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South East Asia GLOBAL SMT & PACKAGING

Covering India, Thailand, Malaysia, Singapore, The Philippines and Hong Kong

Volume 2 Number 3 May/June 2011

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South East Asia
GLOBAL SMT & PACKAGING

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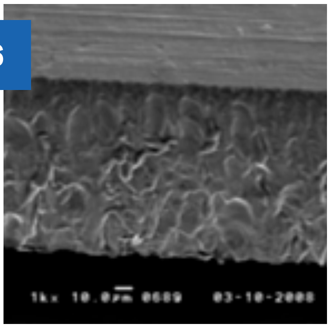

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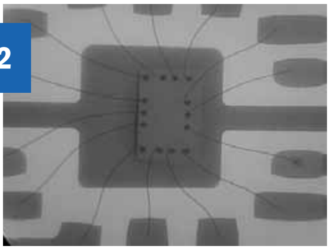

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Pradeep Chakraborty
Technical Editor

Latest ISA study

This is the time of the year when the India Semiconductor Association (ISA) comes out with its report on the Indian semiconductor and electronics industries, an exercise conducted with Frost & Sullivan.

As per the ISA-F&S report, the overall Indian semiconductor market's performance in 2010 included the following:

- India's semiconductor market grew by a phenomenal 28.3 percent in 2010; the global semiconductor market's cyclical trends have minimal impact on India.
- Mobile devices, telecommunication and IT/ OA contributed 82 percent to the total semiconductor market (TM) in 2010.
- Local manufacturing of telecom equipment by OEMs and EMS companies will propel related semiconductor consumption by a massive 50 percent during 2010 to 2012.
- Influenced by regulatory norms and sharpening competition, the automotive segment is expected to account for the highest growth in semiconductor demand, at 31 percent from 2010 to 2012.
- The sustained gulf between semiconductor TM and total semiconductor available market (TAM) from 2010-2012 highlights the urgency to promote local manufacturing to drive higher growth in the TAM.

The report further summarizes that products demonstrating potential for explosive growth include mobile devices, telecom base stations, LCD TV, STB, EMS, CFL, LED lights and smart cards, and products with low MI—notebooks, tablets, STBs, routers, digital cameras, etc., need to be given preferential treatment for indigenous manufacturing.

Semiconductor TM revenues are poised to grow from $6.55 billion in 2010 to $9.86 billion in 2012. The market is expected to witness a CAGR of 22.7 percent.

During the corresponding period, the semiconductor TAM revenues are likely to grow at a CAGR of 22.3 percent reaching revenues of $4.71 billion in 2012 from $3.14 billion in 2010. Mobile devices and telecom are said to be the key contributors to TAM, while mobile devices and IT/ OA are the likely key contributors to TM. The memory market leads the contribution to semiconductor revenues with 23.4 percent and 20.1 percent of TM and TAM, respectively.

The need of the hour is a focused mission for local electronics manufacturing promotion. A National Electronics Development Plan is also required, as are an electronics policy for ecosystem development, subsidies for manufacturing, funds for R&D, extended tax breaks, and hardware development parks.

One gets the feeling that this study is still a mixture of what the India centers of global MNCs are doing, and the numbers from the Indian companies are simply being added to beef up the numbers. I may be wrong, but that's what it seems like!

First, when a similar study is done for other Asian countries, such as China, Japan and Taiwan, for example, one does not find names of leading MNCs within those studies. Next, how many Indian electronics manufacturing companies are involved in EMS? SFO, based in Kochi, Kerala, is one of the very few among them. Who are the others? And, more importantly, where are they based?

Would it not be proper for the ISA or any related Indian industry body to come up with a study focusing entirely on the Indian electronics and semiconductor manufacturers? It would really not matter how large or small those companies are. Even better, why not also publish a list of names of the companies that are part of such a report? At least, the real strength of the Indian electronics and semiconductor industries would be well known to everyone. This is just an honest suggestion.

Industry news

DuPont™ Vespel® parts and shapes expands production in Asia Pacific

DuPont Performance Polymers has almost doubled its production capacity for DuPont™ Vespel® CR-6000 series parts and shapes with the addition of manufacturing capability at its site in Tuas, Singapore. CR-6100 parts and shapes have experienced growth in critical applications in refineries due to its improved chemical resistance, temperature performance and wear properties. Tuas, Singapore, opened in July 2008 as an additional manufacturing site for Vespel® S parts and shapes. *vespel.dupont.com*

Essemtec Asia founded in Singapore

Essemtec Switzerland founded a new central office for the Asian market in Singapore. Essemtec Asia will operate as a regional hub that coordinates customer requests with the local business partners throughout Asia.

"Essemtec Asia works as a hub that coordinates customer requests with the local partners in Asia," says COO Jay Kumar.

Contact details for Essemtec Asia are Jay Kumar, chief operating officer, Phone: +41(0)79 729 10 10, Email: jak@essemtec.com. *www.essemtec.com*

BTU ships 3000th thermal processing system out of Shanghai

BTU International has shipped its 3000th thermal processing system from its manufacturing plant in Shanghai, China. The facility, located inteh Waigaoqiao Free Trade Zone in Pudong, China, first opened in February 2004. It has been expanded a number of times since opening.

"We are certainly proud of our China facility and the global teamwork that has enabled our success there. Being physically located in the region has allowed us to respond more quickly to our customers in China and the rest of Asia," said Paul van der Wansem, chairman and CEO of BTU International. "We have a long-term commitment to the region and it is a key part of our plans for continued growth in the future." *www.btu.com*

Cobar BV hires business manager for Southeast Asia

The Balver Zinn Group added Marshal Jusmal to its sales team in Singapore, appointing him as the company's Southeast Asia Business Manager. In his new role, Marshal will be responsible for sales in Singapore, Indonesia, Malaysia and Thailand, reporting directly to Stan Renals, managing director CEO Cobar Division. Marshal has more than 20 years experience in the electronics and semiconductor industries. *www.cobar.com*

element14 and Littelfuse expand their regional distribution agreement

element14 recently expanded its partnership with Littelfuse, the manufacturer for high performance circuit protection devices. Offering the widest range of Littelfuse products stocked in Asia Pacific with no minimum order quantity required, element14 adds over 400 new products from Littelfuse POWR-GARD circuit protection solutions across three distinct classes of fuses to electronic design engineers and maintenance and repair professionals in South East Asia, India, Australia and New Zealand. in.element14.com, *www.littelfuse.com*

Intertek inaugurates electronic and electrical lab in Mumbai

Intertek inaugurated its first testing laboratory in Mumbai running on electronic and electrical platform to provide enhanced testing services to their customers across diverse industries.

"This is our second lab launch in Mumbai in the last three months", said Mr. Paul Yao, executive vice president, Intertek Group, "and this will cater to the certification of certain products to Indian, international, European and North American standards."

Intertek conducts electrical safety testing to ANSI/UL, CSA, NFPA, IEC, EN and other standards, EMC testing to local or global requirements, benchmarking and performance testing for R&D or competitive differentiation, environmental compliance to different energy efficiency programs, RoHS, or ErP Directive (formerly EuP) requirements, and turnkey certification management. *www.intertek.com*

WD® establishes hard drive R&D center in Singapore

Western Digital® has established a research and development center in Singapore. Located in Singapore Science Park, near WD's newly acquired media manufacturing operation, the Western Digital Singapore HDD R&D Center is now operational. The company also announced that it is entering an agreement with Singapore's A*STAR Data Storage Institute (DSI) to collaborate on the development of advanced head, media and hard drive system design. WD will have invested S$500 million (approximately $390 million USD) in Singapore over the next five years, including its recent media plant acquisition, capital equipment for capacity expansion and technology enhancements and the HDD R&D Center. *www.westerndigital.com*

Computer Simulation Tech opens Malaysia and Singapore offices

In order to meet the growing demand for simulation products and to fulfill customer requirements with respect to technical consultancy and support, CST, Computer Simulation Technology (Darmstadt, Germany), has founded two new companies: Computer Simulation Technology Malaysia Sdn. Bhd. in Kuala Lumpur and CST South East Asia Pte. Ltd., based in Singapore. CST develops and markets high performance software for the simulation of electromagnetic fields in all frequency bands, allowing customers to characterize, design and optimize electromagnetic devices all before going into the lab or measurement chamber. *www.cst.com*

Malaysia government looks to E&E sector to contribute RM90 billion To GNI by 2020

The Government of Malaysia is hoping to revitalize the country's electrical and electronics (E&E) sector and increase its contribution to the gross national income (GNI) by RM53 billion to reach RM90 billion by 2020. Deputy Prime Minister Tan Sri Muhyiddin Yassin said this would provide an additional 157,000 high-skilled and medium-skilled jobs in the country. He said he hoped the pro-business environment in Malaysia will continue to attract more forward-looking multinational investors.

