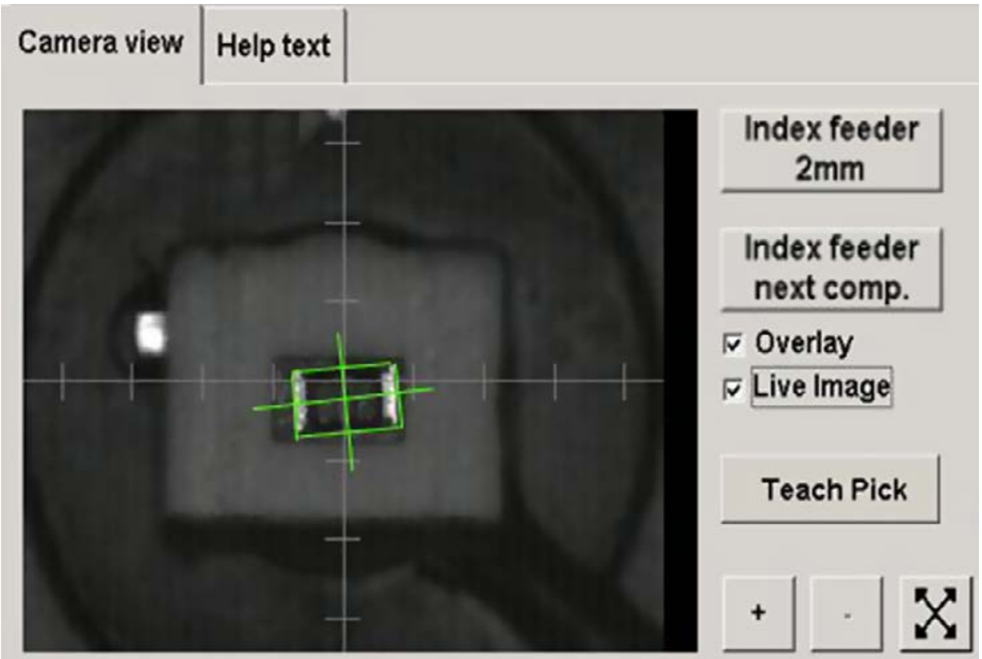


Figure 3: Accuracy needs high-resolution alignment.

than repeatability. The system can handle the other pick-related functions like finding the first component and determining the center of pick. From there, with a good repeatable positioning, the rest should happen automatically.

Head Travel as Light as a Feather

What about head motion (travel)? The accelerations, decelerations, rotations, airflow during movement, and all other factors can dislodge the feather-light (actually, lighter) components. The vacuum alone needs to hold the component tightly.

Accuracy needs a good alignment system with enough pixels per component. At what moment do you align, exactly? Any of the forces acting on the component on the nozzle tip after alignment can move it. Yes, we can slow the whole thing down, but that could increase the price of your product.

Then there's mass: All that equipment mass behind the component, just hanging there at the tip of a nozzle. Without special measures

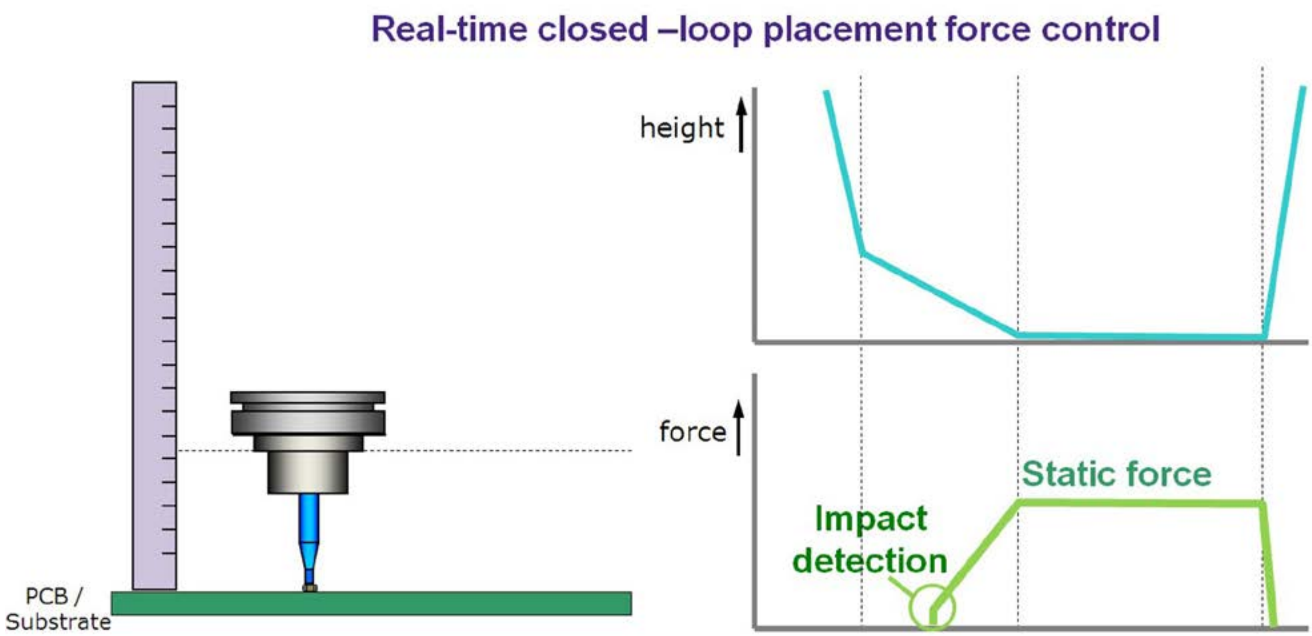


Figure 4: Slow buildup of placement (static) force without impact forces.

the impact can be huge at the moment of first contact. This needs to be precisely controlled; otherwise you can never guarantee the quality of the component after placement. If the board is not flat you must be sure to detect the curvature before you get a nasty surprise.

And good luck with rework. A single, incorrectly placed component is so small and difficult to rework by human hands that you have to ask whether or not the reworked product will last.

Ever Smaller and Thinner

These are big challenges for pick-and-place equipment, but they will be overcome. I'm not expecting to find the new 0201 metric (008004-inch) on the PCB of a consumer product within five to 10 years, but like the 0402M (01005-inch) it will very soon enter the module market. There it will be placed by existing pick-and-place equipment with advanced placement process control. This will bring IC packaging one step closer to packing even more functions into your future, ultra-thin smart phone.

So, will miniaturization end with the 0201M? I think not. **SMT**

Eric Klaver was born in Rosemere, Quebec, and, via Oklahoma, he moved with his family to Holland at the age of 12. After finishing school, he became a radio officer for the merchant navy. After studying computer science where he learned how to program and design ICs Klaver enjoyed a career at Philips. This was followed by a move to Assembléon in 1998. As commercial product manager he translates high-level technical developments into easy-to-understand commercial material. Klaver specializes in vision technology and feeding and is currently the chairman of IEC work group TC40WG36, which specializes in component packaging.