"As such, Malaysia has identified 15 high value added entry point projects (EPP) in the E&E sector under the Economic Transformation Programme (ETP). Ultimately, we aim to strengthen Malaysia's E&E capabilities across the value chain," he said when launching the AMD Global Services Centre earlier this month. The new four-story centre employs about 400 personnel.

AIM expands technical sales support in Philippines

AIM has hired Orlando Ilano as technical sales support manager for the Philippines. Orlando has 18 years of experience in the areas of SMT and THT processes and systems. He will be based in the Philippines and will focus on the sales and support of AIM solder materials throughout the area. Orlando may be reached at oilano@aimsolder.com or by phone at +639158147977. AIM produces solder paste, liquid flux, cored wire, bar solder, epoxies, preforms and specialty alloys such as indium and gold. *www.aimsolder.com*

Multitest's Mercury contactors for wafer-level test successfully deployed to subcontractors in Asia

Multitest, a designer and manufacturer of final test handlers, contactors and load boards used by integrated device manufacturers (IDMs) and final test subcontractors worldwide, announced that another major fabless semiconductor manufacturer has evaluated and approved its Mercury-based wafer-level contactors. The Mercury contactors passed all qualification tests in the United States and now have been deployed to multiple testing subcontractors in Taiwan and Singapore. Based on this successful evaluation, the manufacturer has awarded Multitest with two additional WLCSP projects. Several of the Asian subcontractors have experience with the Mercury technology and are pleased with the long life, low maintenance requirements and low replacement probe price that the Mercury contactors provide. *www.multitest.com*

India electronics export grew 40%

According to India's Commerce Secretary, Shri Rahul Khullar, during February 2011, India's exports reached an overall growth of 49.8%, the equivalent of US $23.6 billion. During the period from April 2010 through February 2011, total exports reached $208.2 billion--an increase of 31.4%.

India's imports in February 2011 are estimated to be US $31.7 billion. The balance of trade for the month of February stood at US $8.1 billion.

From April 2010 to February 2011, electronics sector exports grew 40% ($7 billion). Electronics imports over the same period grew 5.6% ($20.1 billion).

Indian market handset sales expected to approach 229 million units in 2015

India's consumer electronics devices market, defined as the addressable market for computing devices, mobile handsets and AV products, is projected at about US$29.4bn in 2011, according to Research and Markets. This is expected to increase to US$50.6bn by 2015, driven by rising incomes and growing affordability. Only nine out of 1,000 people in India own a computer, one-fifth of the level in China, while Indian handset population penetration is about 57%.

Spending on consumer electronics devices is projected to grow at an overall CAGR of 14% through 2015. *www.researchandmarkets.com*

3M, Quanta form Singapore company to manufacture multi-touch solutions

3M and Quanta signed a definitive agreement to form a new company based in Singapore that will manufacture and commercialize projected capacitive touch solutions for the personal computing market. The agreement combines Quanta's extensive industry knowledge and manufacturing expertise in the PC market with 3M's projected capacitive technology expertise. *www.quantatw.com*, *www.3M.com*

Conquering SMT stencil printing challenges with today's miniature components

Is electroform technology the right solution?

Robert F. Dervaes, Fine Line Stencil, Inc; Jeff Poulos, Alternative Solutions, Inc; and Scott Williams, Ed Fagan, Inc.

The technological advancement of component and PCB technology from through-hole to surface mount (SMT) is a major factor in the miniaturization of today's electronics. Smaller and smaller component sizes and more densely packed PCBs lead to more powerful designs in much smaller product packages. With advancement, however, comes a new set of challenges in building these smaller, more complex assemblies. This is the challenge original equipment manufacturers (OEM) and contract manufacturers (CM) face today.

Keywords: stencil printing, stencil technology

One of the challenges facing OEMs and CMs in building assemblies with miniature components is the stencil printing process. Many of today's designs incorporate a mix of miniature and much larger components. Manufacturing engineers are faced with the dilemma of choosing a thinner stencil foil to ensure solder paste release for the miniature components or a thicker foil to ensure sufficient solder volume for the larger components. With a standard laser-cut stencil using 300 series stainless steel, one would have to make that difficult choice. An electroformed stencil gives more options in balancing release for miniature components and volume for larger ones due to its ability to successfully print smaller components without reducing the foil thickness. However, many have difficulty justifying the 3X-4X cost increase and added schedule delay for an electroformed stencil, especially with more and more companies moving to a low-volume, high-mix array of jobs. Faced with these two options, is electroformed technology the right solution or have technological advancements allowed new developments in stencil technology?

This article discusses new developments in stencil laser and material technology and shows how these advancements, when combined, provide comparable and cost-effective alternatives to traditional electroformed stencils. The results are improved yields, cycle time reductions, and significant cost savings.

Brief history of stencil technologies

Before stencil lasers were developed, the only manufacturing methods for producing solder paste stencils were silk screening and chemical etching. The etching process was time consuming and hazardous due to the powerful chemicals used to etch the metal. There also were limitations as to how small a stencil aperture could be effectively produced during the etching process. Chemically etched stencils typically were limited to component pitches no smaller than 0.025" and registration of the stencil apertures to the SMT pads was not precise enough as component sizes decreased. These limitations would not allow chemical etching to keep pace with the rapid advancements in component and PCB design.

In the early 1990s, lasers started being used to produce solder paste stencils. This new technology was a major improvement over traditional silkscreen and chemical etching in producing stencils quicker, cheaper, and with much smaller aperture sizes. The motion systems on the laser systems also provided a much higher positional accuracy for the stencil apertures, leading to much better alignment between the stencil and PCB. With these significant improvements, component pitches down to 0.016" could easily be cut.

While these laser systems are capable of producing high-quality solder paste stencils for the majority of assemblies, advancements in component and PCB design continued. With the introduction of components like micro BGA (µBGA), quad flat no-lead (QFN), and 0201s, laser-cut stencils struggled to produce acceptable solder paste release for these very small apertures without a reduction in the thickness of the stencil foil. This was not always an acceptable solution, as the larger components would have insufficient solder volume. Enter electroformed technology. Electroformed stencils are produced by electroplating nickel on top of a stainless steel substrate under various specialized and challenging conditions. The plated nickel film is later removed from the stainless steel substrate resulting in the nickel foil that is the electroformed stencil. This manufacturing process produces an exceptionally smooth stencil aperture wall compared to chemically etched and traditional laser-cut stencils. The smoothness of the aperture wall is a vital component of a high performance stencil allowing printing of smaller apertures without reducing the foil thickness.

For many years, electroformed stencils have been the premier solution for these new, challenging assemblies. However, the assembly industry as a whole is being driven to turn product faster and cheaper. Electroformed stencil prices typically are 3X-4X higher than traditional laser-cut stencils and it takes longer to produce an electroformed stencil. In most cases, the turn time is three to four days, and this technology is limited to only a few shops that have the knowledge and expertise in plating very thin nickel foils. Many OEMs and CMs need stencils produced and shipped the day the order is placed in order to meet their schedule. The higher cost and longer lead-time of electroformed stencils make it more difficult to meet the schedule and cost demands of today's assemblies. How does one determine if a traditional laser-cut or electroformed stencil is required?

There are two formulas used to determine whether or not the smallest aperture on a stencil will have acceptable solder paste release with a given stencil technology. These are *surface area ratio* and *aspect ratio*. The *surface area ratio* can be used for any stencil aperture shape and is the contact area between the paste and PCB pad (L x W) divided by the contact area between the paste and stencil ((2 x L x T) + (2 x W X T)). The *aspect ratio* is limited to rectangular, square and round stencil apertures and is the smallest dimension of an aperture (width (W) for rectangles and squares, diameter for circles) divided by the thickness (T) of the stencil foil (historically the aspect ratio has been limited to 1.5 for rectangles and 2.5 for squares and circles). Since the majority of stencils have a mixture of aperture shapes, including custom shapes (homeplates) for 2-pin components, the *surface area ratio* formula is the most accurate when determining which stencil technology to utilize.

To successfully print small components without reducing the stencil foil thickness, the stencil must be capable of producing acceptable solder paste release at as low a *surface area ratio* as possible. The historical limit of chemically etched and traditional laser-cut stencils has been a surface area ratio of 0.66. In the case of electroformed stencils, the limit has been improved to 0.5. The lower surface area ratio limit of electroformed stencils is the reason for selecting this technology when facing challenging assemblies.