Video Interview

Surface Chemistry Improves Printing Efficiency

by Real Time with... IPC APEX EXPO 2013

Aculon, Inc.'s Director of R&D Eric Hanson describes to Technical Editor Pete Starkey how self-assembled monolayer nanotechnology can improve the performance of solder paste stencils.

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Real Time with... Panel Discussion Spotlight:

Best Cleaning Practices

by Lisa Lucke, I-CONNECT007

In an effort to ensure *SMT Magazine* readers don't miss an important new member of the *Real Time with...* family, Panel Discussions, we're dedicating a little space this month to highlight one that covers a topic near and dear to the hearts of many of you: *Best Cleaning Practices*. It's one of a dozen or so panel discussions taped on site at IPC APEX EXPO 2013.

It isn't every day that known and respected industry professionals like Mike Konrad (Aqueous), Eric Foresite (Camden) and Umut Tosun (Zestron) have a chance to sit down and talk shop, in person, with a camera present and catching every word. However, at IPC APEX EXPO, they did just that—along with "neutral third-party consultant" (as Konrad points out) Barbara "The Cleaning Lady" Kanegsberg, of BFK Solutions and author of *Handbook of Critical Cleaning*. All told, it made for a discussion rich with insight and ideas for the industry to consider.

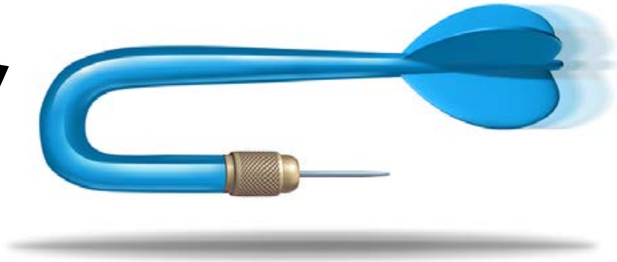
With such a broad topic as cleaning, it wasn't long before our film crew realized that what we really needed to do was just let this bunch go, giving them as much time as possible to cover as many relevant questions posed by Konrad, who was moderating, as we had time for. Questions like, "Is there such thing as too much cleaning?" which, of course, begged the question, "Do we even need to clean?" From there, the discussion, which runs just over 30 minutes and hops from one critical piece of the cleaning puzzle to another (are cleaning responsibilities being pushed down the line by OEMs to contract manufacturers, who are then held to higher standards?) proceeds to cover a vast amount of ground for anyone involved in cleaning and assembly. How do we not just *train* our line personnel, but *educate* them on the processes that they are monitoring and facilitating? How does a company address capital equipment and chemistries expenditures and the many choices available today? What is the next environmental concern going to be?

One of the final points that the panel covered focused on proactive management of the cleaning process itself. As Kanegsberg, an analytical chemist herself, points out, "There needs to be baseline analytical testing before problems occur; otherwise you have nothing to compare the problem to."

If cleaning is on your radar screen, you won't want to miss this video. Just click here to watch *Best Cleaning Practices*. And don't forget, all 145 of our *Real Time with...* videos, shot on the show floor at IPC APEX EXPO 2013, are accessible on our RTW site. Please let us know what you think!

If you have a topic you'd like to see covered at an industry event, or to find out how to participate as a moderator or panelist in one of our panel discussions, drop me a line at lisa@iconnect007.com. **SMT**

The Opportunity to be Agile



by Michael Ford
MENTOR GRAPHICS CORPORATION

SUMMARY: MRP and ERP logic were designed to manage the traditional distribution chain, but that system has now become an antique. If manufacturers act now, they will be able to embrace the coming changes and become masters of inventory.

Since beginning life as MRP technology in the 1970s, the traditional distribution chain has become an antique. The world has evolved with Internet technology replacing traditional points of sale. Many electronic products have also become fashionable. Such changes have completely altered the demand patterns that MRP and ERP logic were designed to manage.

Such technologies have, to some extent, evolved with the changing landscape, but, no matter what they do, they remain fundamental forecast "pipes" to communicate demand from the customer back to the factory and, in turn, out to the materials supplier. As the pipes grow shorter and wider, the bottleneck in the process moves more and more toward the factory. This has already led to cases of near panic, as demand to the factory often changes without warning. With every problem, however, there is opportunity. Manufacturers acting now can differentiate themselves by embracing the need for change and understanding what needs to be done to offer a service fit for this evolving market over the next five years.

What's the Problem?

Motivation for change begins with an understanding of the problem. The traditional distribution chain can stretch across the country or even continents, depending on the scope of the business. At the end of the chain is the point of sale, for example, a store selling electronic goods. When selling a physical product at a physical store, there has to be physical stock available. A good salesperson will not allow anyone entering the store to leave empty-handed. If a product has sold out, alternatives will be offered, promoted as being equally as good as the product the customer intended to buy. This fundamental principle drives the need for manufacturers to ensure continuously maintained and replenished stocks at the store level.

The store, however, does not want to carry a huge inventory of stock. This adds to their operational costs and, especially as products come to end of life, it may be hard to sell the remaining units, the value of which inevitably depreciates rapidly. Stock levels should be minimized and the replenishment cycle quick enough to ensure no starvation. Local distribution hubs are set up to handle local replenishment stock, close enough to the point of sale to provide required replenishment as required.

The exact same principles of the cost of stock also apply to these warehouses. This leads to

THE OPPORTUNITY TO BE AGILE *continues*

Figure 1: Layers in the distribution chain.

the need for regional hubs to replenish the local hubs, then, in turn, national hubs, and then even continental hubs. Many layers can be found in the distribution chain (Figure 1); each part of the chain ensures that just enough stock is available to customers. Considering the distribution chain as a whole brings the realization that the cost and value of stock overall is a huge investment. If demand for products were fairly constant, then it could work out relatively well. Demand is not constant however; as new products are introduced demand should increase. As old products become end-of-life, demand may decrease unless they are put on sale. Competition and seasonality can also have an effect. Overall demand can fluctuate quite significantly and quickly.

The sales forecast is made by ERP bearing in mind the expected demand for products, taking into account trends and stocks remaining in each stock location, and the lead time for product availability from manufacturing. It omits, however, one of the most significant factors of demand pattern change—the knowledge of what competitors are doing. Technology products, especially fashionable ones, evolve rapidly as compared to products in other industries. New products and prices are coming out all the time.

This can be balanced somewhat by competitive intelligence to try to predict what is coming, but the weakness in this assessment is back at the store, where there is a choice for products from any manufacturer to sell, and continuous critical evaluation of what will sell and what will not. This uncertainty leads to unpredictable tremors in the demand pattern. Millions of dollars can be spent trying to fine-tune the logic to ensure that the distribution chain is effective and efficient.