With all of the advancements in component and PCB design, has advancement in the stencil industry remained stagnant or has technological improvement benefited this industry as well? Is the stencil industry now in a better position to provide solutions for printing miniature components while meeting customers' tighter delivery and cost requirements?

New developments in stencil laser technology

Stencil laser technology has seen continuous advancement over the past 10 years. The majority of advancement has been in linear motor technology, leading to improvements in the cutting speed of stencil lasers. Until recently, *the source of the laser beam has remained the same* with reliance on lamp pumped technology. The lamp pumped technology is comprised of flash lamps, YAG rods, mirrors, and focal lenses. With this technology, the smallest diameter laser beam possible was approximately 40 µm. While this diameter beam is fine for the majority of stencil designs, the energy density with a 40 µm beam diameter is not high enough to produce the smoothest aperture walls when cutting stencil apertures for miniature components.

In the past two years, there has been a major leap forward in laser technology. The most significant development is the introduction of the single mode CW Ytterbium fiber laser ("fiber laser" for short). The new fiber lasers produce shorter pulse widths, higher frequencies, and have a fully programmable pulse/pause ratio. In addition, they produce a smaller laser beam diameter of 19 microns with a corresponding 4X increase in energy density. The 4X increase in energy density significantly increases the laser beam's ability to cut through the metal and the result is a much smoother aperture wall (*Figure 3*).

Aspect ratio = W/T >= 1.5
Area ratio >= 0.66 (historical limit)
Area ratio >= 0.5 (electroformed)
Area ratio = (LxW)/((2xLxT) + (2xWxT))

Figure 1. Aspect ratio, area ratio.

Figure 2. LPKF MultiCut Fiber Laser.

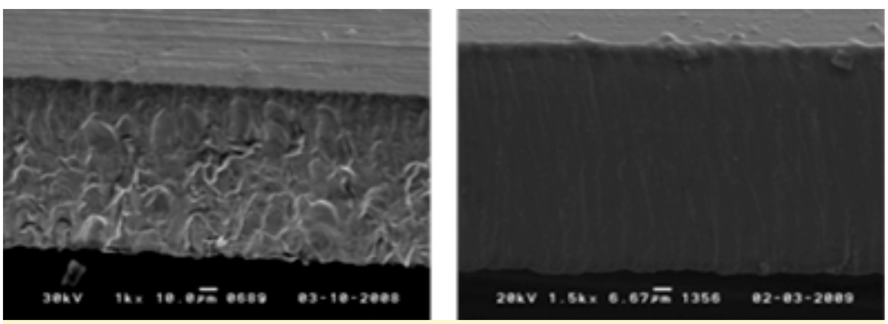


Figure 3. SEM photos of SS 300 series (left) and new material (right) aperture walls.

New developments in stencil material technology

Along with advancements in laser technology, there also have been advancements in stencil material technology. For many years, laser-cut stencils used either 300 series stainless steel or a higher nickel alloy (Invar Alloy 36, Alloy 42) for the stencil foil material. These are good solutions for the majority of assemblies, but their paste release performance reduces considerably when printing apertures with surface area ratios below 0.66. As a result, one would have to either increase, "overprint," the aperture sizes when selecting a thicker foil or reduce the foil thickness for acceptable prints.

Overprinting miniature components, however, is not always a guaranteed solution since the crucial surface area in the surface area ratio formula is the common metallic surface area between the SMT pad and the stencil aperture. If a PCB has a CSP component with a 0.010" diameter pad and the stencil overprints with a 0.012" diameter aperture, the common metallic surface is still limited to the 0.010" diameter of the SMT pad. The additional paste beyond the 0.010" limit of the SMT pad is not in contact with the metallic surface and, therefore, does not contribute to pulling the paste from the stencil.

Figure 4. Grain size comparison: SS 300 series (left) and new material (right).

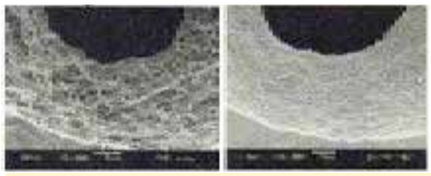


Figure 5. Aperture edge comparison: SS 300 series (left) and new material (right).

Advancements in stencil material technology include new stencil materials specifically designed for stencil laser cutting. The *Fine Grain* material (distributed by Ed Fagan, Inc.) has a much finer grain structure (*Figure 4*) when compared to standard 300 series stainless steel and alloys, and contain smaller and fewer voids in the material. With smaller and fewer voids, the solder paste does not adhere as easily to the stencil walls. This is primarily due to the micro size of the voids (in some cases smaller than the particle sizes in the solder paste) that makes it more difficult for the solder paste particles to get a grip on the stencil walls. When the solder paste is pulled from the stencil as the PCB drops, release is easier and less paste residue is retained in the stencil. The easier release allows for the printing of smaller stencil apertures, without reductions in foil thickness, and the reduction in paste residue allows for an increase in the number of prints before having to clean the stencil.

Design of experiment details

Test Items

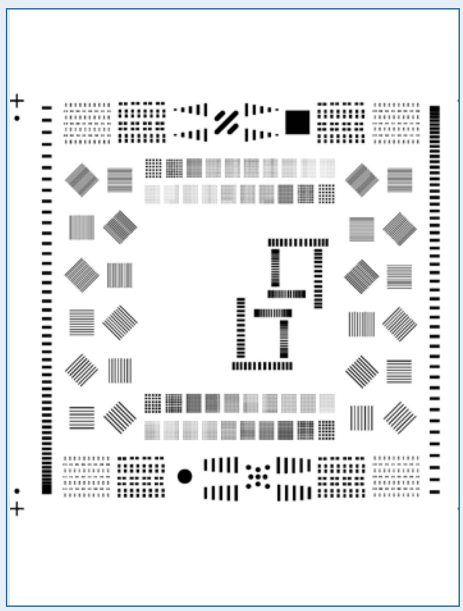
Lasers:	LPKF LPKF MultiCut (high-power Nd:YLF fiber laser , new technology) LPKF SL 600 (lamp-pumped Nd:YAG laser, current technology)
Materials:	New Fine Grain (UltraSlic™ FG) material Slic™ material Electroformed Electroformed nickel sheet with laser-cut apertures Rolled nickel sheet with laser-cut apertures SS 300 series
Solder Pastes:	Water Soluble—WS150 Type 3 and Type 5, WS157 Type 3 and Type 5 No-Clean—NC650 Type 3 and Type 5 Lead-Free—Sn100C Type 3 and Type 5, SAC 305 Type 5

Test Equipment and Parameters

Printer:	DEK 265GSX
Blades:	DEK
Print Speeds:	50.8 mm/sec and 127 mm/sec
Separation:	0.3 mm/sec and 7 mm/sec
Print Gap:	0 (on contact)
Stencil Clean:	Every print
Inspection:	Koh Young KY-3030 3D

Test Board
(image at right)

Finish:	Electroless Nickel/Immersion Gold (ENIG)
Surface are ratios:	0.17 to 15
Pad count:	4,188



In addition to improved paste release for smaller apertures and much cleaner paste release throughout the entire stencil, the finer grain structure of these new materials also produces a more defined aperture edge (see picture at left) when cut with a properly tuned laser beam. As the aperture size decreases, the importance of repeatable and accurate solder paste release rises. With miniature components, small fluctuations in solder volume have a much larger impact on solder joint reliability due to the minimal solder volume required. A more defined aperture edge, along with improved paste release, leads to more repeatable and accurate solder paste release.

The new materials are a stainless steel composition and are rolled so thickness tolerances are extremely tight. They also have improved thermal conductivity as well as similar mechanical and corrosion resistant properties when compared to standard 300 series stainless steel. Stencil life and durability are similar to standard 300 series stainless steel stencils.

Stencil laser and material technology advancements: performance

Technological developments in component and PCB design are beginning to outpace current stencil technology. Do these significant advancements in stencil laser and material technologies provide the current and future solutions the electronics assembly industry requires? That question is best answered through a design of experiments (DOE) comparing the new laser and material technologies with the standard stencil technologies available today.

DOE: The Viability of New Stencil Laser and Material Technology

The objective is to determine the viability of this new stencil laser and material technology and its impact on the current, and future, demands of the electronics assembly industry.

The objective of the DOE is to determine the viability of the new stencil laser and material technologies. The results of the current technologies were as expected—of those, electroformed had the best solder paste release. How did the new stencil laser and material technology compare to current stencil technologies?

New Fine Grain performance

The surface area ratio limit for electroformed technology is 0.5. While a significant improvement over standard laser-cut stencils, materials that offer improved performance at area ratios of 0.5, and below are going to be a requirement as component and PCB technology continues to advance.

Solder paste volume

The results in *Figure 6* illustrate the print performance of the various stencil technologies over the entire range of solder paste types tested. All were laser-cut on the new LPKF Multicut fiber laser, except the electroformed stencil, which utilized traditional electroform technology. The electroformed stencil was the performance baseline with acceptable paste volume % at a surface area ratio of 0.5. The laser-cut electroformed nickel sheet had acceptable paste volume % down to 0.45, but its print performance quickly flattened out compared to the fine grain and electroformed stencils. The fine grain stencil had acceptable paste volume % at 0.45, and its print performance continued to outperform electroformed as the surface area ratio increased. The performance increase down to a surface area ratio of 0.45 allows the printing of even smaller components without a corresponding reduction in the stencil foil thickness. The result is additional solder paste volume for the non-miniature components, resulting in less rework and improved solder joint reliability.

Aperture registration

As component pad sizes continue to decrease, alignment accuracy between the stencil and PCB is becoming more critical. The adhesion of the solder paste to the SMT pad is the sole force involved in pulling the paste from the stencil. Since PCBs will tend to shrink during the manufacturing process, SMT pad locations tend to be slightly short of their expected locations. Long PCBs, of course, will have significantly greater shrinkage than short PCBs.

In addition to PCB shrinkage, the electroformed stencil process uses Mylar film to create the stencil image. The film is dimensionally unstable due to its susceptibility to temperature and humidity fluctuations. Without tight temperature and humidity controls in the manufacturing area, shifts in aperture locations can occur during plotting of the Mylar film and during its use.

Since the electroform process only produces the electroformed foil, it typically has to be mounted into a stencil frame. During the electroform process, no tension is applied to the electroformed foil. When mounted into a stencil frame, tension is applied to electroformed foil by the stencil frame's polyester mesh. This tension pulls on the foil causing slight shifts in the locations of the stencil apertures. In most cases, the electroformed stencil aperture locations will be long, or further away from their expected locations. If the PCB has SMT pad locations that are short of

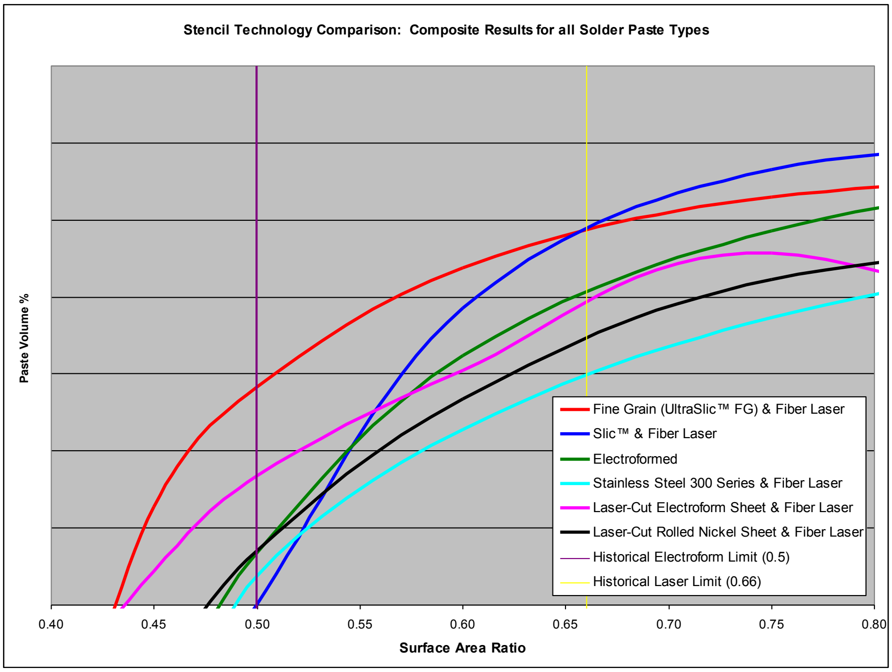


Figure 6. Stencil technology comparison.

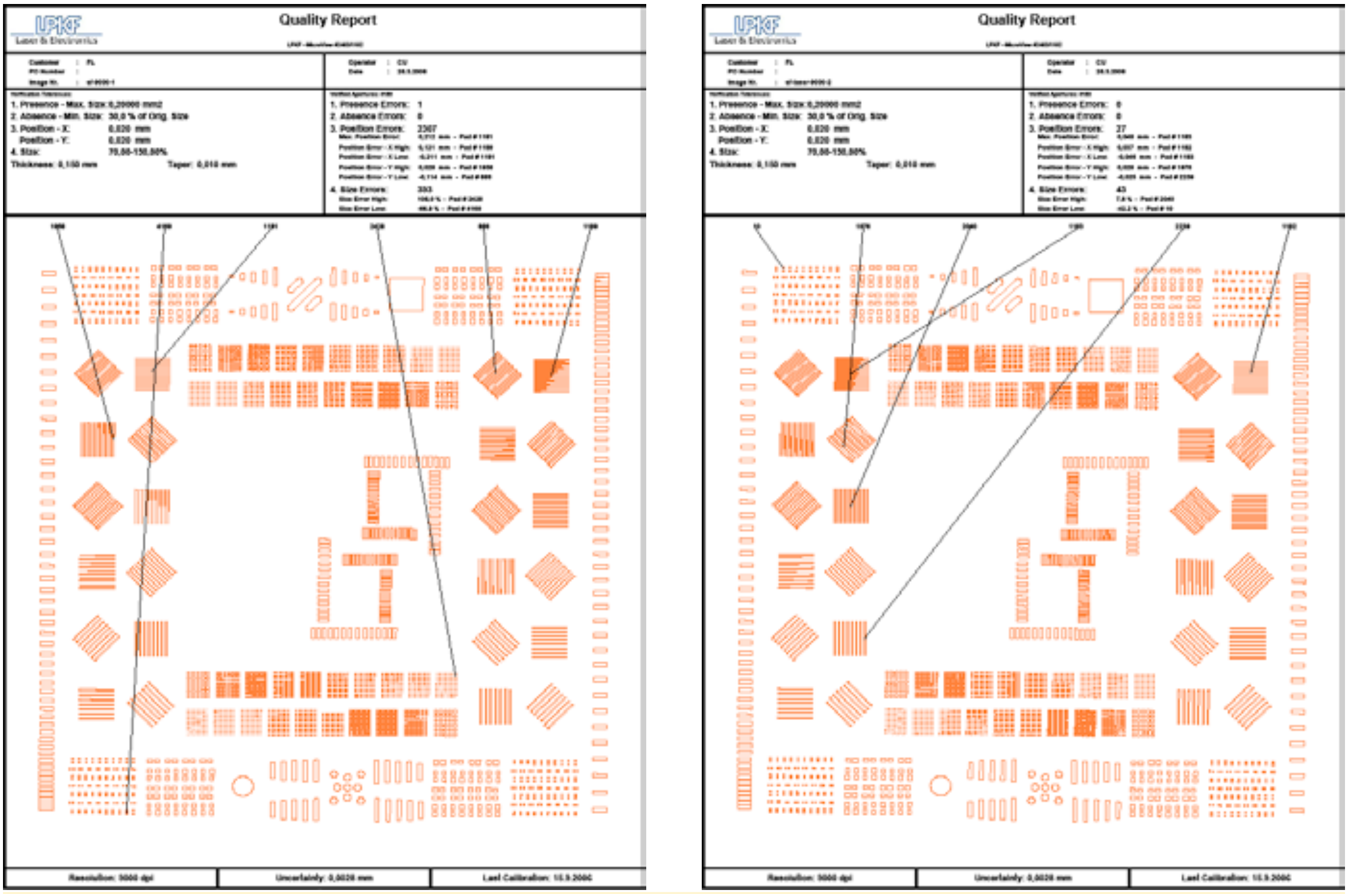


Figure 7. Electroformed (left) and Fine Grain (right) stencil aperture registration accuracy. 2,307 position errors with electromed stencil; 27 with Fine Grain.

expected locations and the electroformed stencil has aperture locations further away than expected, there can be a significant shift, or misalignment, between the stencil apertures and PCB pads.

A shift between the stencil aperture and PCB pad reduces the amount of solder paste in contact with the surface of the PCB pad. This lowers the adhesive force between the solder paste and PCB pad, effectively reducing the ability of the board to pull the paste from the stencil. Miniature components already have very low surface area ratios. The lower the surface area

ratio, the more critical the alignment between the stencil aperture and PCB pad. The fine grain stencil in this DOE was cut in the frame on the new LPKF high-power short-pulse fiber laser. The intent was to minimize stencil aperture registration errors, thereby increasing the alignment accuracy between the stencil and PCB. The results (27 position errors for the fine grain stencil and 2,307 position errors for the electroformed stencil) below show a marked improvement in aperture registration when compared to an electroformed stencil.