Technology Challenges

The complications began in the electronics industry when designers found that they could establish a competitive edge by creating fashionable products. Technology has become sexy and personal. This has led to an increase in the frequency of new products coming into the market, meaning a decreasing life cycle for each product (Figure 2). Fashion also brings with it the demand for personalised options, leading to multiple product variations, effectively multiplying the number of individual products to be managed.

Take cell phones, for example. One core chassis can be used for a range of models, each of which can have different levels of feature sets and memory options, each then can be available in different colors, with variants for the different

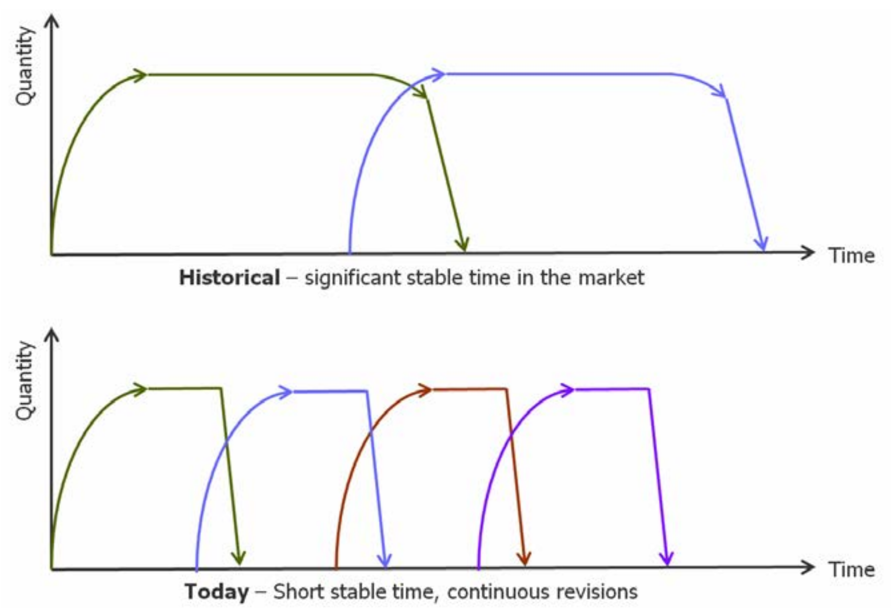


Figure 2: Product life cycle—historical versus present day.

countries and regions across the world, customized then for the many different service providers in each location. It can easily create more than 3,000 different unique product variations from just one basic design. This can all be a real strain for the management of products in the distribution chain. Products seem to go straight from the introduction stage to the end-of-life stage, almost missing out completely the steady state in between.

Marketing strategies that seek to create artificially limited product supplies, as well as genuine limitations in product supply, often governed by the availability of key component technologies, also contribute significant challenges.

Together, these elements create strange effects when running through the traditional distribution chain sales forecast logic. The demand fluctuates from customers, but the effects of the many variables based on the volatile and almost fragile nature of these product life cycles, creates "boom and bust" ordering cycles (Figure 3), with sudden urgent demand followed almost immediately by the panic of over-stock.

For many companies today, this is already history. For a long time, attempts have been made to shorten and flatten the distribution chain, at the expense of transportation. As transportation and logistics became more sophisticated, layers of the distribution chain could be removed without a drastic increase in cost or risk of product starvation. More recently though, transportation costs have increased, limiting this as a longer-term strategy. Still, in extreme cases for some key fashionable products like mobile handsets, we see examples where products are routinely air-freighted from almost literally the factory door directly to the local distributor. The consideration of product value depreciation given the lifecycle of the latest technology and fashion-sensitive products can be more significant than the increased shipping costs.

Internet Role

Another significant factor affecting the distribution chain is the growth of Internet shopping. There is no salesman to convince a customer to buy an alternative; the customer now has many sources from which to choose his preferred product, the only penalty or differentiator being the price, delivery terms, and the trust of the vendor. Stock is no longer needed at the point of sale. The company selling the item may not even hold actual stock; the order can simply be forwarded up the commercial chain until it gets to an entity, usually at a national level, that actually holds the product. The raw demand signal from the customer in this case can immediately be seen short-circuiting several levels of what was the distribution chain, far fewer steps away from the factory door than ever before.

The mind-set of this distribution, however, is still the same as the distribution chain of the past. Over-stock and product starvation are still

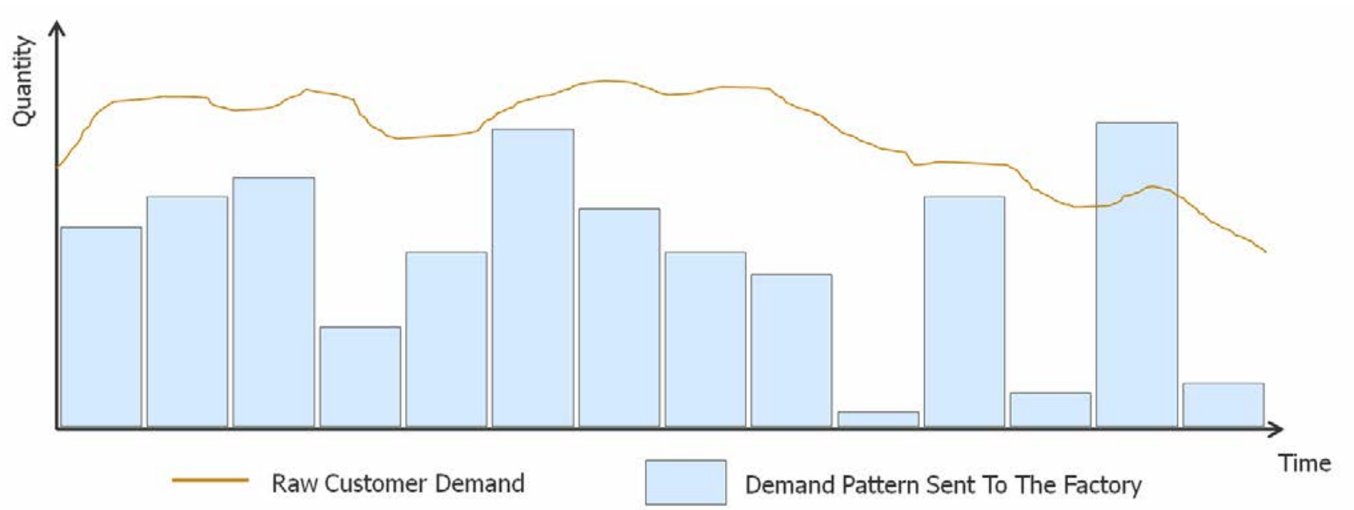


Figure 3: "Boom and bust" demand pattern.

THE OPPORTUNITY TO BE AGILE *continues*

bad. It is likely that the distributor will push back on the original vendor to take responsibility for quick replenishments, thus allowing a low stock overhead.

As with the distribution chain for final products, a very similar situation also exists for sub-assemblies and components that make up final products. Automotive is a good example, where customer demand for cars with what can be hundreds of individual configuration options translate to demand for components. Just the in-car entertainment can now comprise many different systems: Audio output powers, choice of FM or satellite radio, CD, DVD, hard disk storage, USB connection, video screens, etc. The prediction of demand of each of these options is just as unknown and as raw as the demand for end consumer products. The overall effect is the same; the raw demand is brought a lot closer to the factory.

Such changes in the distribution chain and the ability to provide a sales forecast put a lot of pressure on the planning systems for manufacturing and also for the supply chain. As with the automotive assembly example, factories of electronic products will push the demand requirements in turn to their suppliers and also will try to simplify and standardise the materials across different end products as much as possible. Often, such product differentiation involves only the change of software. The common factor linking all of these processes, from the final assembler back through component assembly, and back up to the materials suppliers, is agility.

Be Agile!

True agility is the ability to produce on demand whatever is required as the raw customer demand changes, without the need for excess stock holding of finished goods at any location. In commercial contracts, it is quite often the case that responsiveness to changes in demand is defined rather than fixed definitions of quantities and dates. Contracts may contain terms that state that the company is the provider of a certain set of products or components over a set period of time, during which the product specification and quantity can change at any time, with the actual supply demanded as needed.

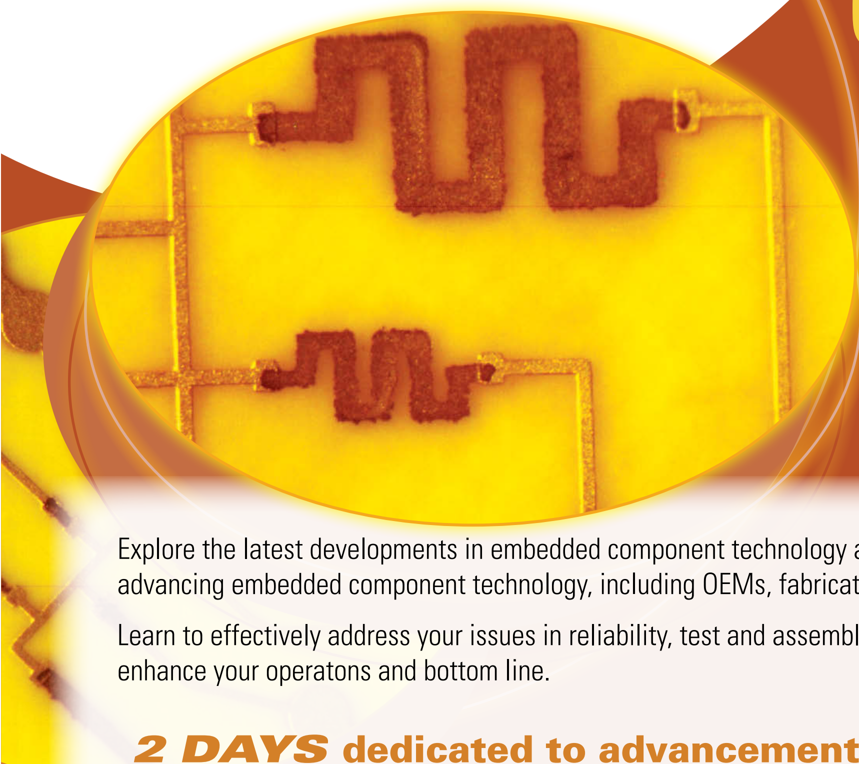
For many in the industry then, it will be seen that the long-range forecast is dead, replaced by a leaner system of demand coming more or less straight from the customer to the factory. The "make-to-order" system also has been around for a long time; unfortunately, however, these operations are almost always very inefficient and have long lead times. This model was not chosen for any significant volume production for good reason, and as-is, cannot be suitable for high volume operations, whatever the mix of products may be.

With all of the above comes a realization. Forecasts will only get shorter, mix will only get higher, and demand will only face more change. Fixes applied to manufacturing operations as this trend evolves are, at some point, going to fail. Internal management through ERP, as well as the traditional MES solution approach, is significantly challenged when it comes to the complexity of SMT and electronics assembly and test processes, now much more so in the light of the need for agility. Most of the available functionality of such systems is heavily customised, fixing operational methods and flows, merely contributing to making the current working practices faster rather than allowing new standard ways of working to make the operation meet its demand expectations, and yet be just as efficient and productive as it had been in the past before the mix and variability of demand came along.

> ***"A good start to finding the solution is to look at the bottlenecks, not the ones that prevent throughput, but the ones that resist change."***

A good start to finding the solution is to look at the bottlenecks, not the ones that prevent throughput, but the ones that resist change. Every factory operation has a different personality, but there are common elements that run through all of them.

Materials are a major issue in SMT production, since they are an expensive overhead to the operation, are numerous, small and liable to loss and damage, yet literally millions of components can physically be moved into the shop floor, assigned to work orders that may be executing



THE OPPORTUNITY TO BE AGILE *continues*

now, or over the coming shifts and days. There are also materials on the shop floor left over from previous work orders, moved to local storage areas rather than being returned to the main warehouse, since in spite of having so many materials available, shortages in the supplied materials on the shop floor are frequent which require alternative materials to be found at short notice at any time of day.

SMT machines especially have a habit of creating spoilage without warning, normally at low levels, but sometimes this can suddenly spike for a variety of reasons, making the supplied materials inadequate. An entire manufacturing work order can be forced to stop if only one insignificant material is missing. The variable spoilage creates errors in the inventory accuracy. There are now two major materials issues that contribute to the resistance of change. The first is the huge physical effort of re-allocation of materials already on the shop floor, and the other is how changes can be made reliably without knowing exactly the material inventory available.

The solution is to link the machines directly with the materials and planning systems, so that each piece of material usage and spoilage can be accounted for as it happens, locations of materials can be tracked precisely, and, most importantly, materials can be sent out to the shop floor "just in time" as they are needed. This allows minimum resistance to any change of plan as well as the confidence to know that the changes made can be executed correctly.

It is not only physical things that resist change. High-volume production normally means dedication of products to production lines. As a higher mix of demand comes in, there will be the need to share the line between products performing frequent product changeovers and even to move products from line to line to get different run rates. The work required to prepare the data of the product for different line configurations can consume significant resources and can quickly become a bottleneck. Complexity increases almost geometrically as effort needs to be made to consider change-over times versus regular program optimisation, the management of data in several different databases, plus the potential line disruption for fine-tuning each product on the line.

> ***It is not only physical things that resist change. High-volume production normally means dedication of products to production lines.***

This creates two additional issues that contribute to the resistance to change. The first is how to keep each line running at the maximum capability in spite of frequent changes between products. Simple programming tools from the machine vendors will offer simple solutions to optimise this scenario, but these will be limited to the machines of a particular platform and have limited capability to consider a small number of products. It may be required that literally hundreds of products are to be made on a series of lines of different configurations over the coming month.