Conclusion

As advancements continue in component and PCB technologies, will the stencil technology of today provide current and future solutions to the challenging assembly issues faced by OEMs and CMs? Is electroformed technology the right solution or have new developments in stencil laser and material technologies caught up with and surpassed the electroformed technology of today?

The answer to these important questions is in our view an unequivocal "yes." Stencil laser and material technologies have advanced to the point where laser-cut stencil performance is beyond that of current electroformed technology. Using the new LPKF high-power short-pulse fiber laser technology and the new fine grain material, stencil performance is significantly improved over electroformed, especially when printing miniature components. Improvements in stencil laser and material technologies have lead to significant improvements in solder paste release down to a surface area ratio of 0.45 as well as improved aperture registration accuracy. These improvements are critical to meeting future requirements when printing miniature components like 01005s. The technology summary is shown in *Table 1*.

At a cost savings of 30-50 percent compared to electroformed, the ability to produce multi-thickness (step) stencils, and the option of same day turn times, fine grain stencils, cut with the new fiber lasers, are a marked improvement compared to the high-performance stencil solutions available today. OEMs and CMs can get the performance they need while reducing costs and meeting critical delivery schedules. The new stencil laser and material technologies available today give stencil manufacturers the tools and materials needed to supply an ever-changing industry for many years to come.

Acknowledgement

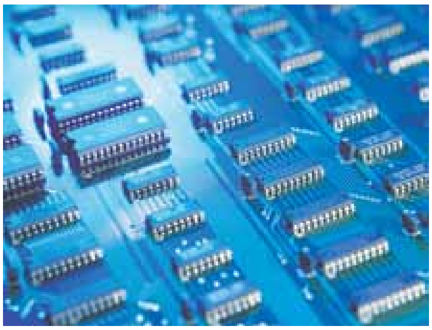
The authors would like to thank Stephan Schmidt and Sebastian Gerberding of LPKF Laser Electronics (www.lpkfusa.com) for their contribution to this article.

Using x-ray to crack the case of the counterfeit component

Kathryn Cramer, Glenbrook Technologies

Many distributors rely on only two verification steps: checking the components' documentation and conducting visual inspection, sometimes with minimal magnification. Some companies also select sample parts for decapsulation, a destructive technique, to inspect the internal die. But without sufficient magnification, verification of questionable components cannot be assured. Adding x-ray inspection to the process enables the inspector to compare the components' internal features nondestructively, within a lot and with known good samples. Among the problems that can be identified through x-ray inspection are broken or damaged wire bonds, totally missing internal features, variations in die size and sometimes parts that are marked backwards.

Keywords: Counterfeit Components, X-Ray Inspection



The first time a component distributor called Steve Zweig, vice-president of sales for Glenbrook Technologies, to ask about using the company's x-ray inspection equipment to detect counterfeit components, Zweig thought it was an isolated incident.

Little did he realize that, four years later, the problem would have grown to such epidemic proportions that he'd embark on an investigation, going directly to the source and purchasing components from a Chinese market, then subjecting them to visual and x-ray inspection to discover what each technique would reveal.

Both the U.S. Department of Homeland Security and the U.S. Chamber of Commerce have reported that the incidence of counterfeit components has increased dramatically over the past decade, continuing right through the global economic slowdown. One estimate values the worldwide market for counterfeit electronics at up to $10 billion annually and names China, particularly the Shenzhen area, as the source of approximately 70 percent of those counterfeits.

The issue even attracted the interest of television's Sixty Minutes. The program aired a segment highlighting two areas of concern: the potential economic cost to manufacturers who use counterfeit parts unwittingly and have to deal with product failures, as well as the health hazards associated with workers' handling toxic materials and the impact of their improper disposal on the environment.

While the ideal solution would be to use only parts from Original Component Manufacturers, this is not always feasible, especially if the part is in short supply or is no longer manufactured. On the open market, parts are sourced through electronic component distributors, brokers or resellers—of which there are thousands in the U.S. alone.

"Since the counterfeit parts mix openly with other products, it doesn't take long for them to slip into the inventory of even reputable firms," Zweig explains. And many assemblers look for the lowest bids, even for critical requirements such as military or commercial aircraft. It is in just such instances that counterfeit parts can be introduced into the supply chain.

Zweig's interest in the counterfeit issue grew as component distributors began purchasing and using Glenbrook's x-ray inspection equipment to build image libraries of known good parts against which they could verify images of incoming parts that have shown a history of being counterfeited. Glenbrook's customers range in size from large firms that maintain more than 100,000 line items in stock and make thousands of component sales each month to hundreds of small companies, each employing fewer than 15 people.

Whether they are large, small or mid-size, all distributors share one concern: ver-

ifying the authenticity of the components they buy and sell is critical to maintaining customer bases that include Fortune 500 firms in the high-tech, military and medical sectors. No company wants to develop a reputation for passing on counterfeit parts, even unwittingly. Yet, industry-wide, relatively few distributors are using what appear to be all the necessary inspection techniques to identify counterfeits.

Many distributors rely on only two verification steps: checking the components' documentation and conducting visual inspection, sometimes with minimal magnification. Some companies also select sample parts for decapsulation, a destructive technique, to inspect the internal die.

"I've visited some very large component distributors that did not use greater than 5x magnification," Zweig says. "Yet many of the smaller distributors were using up to 1,000x magnification." A number of courses are offered in visual inspection of components, he notes, and they are quite comprehensive. One offered by the IDEA (Independent Distributors of Electronics Association) provides attendees with a hefty volume of reference images.

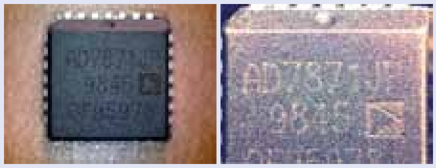
But without sufficient magnification, verification of questionable components cannot be assured. "With the use of a metallurgical microscope, generally up to 1,000x, the inspector can see the entire die with its markings and logo as well as the bond wires," Zweig explains.

Adding x-ray inspection to the process enables the inspector to compare the components' internal features non-destructively, within a lot and with known good samples. Ideally, the distributor builds a library of part numbers and compares each new x-ray image to a known good image. Among the problems that can be identified through x-ray inspection are broken or damaged wire bonds, totally missing internal features, variations in die size and sometimes parts that are marked backwards.

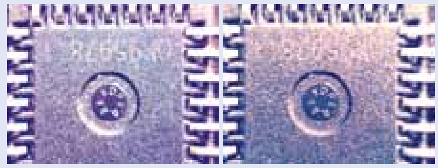
The x-ray images can be used to demonstrate to a component provider why parts are being rejected, and to verify to

Results of a combination of x-ray & visual inspection

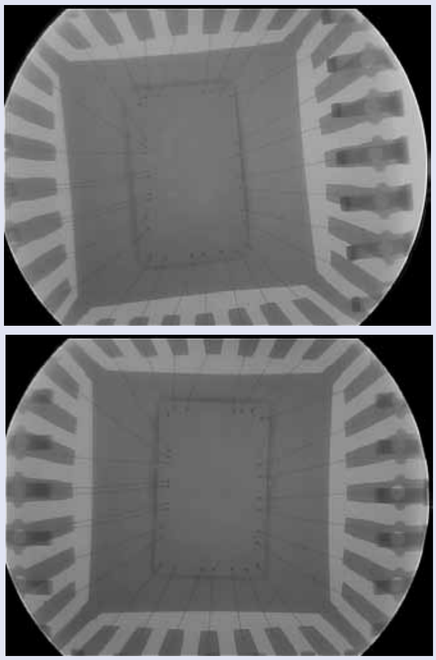
AD7871JP



A. The original part, and the part after solvent testing.



B. Comparing the bottom of the part visually for consistency with IDEA standards.

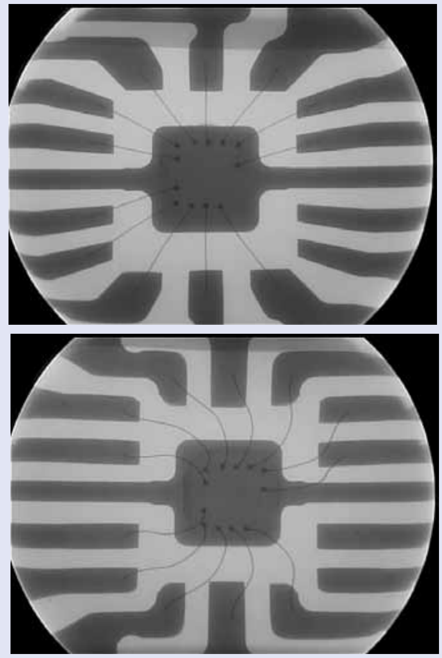


C. X-ray inspection shows no noticeable variation internally.

Test Result: Visually, the part appears to show bad lasering. But the solvent did not remove the blacktop and the x-ray did not show any problems. While this is likely to be a good part, some distributors have indicated that they would reject it based on the lasering quality.