The second issue is the time and effort it takes to prepare multiple sets of programs for a product on different line configurations. Finding the best opportunity considering the amount of possible variants of grouping products according to commonality and assignment of feeders, to capable lines and such that the required output deadlines can be met, is huge. The calculations are very complex as machines have many feeder positions and different performance levels. To provide a real choice during planning, not only must a reasonably accurate timing model for the product on each line be made, but all the data for the processes must be prepared ready to execute production. To offer many choices of where to run products can be very costly and disruptive, but without these options, planning will be unable to balance the changing load of demand across the shop floor effectively.

The solution to this challenge is to have a process preparation environment which works centrally for all machines providing data translation and modelling of all machines on the shop floor, linked directly with a production planning optimization tool that can take the existing schedule and modified requirements and immediately rebuild the optimised assignments of products to lines in sequence with demand whilst maintaining the lowest possible changeover loss. The key is the integration of planning and product grouping optimisation ability.

Other related factors should be considered when designing a production operation to meet unknown and volatile demand. Work orders planned as a flow instead of batch, utilising dynamic module lines. The key tools to manage materials, planning and process preparation do exist today which, when put together with a smart manufacturing layout and operational flow, can yield a dramatically more agile factory specifically capable of peak performance even following raw customer demand patterns. Change capability for agility needs to be built in as part of the factory operation and supporting tools.

The Need for Agility is Here, Now

Companies in different tiers and sectors will experience the need for agility sooner or later, and for different reasons. The common factor however is that it is coming. Take this as a heads up. Agility today creates a competitive advantage opportunity in the market. Waiting instead until the situation becomes critical can lead to a negative spiral from which it can be hard to recover. The choice is there. **SMT**

Michael Ford is senior marketing development manager with the Valor division of Mentor Graphics Corporation. Utilizing his 30-year experience of industry knowledge, Ford examines key business objectives with his technology expertise to find solutions and opportunities where the industry had previously faced challenges. He began his career as a computer software and hardware engineer and created and managed manufacturing solutions for Sony where, he became one of the first successful adopters of computer technology for manufacturing, materials, and testing for the PCB-A shop floor. Ford is well versed in the principles of Lean thinking and sustainability and offers his expertise and knowledge in this bi-monthly column.

Video Interview

A High-Speed Jetted Soldering Solution

by Real Time with...
IPC APEX EXPO 2013

MYDATA's Gustaf Martensson, innovation field expert, R&D, reveals his company's high-speed jetting solution for solder paste dispensing, which provides a way to "jet" solder paste onto boards and features advantages in challenging board designs, pin-in-paste, and component add-ons.

realtimewith.com

Top Ten Most-Read Supplier/ New Product Highlights

Photo Stencil Debuts New Nanolayer Stencil Coating

Tests performed at OnCore Manufacturing Services showed that Smart-Release, a new nanolayer stencil coating, considerably reduced the frequency required for under-screen cleaning on the printer, saving time, money, and consumables, reducing defects and contamination, and improving throughput.

Chemtronics Debuts Ultra-Flexible Conformal Coating

Konform® Flexcoat conformal coating is designed for applications where flexibility and protection are paramount. It is as flexible as an RTV silicone, but without the disadvantages of silicone. Providing a soft, rubbery protective coating, the product will coat evenly and provide a flexible and durable protective barrier against humidity, salt, corrosive vapors, and fungus.

Panasonic Debuts AM100: A Single Machine Solution

Panasonic Factory Solutions Company of America introduced the AM100, a single machine solution for productivity and versatility. This modular placement machine features a single head (single beam) capable of placing a component array ranging from 0402 mm to 120 x 90 x 28 mm, large connectors, odd-shaped components, and advanced packaging types such as PoP.

Manncorp Launches MC-LEDV3; P&P for LED Boards

The MC-LEDV3, a new high-speed pick-and-place machine, features three pick-and-place heads mounted on a high-precision, ball-screw-driven gantry. Simultaneous pickup, on-the-fly (vision-based) component alignment, and feeder placement optimization combine to achieve placement rates of up to 10,000 LEDs per hour, per IPC-9850.

Panasonic Reveals Latest Screen Printer Solution: SPG

The SPG delivers both high-quality and high-productivity screen printing and comes standard with the company's hybrid squeegee head that further reduces cycle time. This screen printer can maintain a 15-second cycle time, cleaning and printing every time.

Essemtec Launches Reflow Oven Control Deluxe Duo

RO-CONTROL and RO-SOFT are state-of-the-art software packages for simulation, control, and documentation reflow and curing ovens and processes. Operators, process engineers, and quality managers profit from the advanced functionality of the new version 7. All new reflow ovens from the RO300 and RO400 series are delivered with RO-CONTROL 7 and RO-SOFT 7.

Photo Stencil's Printing Solutions Study Available Online

The company announces that "Screen Printing Solutions for Small Die and Precision Alignment Challenges," by William Coleman Ph.D. and Travis Tanner, Plexus, is now available. The paper details the process the companies followed and the solution they found to print solder fillets on very small gold Kovar tabs.

Nordson Enjoys 26% Sales Increase in Q1

Nordson Corporation has reported results for the first quarter of fiscal year 2013. For the quarter ending January 31, 2013, sales were $347 million, a 26% increase over the prior year's first quarter sales. This sales improvement included an 8% increase in organic volume, and an 18% increase related to the first year effect of acquisitions.

Panasonic Presents New Distribution System

Panasonic Factory Solutions Company of America presented a new, self-contained distribution system for its PanaCIM manufacturing execution system (MES) software that is relevant for any factory. The beauty of the new solution builds off the inherent modularity and scalability of PanaCIM MES and makes this deployment solution relevant and cost-effective for any factory regardless of size or IT staffing.

HDP Welcomes Sekisui as New Member

The High Density Packaging Users Group (HDP) headquartered in the United States announces that Sekisui Corporation has become its newest member. Hiroya Ishida, assistant manager for Sekisui, said, "We are keen to provide highly-reliable solder materials based on our key polymer particle technologies and contribute to packaging innovation by participating in HDP user group projects."

EVOLUTIONARY SOLUTIONS

A New Union

by Karla Osorno
EE TECHNOLOGIES, INC.

SUMMARY: Creating a partnership with a new customer mirrors another important milestone in the life of most adults: Dating and, eventually, marriage. Karla Osorno walks you through the important steps OEMs and EMS providers must follow to make a working partnership successful.

EMS providers, by their very nature, are like multiple companies or OEMs in one location. They exist because they have mastered manufacturing and successfully capitalize on economies of scale, passing along savings to the OEM.

One of the trickiest aspects of business for EMS providers is on-boarding a new OEM customer into the mix of existing customers. There are as many unique ways for on-boarding customers as there are customers. Here we will describe one successful approach to on-boarding new customers.

Before we begin, an understanding of the full process of establishing an OEM/EMS relationship will be helpful. Much like the most commonly-known partnership—the one that leads to a life-long commitment: Courting, dating, and marriage—three phases make up the process of selecting an EMS provider:

1. During the selection phase (courting), the customer identifies the key characteristics desired in a partner and actively searches for these capabilities, core competencies, and services.
2. During the on-boarding (dating) phase, the customer and EMS provider discuss hopes, dreams, and desires, learning to communicate about each.
3. During the partnership (marriage) phase, the relationship becomes about coexisting peacefully, sharing successes and resolving issues as they arise.

EMS providers find that these processes work best for all involved in these three phases (with emphasis on on-boarding).

Courting: The Selection Phase

Choosing the right supplier is a critical task and key questions should be asked during the process (see [Selecting a Foreign Provider: 10 Crucial Questions]). As part of this phase, the OEM is asking questions and gathering information. Answers to these questions are important.

The most important aspect of this phase is assessing a provider's responsiveness, flexibility, knowledge, and professionalism. Such characteristics will be critical to the ongoing relationship. Understanding if the supplier will be a good fit and an asset to the overall output of the organization is the single most important result of the selection phase.

Ultimately, all EMS suppliers have strengths and weaknesses, but you want a supplier you can trust to be managed minimally from a distance. The selection process is about quickly gathering information, but also about beginning to clarify expectations and establishing an ideal partner relationship.

> ***"Ultimately, all EMS suppliers have strengths and weaknesses, but you want a supplier you can trust to be managed minimally from a distance. The selection process is about quickly gathering information, but also about beginning to clarify expectations and establishing an ideal partner relationship."***

Dating: On-boarding Phase

So your advertising efforts and reputation have paid off and you have converted your prospect into a customer. Excellent work! Now what? It is time to bring the customer on board. You will be integrating this new customer in your existing operations and alongside other customers.

During this phase you will be communicating, communicating, communicating, and communicating some more about expectations, measurements, success evaluation, and even about, of course, communicating. The more you communicate now, the less you'll have to communicate later. These initial communications are best in person with all functional areas represented from both organizations. However, some participants may join by Skype depending on geographic locations in an effort to save money. Key communication topics that have proven successful in on-boarding customers follow.

Expectations

The OEM will summarize the expectations communicated during the courting phase and the EMS provider will summarize the expectations for how the relationship will best function. This is the ideal time for the EMS provider to reiterate that to provide the cost savings discussed during the courting phase, significant administrative and functional processes must be consistent across all customers. This enables the EMS provider to realize savings that economies of scale bring. If each customer wants specific administrative systems, costs are higher and issues larger for all customers.

Individual product-specific processes and isolated special requests can be accommodated. The OEM must clearly communicate any requirements that are non-negotiable. At this point of the conversation, asking the OEM to list their top five non-negotiable requirements is beneficial.

During these discussions or meetings, value stream mapping may prove useful for dialoguing about the value of specific parts of the process and finding solutions that meet the needs of the OEM and the EMS provider.

Attaching expectations to metrics that will be measured for accountability is vital during this phase. Ideally the metrics will be in line with the OEM's top five non-negotiable requirements. The metrics will hold the EMS provider accountable for results and also help the OEM stay on track with what matters, the metrics, rather than micromanaging the EMS provider.

Each company has different key performance indicators so it is good during this time to create alignment and decide on the exact metrics that will be evaluated. Most likely the OEM will have metrics or scorecards they use for all suppliers, which commonly include:

Quality, on-time delivery, cost reduction, and customer service metrics. Determining the specific details is critical as these metrics are very general.

Those in charge will want to make decisions on how each metric will be measured and monitored (what frequency and by whom). The EMS provider must determine how the internal metrics feed in to these OEM metrics or scorecards. For example, how is on-time delivery tracked internally and how does it differ from how the OEM tracks on-time delivery (window of time versus arrives on exact date)? EMS providers will want to perform and have metrics that show performance and gaps quickly so corrective action can be taken.

Product Migration

The EMS provider builds many products for many different customers. For existing customers, the OEM sends the build documentation and the EMS provider quotes the project. Then the OEM orders the product from the EMS provider. When on-boarding a customer, it is likely that multiple products or product lines will require transfer to the new EMS provider.

New product introduction (NPI) builds warrant significant attention and the migration of products will be critical to the success of the relationship. If the flow is too fast or too slow there will be issues that result in significant costs and poor performance. The EMS provider can greatly facilitate this process by recommending the ideal flow based on knowledge of internal processes and quality of build documentation. The warning here is to avoid a large bubble flowing through the EMS provider (at quoting, then purchasing, then scheduling, then manufacturing, then shipping).

During product migration discussions, the expertise of all participants can be capitalized on and a migration schedule created. It may be adjusted with any new information, but the initial migration schedule is an expected primary outcome.

Processes

The EMS provider will share the manufacturing processes used for the customer's products. In-person or virtual tours and/or procedure reviews will be provided. This will most likely be a review since it was covered during the courting phase. It is critical to not skip this step as there may be additional needs that have been realized by the OEM or new processes added by the EMS provider during the courting phase. These processes can often take months to complete. New processes may be recommended by the OEM and integrated in the strategic plans of the EMS provider.

Quality

Earlier, as part of the metric development discussions, quality metrics were determined. Now the OEM should delve deeper into quality objectives and systems supporting these objectives. Existing quality metrics and systems are shared with the OEM so they will know what to expect. Corrective action systems should also be reviewed to ensure they meet customer expectations and compliance requirements.

Manufacturing Locations

Depending on the product and company requirements, restrictions may exist as to where the product can be manufactured. It will be important to clarify whether products can be produced at all locations, especially if international. For example, some military suppliers want all products manufactured in the United States. Many companies only want their products produced at a lower-cost Mexico facility to take advantage of cost reductions.

"Depending on the product and company requirements, restrictions may exist as to where the product can be manufactured. It will be important to clarify whether products can be produced at all locations, especially if international. For example, some military suppliers want all products manufactured in the United States."

Tooling

Many times special tooling needs are required for a particular project. Discuss what the requirements are and add actions to the migration plan so tooling can be relocated to the facility or purchased in advance if needed.

Data Interchange

As technology capabilities expand, many companies elect to use data interchange to streamline communication and eliminate duplication. Managing inventory, processing shipping documents, and issuing invoices are examples of the data shared through compatible systems.

Rules of Engagement

During this phase of the relationship the rules of engagement will be established. Discuss and decide how you will handle the relationship. The EMS provider should have the right metrics in place and encourage the OEM to not only focus on daily operations, but also results. Establish a system to minimize unnecessary reports and any need for micro-managing. Communication channels (who and how) should be determined as well. Determine whether or not there will be a team in communication or one person at each company handling the relationship. Establishing these rules of engagement and communication channels will set both companies up for success.

Pricing Models

The EMS provider will want to share the pricing model used so the OEM understands the quotes received. Topics like whether or not the cost is open or closed are critical to understand during this phase. Other discussion points may include methods for quoting materials and the individual components of labor and overhead rates.