CD4000BE

A. The original part, and blacktop removed by solvent testing.

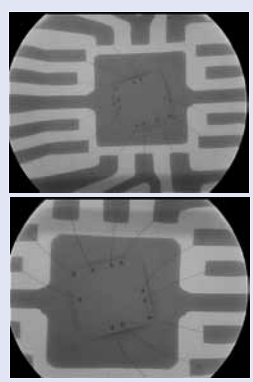


B. The part has a good appearance, but note the twisting of the wire bonds.

Test Result: The visual inspection showed that the original blacktopping was removed. The x-ray image confirms that this is a suspect part. It would be rejected.

LM565CN

A. A visual image of the part. A total of seven parts were lined up in the same configuration.



B. During x-ray inspection, two of the seven parts show this reversed internal image. It appears that the parts were remarked backwards.

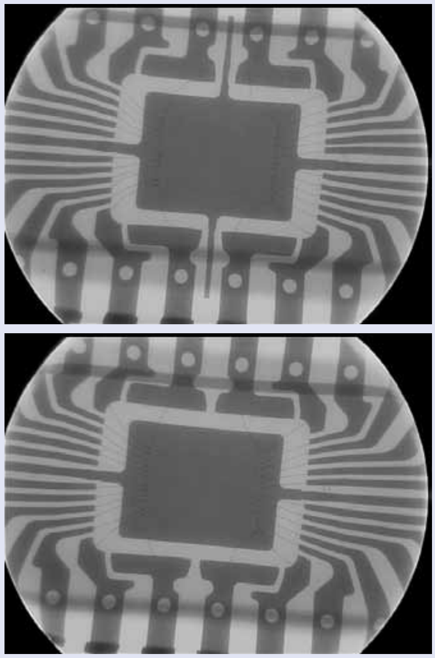
Test Result: Visual inspection did not identify any problems, but x-ray inspection allowed us to find parts that were remarked.

LH5164A

A. Visually the parts seem good and the solvent did not remove any blacktop.

B. When the bottom of the part is inspected visually, the Japan logo is reversed.

Test Result: The flipped logo on the bottom results in a part that is rejected.



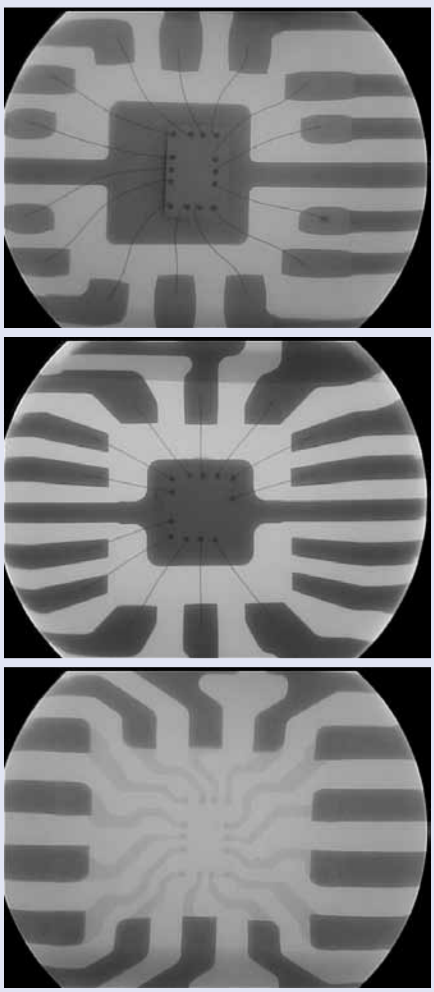
C. The x-ray image reveals no internal differences.

MM74C08N

A. Visually, the part seems okay, and solvent testing does not remove the top surface.

B. A series of x-ray images from three different parts: The top part seems acceptable; the middle part has wires that are twisted; the bottom part is empty.

Test Result: The visual inspection found no obvious problems, but the x-ray inspection clearly identifies these parts as defective.



the distributor's customer that the parts are authentic. Assemblers may even require x-ray images along with written documentation. Indeed, the more assemblers insist on such verification, the more difficult it will be for counterfeit components to make their way into the distribution channel and ultimately into cell phones, video games, aerospace instruments or medical devices.

How do these counterfeit parts make their way into the inventories of reputable companies? And how can they be identified before being assembled into everything from consumer electronics to critical military or medical devices? Zweig decided to track the suspects back to their source to see how easily counterfeit or bad product can be acquired and circulated into the component distributor channel.

With the aid of several Glenbrook customers, he developed a list of parts that have shown a history of being identified as counterfeit. He learned that recycled parts tend to come from the ever-increasing quantities of electronic scrap that provide a tremendous amount of raw material to counterfeiters, many of whom operate in the Shenzhen area of China.

"In these facilities," Zweig reports, "board sorting can take place almost anywhere, in large warehouses or small shops. Workers remove parts from the boards with their bare hands or basic tools, with no protection from contamination and no ESD precautions." As a result, parts that are labeled "recycled" are not always guaranteed to work properly. The sorting process involves nothing more than placing the parts into cups or jars. Generally, they are separated by package type and later by manufacturer or part number. At this point the refinishing or recycling process starts.

The parts are sanded to remove the original marking and then blacktopped and remarked. Blacktopping involves applying a black filler to the top surface of the part, then it may be marked with a different company name, logo and part number. An original Xilinx part may be remarked as a Motorola part. If the part is used in a critical application, the end result could be catastrophic.

"It used to be possible to identify blacktopping by rubbing the top of the part with a solvent," Zweig says. "But newer blacktopping materials are proving more resistant to standard detection techniques. Clearly, counterfeiters are continuing to improve their techniques to prevent detection." They also seem to have quick access to information regarding poplar part numbers, how to blacktop and repackage them, then insert them into distribution channels through the large number of huge electronic shopping marts devoted exclusively to selling components in the Shenzhen area.

Zweig's next step in his detecting venture was to enlist the aid of an associate. Working with Glenbrook's Hong Kong office, he dispatched one of the office's Chinese engineers to the Shenzhen market with the list supplied by Glenbrook's customers. At the market, components were marked as new or recycled, with the recycled parts priced as much as 80 percent less than the new parts. Glenbrook's engineer bought five to ten of each lot of components, selecting both new and recycled parts on the list. The part numbers purchased were AD7871JP, CD4000BE, MM74C089, LH5164A and LM565CN.

The investigation then entered its forensic stage, with the evidence subjected to a variety of inspection techniques. First, Zweig used Glenbrook's JewelBox 70T real-time x-ray inspection system, with up to 1,200x magnification, to inspect and capture images of each part. Then, because Glenbrook has less knowledge of the visual inspection process, he called on a distributor, Chase Components in New Smyrna Beach, Florida, for assistance. Chase, a Glenbrook customer, uses both x-ray and visual inspection as part of its extensive quality control process.

They were very generous in sharing their expertise in visual inspection with us," Zweig said. He traveled to their facility to conduct solvent tests for blacktopping, using two different solutions: 30 percent alcohol and 70 percent mineral spirits, and 25 percent alcohol and 75 percent acetone. Since newer blacktopping is resistant to the first solution, both techniques were used.

The results of the combination of x-ray and visual inspection for the five part numbers are illustrated and explained in the sidebars.

The study strongly emphasized the importance of experience in terms of visual inspection, knowing the correct techniques and current situation, as well as having the ability to use x-ray inspection to check components internally. While some defects can be spotted visually, others are not revealed until x-ray inspection provides an internal image.

It is only through the interaction of both techniques that a distributor can be assured of providing good components to its customer base—and assemblers can have greater confidence in the authenticity of the components they purchase. At the same time, it's easy to see how such defective parts can be re-introduced into the distribution channel without any history of the results.

"Good documentation and thorough inspection is absolutely critical to monitoring and, hopefully, reducing the problems posed by counterfeit electronic components," Zweig concludes.

Embedding components into PCBs needs accurate, reliable placement

Eric Klaver, Assembléon

*Components are increasingly being embedded into substrates, and SMT pick & place equipment is therefore now also being used in PC board manufacturing. The two critical challenges when placing components **into** PCBs are 1) accuracy and 2) avoiding cracked/ defective components.*

In a process driven particularly by the mobile industry, electronic products are rapidly decreasing in size while increasing the number of functions. Designs are therefore running out of space in which to place the components. The first steps to solve the problem have already been taken: a further miniaturization of components along with integration of passive components into ICs and packages. The steep increase in passive components (capacitors, resistors, inductors) in the latest designs of smart phones however demands alternative methods to free up PCB surface area to add more and more features. The next step is to place them *in* rather than *on* the PCB: embedded components.