Integration

Part of the on-boarding process is to integrate the customer's unique systems with your own. It is important to do this in a way that economies of scale can occur and result in cost savings for both the EMS provider and the customer. It can be tricky to provide specialized attention without duplicating the customer's processes.

Always keep in mind that the customer came to you because you can manufacture their products more efficiently with your expertise, allowing them to focus on their core competencies. Product and market development is what they do best. Integration, not duplication, is the goal to save the customer money.

Marriage: Partnership Phase

The dating phase will usually occur in the first few months after the OEM selects the EMS provider. Then the ongoing partnership phase or marriage begins. During the marriage phase, there will be successes and, as in any relationship, also issues. If the courting and dating phases go well, this phase will be profitable for both companies. The partnership will then be simply executing on the key areas and decisions established previously. Be cautious about skipping any on-boarding activities, as the issues will have more serious consequences in the partnership phase.

Congratulations on the new union! **SMT**

Karla Osorno is business development officer for EE Technologies, Inc., an EMS provider delivering complete engineering and manufacturing services with locations in Nevada and Mexico. With education and more than 20 years' experience in finance and operations, Osorno drives completion of projects in marketing, business development, operations, and process improvement. Her passions are to educate and empower others to make changes and a daily difference in the world. Contact Osorno here.

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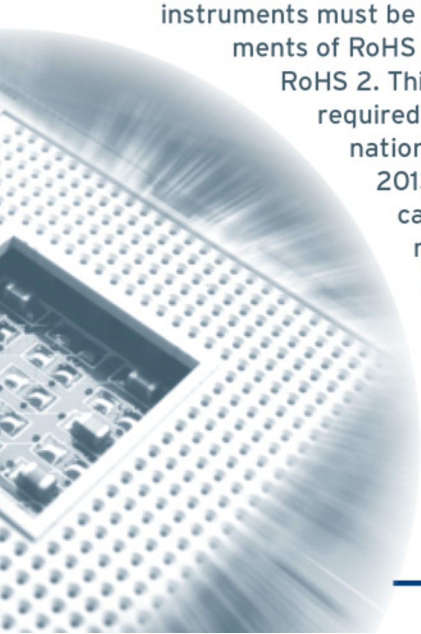
INTRODUCTION

Electronic products, particularly consumer products have become more complex with greater circuit density, finer lines and spacings and more functionality. Reliability issues continue to be a major concern for industrial, bio-medical, aerospace and automotive applications and require materials, manufacturing, test and quality engineers and scientists to be creative in planning for the future. Challenges such as the use of finer powders in solder paste, the greater need for heat dissipation, the use of novel components and technologies are included. Due to cost considerations, new low silver or silver free alloys are being studied. The use of tailored alloy systems, the variety of alloy choices, and smaller passive components are among the concerns being addressed. Now, a new group of engineers and scientists involved in the design and manufacture of (a) medical devices, and (b) monitoring and control instruments must be ready for the requirements of RoHS recast, also known as RoHS 2. This EU directive officially required that it be made into national laws by January 2, 2013 and these two new categories of electronics must become compliant by July 22, 2014. Soldering and reliability professionals need to come together to share their knowledge and their vision for addressing these challenges.



KEYNOTE ADDRESS

Solder Assembly Solutions for 3D IC Packaging

Charles G. Woychik, Ph.D.
Director of 3D Technology and Marketing,
Invensas Corporation

3D IC packaging is transitioning from the lab to commercial adoption. The arrival of the first commercial 2.5D (silicon interposer) product challenges us to question "which parts of the process and supply chain are maturing, and which parts are ripe for reinvention?" Invensas has been developing HVM fine-node 2.5D interposer technology in partnership with AllVia, in conjunction with advanced micro-bumped die that accommodate interconnect schemes exceeding 10,000 I/O. Modeling of the assembly process has been used to evaluate different process flows in order to develop a high yielding, and reliable 3D package design. An overview will be given of this development activity, as well as a brief discussion of the remaining "choke-points", those areas in need of reengineering and reinvention.

TECHNICAL COMMITTEE:

Laura Turbini, Ph.D.
International Reliability Consultant, Program Chair

Bev Christian, Ph.D., Blackberry

Matthew Kelly, P. Eng, MBA, IBM Corporation

Polina Snugovsky, Ph.D., Celestica, Inc.

Tim Luke, Alpha

Learn more: www.smta.org/icsr/

Top Ten Most-Read Mil/Aero007 Highlights

FTG Secures HMI Contract from Rockwell Collins

Firan Technology Group Corporation has been awarded a new multi-year Human Machine Interface (HMI) Enterprise Sourcing Agreement from Rockwell Collins. The agreement incorporates a variety of avionic products for major airframe platforms across business regional, air transport, and government systems market applications.

Sunburst EMS Proves Capability; Earns AS9100 Rev C

"Through the diligence and hard work of our employees, we have implemented a quality management system that has significantly enhanced our ability to deliver world class solutions to our defense aerospace customers," said Andrew Chase, president and CEO.

Nortech Reports Strong 2012 Results; High Q4 Income

"We finished 2012 strong with our highest quarterly income of the year and strongest operating results in more than two years," said Mike Degen, CEO. "We adjusted our cost structure to the sluggish economy and managed cash aggressively." He cited the $5.5 million improvement in cash flow from operating activities throughout fiscal 2012.

Sparton Launches "Conquering Complexity" Campaign

"As we continue to execute our growth strategy, the Conquering Complexity™ campaign concisely defines what we are accomplishing in our businesses," said Cary Wood, president and CEO. "We focus on areas of business that are very specialized, requiring a unique technological and process infrastructure. With that infrastructure in place here at Sparton, we are in fact conquering the complexity of the customers and projects we serve."

Nortech Names Rich Wasielewski President and COO

The company has named Richard G. Wasielewski to the new position of president and chief operating officer, effective immediately. "We're pleased to recognize Rich's invaluable contributions to Nortech," said Mike Degen, CEO. "His transition into this new role will contribute significantly to our future growth and the achievement of our long-term objectives."

Q4 Strongest Period of Year for Orbit

Commenting on fourth quarter results, Mitchell Binder, president and CEO, stated, "Excluding goodwill charges, the fourth quarter of 2012 was our strongest reporting period of the year. Net sales for the 2012 fourth quarter were the highest of any quarter during the year, due to improved sales from our Orbit Instrument Division and continued strong performance from our Power Group."

PartnerTech Releases Disappointing Q4 Results

PartnerTech's sales for 2012 came in at SEK 2,242 million, a decrease from 2011 of 3% in local currency and comparable units. Operating profit for the full year totalled SEK 24 million. Fourth quarter sales declined from the year-ago period by 15% in local currency and comparable units to SEK 550 million—a disappointing result.

Raven's Q4 Sales Drop; Fiscal 2013 Up 6%

Daniel A. Rykhus, president and CEO, said, "Our targeted investments in new product development, capacity expansion, and new market penetration were essential to our overall growth as a corporation." Fourth-quarter net income was $11.1 million, or $0.30 per diluted share, consistent with the year-earlier net income record of $11.0 million, or $0.30 per diluted share.

OSI Wins $6 Million Sub-Assemblies Contract

OSI Systems, Inc., a vertically-integrated provider of specialized electronic products for critical applications in the security and healthcare industries, has announced that OSI Electronics, a business within its Optoelectronic and Manufacturing division, has received orders for approximately $6 million for electronic sub-assemblies from an OEM of advanced skin care solutions.

Suntron Supports Arizona SciTech Festival's "How It's Made"

Visitors viewed the company's electronic manufacturing capabilities first hand and learned about services for mission-critical products. Held annually, the event is designed to expand knowledge about manufacturing careers and manufacturing's value to the Arizona economy. The event is a part of the Arizona SciTech Festival, which is a state-wide celebration of science, technology, engineering, and math (STEM) that occurs every February and March.

TOP TEN

Most-Read News Highlights from SMTonline this Month

① Committee Members, Contributors Honored by IPC

IPC presented Committee Leadership, Distinguished Committee Service, and Special Recognition Awards at IPC APEX EXPO at the San Diego Convention Center. The awards were presented to individuals who made significant contributions to IPC and the industry by lending their time and expertise through IPC committee service.

② Flextronics Upgrades Milpitas Facility; $12M in Investment

The company has underscored its investment in Silicon Valley and to its OEM customers with the unveiling of a state-of-the-art Product Innovation Center in Milpitas, California. The company also announced plans to invest another $20 million in the Center in the near future, following a $12 million equipment and capability upgrade.

③ ESCATEC, UID Enter Partnership

The company has announced a partnership agreement with User Interface Design GmbH (UID), a German design company that specializes in user experience analysis and user interface development. This provides customers with a complete product design and manufacturing solution that is fully integrated through every stage. This turnkey approach will speed time to market and save costs.

④ IPC Conflict Minerals Due Diligence Guide Now Available

"This document will help companies navigate their downstream supply chain due diligence responsibilities," says John Ciba, co-chair of the IPC Conflict Minerals Due Diligence Committee. "There is a real need in the downstream supply chain for step-by-step guidance on what to do when it comes to addressing conflict minerals regulations and that's exactly what this guide provides."

5 Plexus, USR Enter Strategic Partnership

Michael Verstegen, senior vice president of Global Market Development, commented, “This strategic agreement expands and strengthens our ability to support the unique demands of our customers. USR’s focus on quality and reliability, encompassed with lean manufacturing principles, complements Plexus’ business principles.”

6 Increasing M&A Emerging Trend in Global EMS Market

TechNavio’s analysts forecast the Global Electronics Contract Manufacturing market to grow at a CAGR of 5.74% over the period 2012-2016. A key factor contributing to this market growth is the need to optimize resources. The market has also witnessed an increasing number of mergers and acquisitions. However, the increasing threat of in-house manufacturing could pose a challenge to the growth of this market.

7 Foxconn Leads Tablet OEM Biz; Q4 Revenues Up 40%

In November, Foxconn saw revenues reaching a historical high of NT $351.733 billion (US $12 billion), representing an on-month growth of 27.6%. The company’s December revenues will continue to be strong and fourth-quarter revenues are likely to exceed NT $1 trillion, an on-quarter growth of over 40%.

8 Kimball’s Ferris Explains Importance of Facility Location

Tom Ferris, director of business development for medical solutions for Kimball Electronics Group, outlined factors to consider when selecting the right EMS provider, criteria beyond contractor capabilities that should be evaluated. Factors to consider include economic trends in the region, workforce availability, education, turnover, and logistics.

9 Jabil, UPS Collaboration Offers Comprehensive Suite of Services

UPS has formed a strategic collaboration with Jabil Circuit, Inc. UPS’s logistics and distribution business unit and Jabil Aftermarket Services will provide optimized reverse logistics solutions for return and repair programs to high-tech original equipment manufacturers, service providers, and enterprises on a global scale.

10 TT electronics Creates Global Centre in India

“TT electronics looked at India to setup a second global engineering centre adding value across embedded and engineering services, as well as accelerating each customers unique research and development requirements while staying on budget and in line with their go-to-market strategy,” said Geraint Anderson, CEO.

smtonline.com for the latest SMT news—anywhere, anytime.

EVENTS

For the 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 of events, check out *SMT Magazine's* full events calendar here.

FIEE/Electronic Americas 2013
April 1 -5, 2013
Sao Paulo, Brazil

The 27th International Electrical, Electronic, Energy and Automation Industry Fair
April 1-5, 2013
Sao Paulo, Brazil

WAMICON 2013
April 7-9, 2013
Orlando, Florida

Electronics New England
April 10-11, 2013
Boston, Massachusetts

BIOMEDevice
April 10-11, 2013
Boston, Massachusetts

DESIGN & Manufacturing New England
April 10-11, 2013
Boston, Massachusetts

Microwave & RF 2013
April 10-11, 2013
Paris, France

ExpoElectronica
April 10-12, 2013
Moscow, Russia

HANNOVER MESSE 2013
April 12-13, 2013
Hannover, Germany

Hong Kong Electronics Fair
April 13-16, 2013
Hong Kong, China

SMT Hybrid Packaging 2013
April 16-18, 2013
Nuremberg, Germany

BioMEMS 2013 and Sensors 2013
April 16-18, 2013
Cleveland, Ohio

Application of Printed, Organic & Flexible Electronics
April 17-18, 2013
Berlin, Germany

Energy Harvesting & Storage Europe
April 17-18, 2013
Berlin, Germany

Printed Electronics Europe
April 17-18, 2013
Berlin, Germany

South East Asia Technical Training Conference on Electronics Assembly Technologies 2013
April 17-19, 2013
Penang, Malaysia

DESIGN West
April 22-25, 2013
San Jose, California

Ceramic Interconnect and Ceramic Microsystems Technologies (CICMT 2013)
April 23-25, 2013
Orlando, Florida

NEPCON China 2013
April 23-25, 2013
Shanghai, China

2013 Defense, Security, and Sensing Exhibition
April 29-May 3, 2013
Baltimore, Maryland

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Next Month in SMT Magazine

The focus of the May issue of *SMT Magazine* is SMT assembly processes, soldering, and solderless technologies. Concerning reflow soldering, profiling and vapour phase issues will be addressed. In the area of solderless assembly, the issue will take a look at solderless assembly for electronics (S.A.F.E.) and conductive adhesives. Wave and selective soldering will also be covered. Expect in-depth articles from Dr. Ron Lasky, Tetsuro Nishimura, Dr. Hans Bell, and many more.

As always, the May issue will also include columns from industry experts, including Dr. Jennie S. Hwang, Zulki Khan, Chris Torrioni, and Karla Osorno.

If you're not yet a subscriber, don't miss out! Click here to receive *SMT Magazine* in your inbox each month.

See you in May!