The PCB industry has been embedding components into substrates since 2002, when Motorola Corporation announced it would use the technology in its mobile devices. The rise in popularity of smart phones has accelerated the shift from surface mounted components towards substrate embedded components. Chip components are now mainly being embedded into the substrates of packages and modules (memory modules, for example). Most PCB manufacturers are holding off embedding components into the PCB itself because they do not feel that pick & place machines are yet ready to place the components. That, however, is not true. Assembléon's machines are already successfully placing chip components within both packages and pc boards at several of its customers.

Many substrate manufacturers are therefore now dealing with an additional aspect within their process: picking and placing components into the substrate. This brings along a complete new set of challenges, not only for the substrate manufacturers, but also for the manufacturers of the pick & place equipment that have to deal with more fragile component types as well as an increased accuracy.

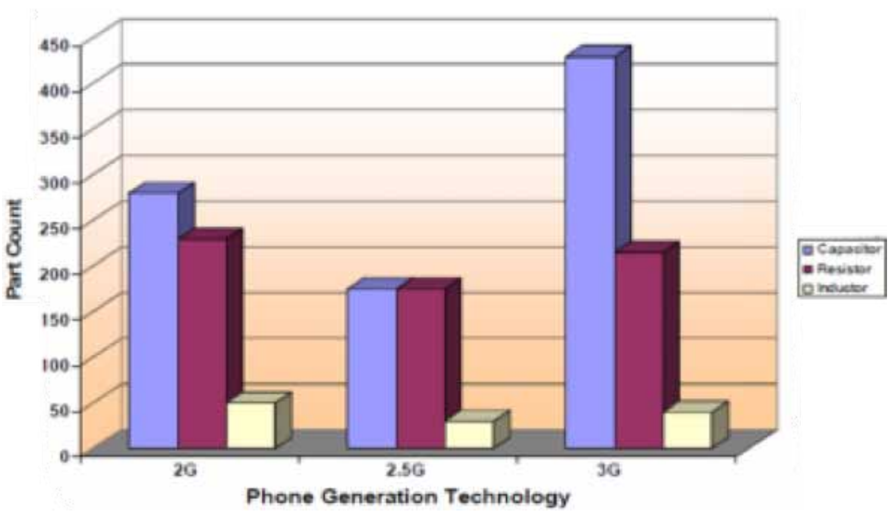


Figure 1. The number of passive components has significantly increased with the new generation of smart phones. All these passives occupy an enormous PCB surface area. [Source: Ohmega Technologies]

Keywords: Embedded Components

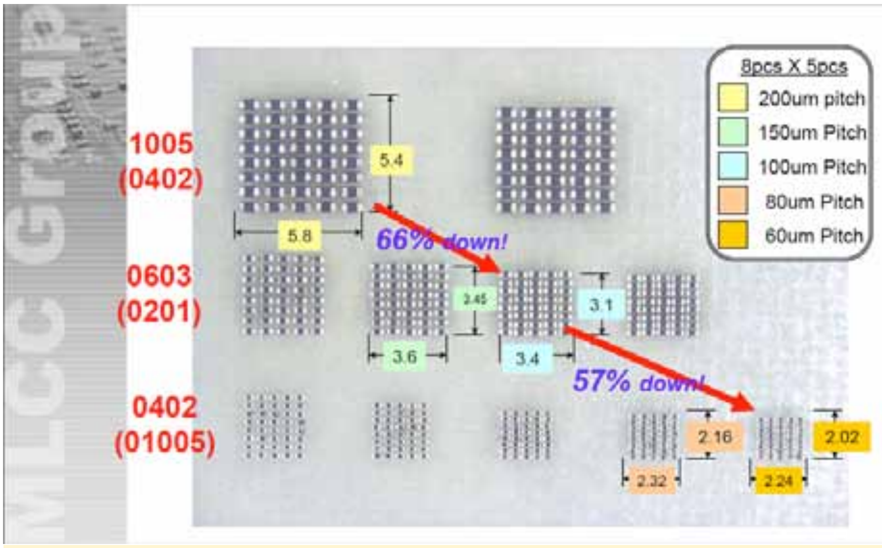


Figure 2. Component miniaturization. [Source MuRata]

Bonding type	2006	2010	2013F
Wirebonding	83%	79%	76%
Flip chip bonding	17%	21%	24%

Table 1. The trend is from wire bonding to flip-chip bonding.

New challenges for the substrate manufacturing industry

Substrate manufacturers dealing with embedded components, EPDs or EADs (embedded passive devices and embedded active devices) are going through some major process adjustment. There are many process steps for manufacturing substrates with embedded components and many challenges for end products, too, especially reliability. Manufacturers need to know the reliability of actually placing the passives or actives into the PCB, and what challenges it brings.

The idea of embedding components to save space has been around for 10 years or so, and the practice has now really taken off. Next generation mobile/smart phones, particularly, need to integrate newer functions in thinner and smaller products (*Figure 1*).

Consumer demand for more functions, features and applications means that passive part counts will only increase in phones that continue to shrink in size. There are three common options for decreasing the area occupied by passives:

a. Reduce the size of the component. So, the industry is shifting from 1.0 x 0.5 mm (1005Metric -EIA coding 0402) towards 0.6 x 0.3 mm (0603Metric -EIA coding 0201) and again towards 0.4 x 0.2 mm (0402Metric - EIA coding 01005).
b. Integrate (embed) passives into ICs to give system in package (SiP) or system on chip (SoC) modules. That has created many off-the-shelf modules for mobile phone manufacturers.
c. Integrate passives into the PCB. That moves the components from the surface *into* the substrate to free up area on the surface for other functions.

Reducing component sizes—PCBA industry challenge

Reducing component sizes and interspacings from 1005M to 0402M can reduce PCB areas by 85% (*Figure 2*). Although 0402M (EIA coding 01005) components can be handled by the backend industry (see next section), placing this component in high volumes can be a severe challenge for equipment that is already installed at customer sites. The processing characteristics of this micro-miniature component can actually demand investing in completely new equipment.

Even though it will take still a couple of years to introduce, the next step in component miniaturization has already been announced. The 0201Metric (0.2 x 0.1 mm) is not yet EIA size coded, but should be called the 0050025. These components will be a real challenge for both surface and embedded placement.

Embedding into ICs or packages—backend industry challenge

Although not every step in the backend processes is handled by SMT equipment (wire bonding, for example), an increasing number of passive components and flip chips are now being placed. The expected trend (*Table 1*), of wire bonding is towards flip chip bonding. So, for active components too, traditional SMT equipment is expected to move into the backend industry.

Any defects in components on a PCB surface can be reworked or repaired (although increasing complexities and costs are making this less and less desirable). Once embedded in a chip, though, there is no chance of rework. Avoiding scrap therefore demands a reliable production process and equipment.

There are actually great similarities to placing components on chip modules. The substrate is usually supported by a rigid frame to keep the surface absolutely straight. Component placements should therefore be done with great care as the impact during placement may cause the component to (micro)crack.

Besides embedding components into the IC/package (*Figure 3*), the package size can be reduced by embedding components within the substrate of the package itself (*Figure 4*). Doing this can increase the number of I/Os per cm3 up to 105 or 106. Placing components into ICs and packages requires great accuracy, repeatability and reliability from the SMT pick & place equipment. Those are fundamental requirements for embedding components into PCBs.

Embedding into PCB—PCB manufacturing challenge

Where traditionally pick & place equipment ends up in the SMT industry, there is now a steady shift towards the substrate (PCB) manufacturing industry because components are now being embedded

Figure 3. Components embedded in package

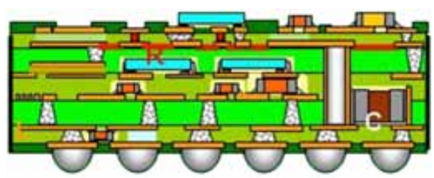


Figure 4. Components embedded in package substrates.

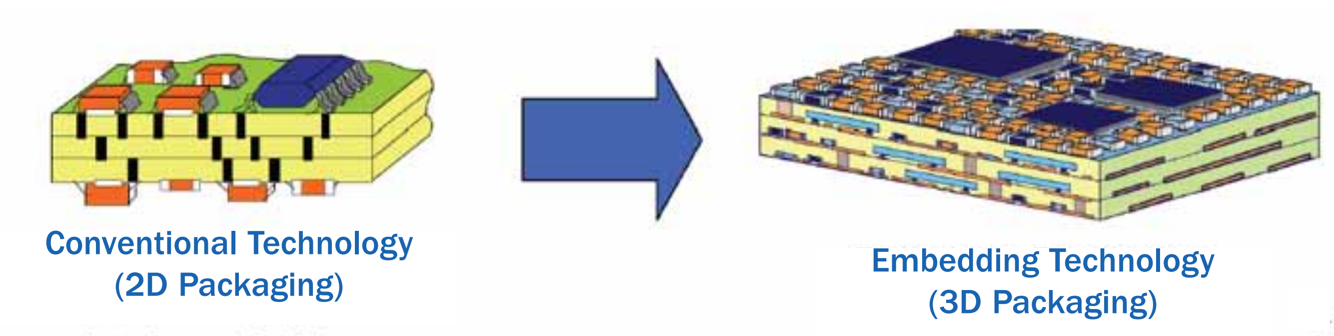


Figure 5. Embedding components gives 3D packaging a much higher component density.

within the substrate (*Figure 5*). These substrates are then delivered to the PCB assembly industry to finalize the electronic product. Space savings (smaller components, integration into ICs) are not the only reason for this.

Transferring components from the surface to inside the PCB frees the surface area by between 30% and 50%—even more with smaller packages and components embedded into ICs. It means that the same PCB size can hold new functions and features, so increasing the flexibility of PCB design. Or, if no extra features and functions are added, the total PCB size can significantly be reduced. Then, less material gives less waste to help meet companies' environmental aims.

Embedding components makes the connections shorter which improves electrical and thermal performance and HF signal integrity. It also helps to reduce power consumption, saving battery life and again reducing environmental effects. And once embedded, the components are fully enclosed by the substrate, are not influenced by external factors, and are shock proof. Embedding by itself therefore increases the reliability of the design.

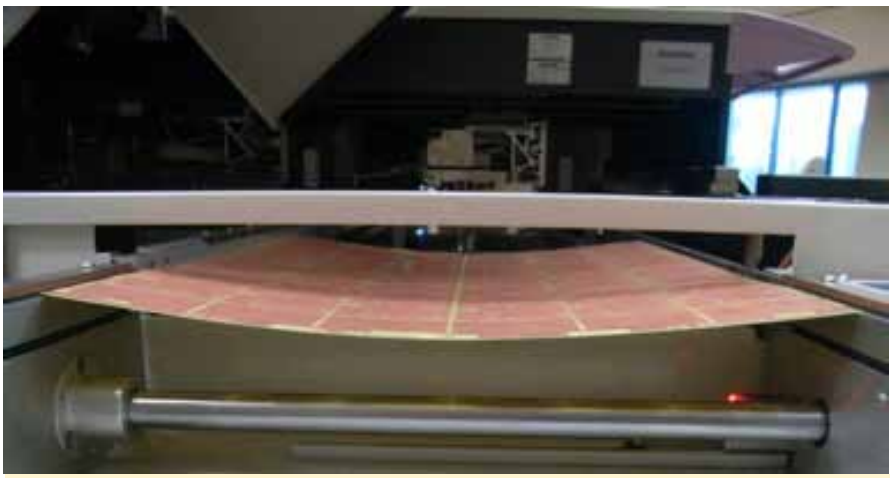


Figure 6. Large thin substrates require support.

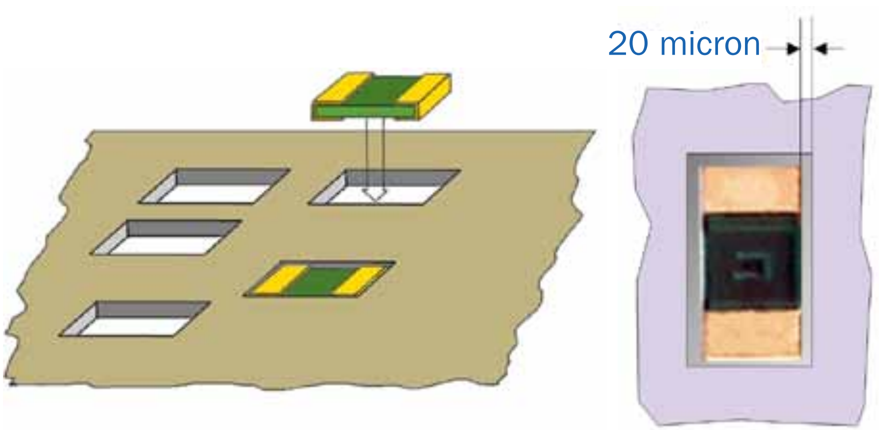


Figure 7. Components placed into the substrate can have tolerances of 20 microns or less.

Challenges to using pick & place equipment in the embedded PCB industry

Dealing with embedded components means dealing with thin substrates (typically 0.3 mm). These are themselves not uncommon in the SMTA industry, but dealing with the relatively large size (lengths of about 500 mm and widths of about 400 mm) is.

Unlike traditional surface mount technology, warpage is not allowed and boards should be absolutely flat. Traditionally board support systems like support pins are not adequate (*Figure 6*), nor is a solid support block since there may instead be positive warpage. And unlike traditional surface mounting, embedded components are placed in cavities in the substrate. The cavity tolerances are very narrow, and distances from the edge of the component to the cavity edge can be as tight as 20 microns or sometimes even smaller (*Figure 7*).

The substrate needs to be absolutely flat. Assembléon has dealt with such requirements in the backend industry (though with much smaller substrates), and the experience can be transferred to the embedded industry. To guarantee absolute flatness, the substrates must be supported by a frame or carrier (*Figure 8*), with or without the use of (for example) vacuum to flatten it. To reduce costs and changeover inefficiencies, the user should standardize the size of the frame or carrier as far as possible, and therefore also the size of the substrate.

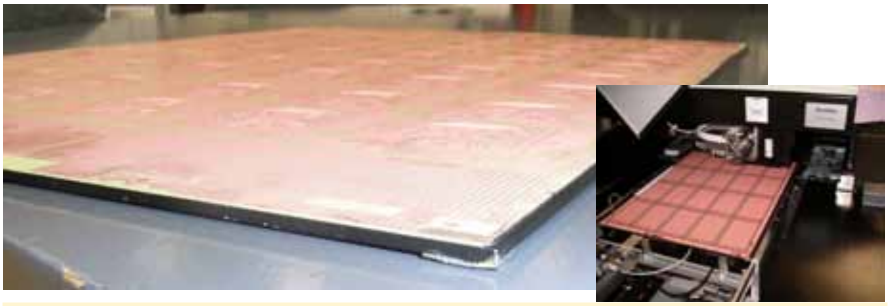


Figure 8. Substrate flattened by support carrier.

Change from SMD to low profile components

Traditional pick & place equipment deals with surface mounted devices/components (hence the name SMD). When talking about embedded components, the 'surface' part of the name disappears, along with a process that belongs to it. Traditional SMD placement is done by placing a component on solder paste. Pick & place equipment can therefore place with certain 'inaccuracies' that will be overcome by the strong self alignment effect of the solder during reflow (*Figure 9*).

Some embedded passive and active devices (EPDs and EADs) are placed the traditional way, in solder paste. This is however not recommended with layers that already carry soldered components, since pre-soldered components may de-solder during reflow. Furthermore, stresses on PCBs may cause solder connections to crack or burst. Since the components are embedded, they are then impossible to repair.

Instead of reflow soldering, EPDs and EADs are usually placed on an adhesive layer. When the next layer of substrate is added to the process, the copper connections make contact with the embedded component. To improve the electrical connections, terminations are changing from traditional nickel and tin to copper (*Figure 10*). Many traditional pick & place machines will have to adapt to these new components.

While solder paste allows components to self align, this is not true for cold (copper) connections. These components must therefore be placed with higher accuracy for precise electronic connections of a layer within the substrate. The typical accuracy (not repeatability) of chip-shooting of around 50 to 70 µm is simply no longer sufficient, and needs to go below 50 µm. Accuracy gives the location where equipment will place components, substrate after substrate. This differs from the repeatability (often specified as accuracy), meaning how accurately equipment can place components at the same spot repeatedly (without moving the PCB). Repeatability usually has a lower value than the real accuracy (if accuracy is 25 µm @ 3 sigma and CpK >1, then repeatability is generally below 10 µm @ 3 sigma and CpK > 1). So do not be fooled by 'accuracy' figures that actually give the repeatability.

It is not only the absence of component self-alignment that requires components to be placed accurately; the tight cavity space (*Figure 7*) requires absolute accuracy. In *Figures 7* and *11* the maximum distance between the component edge and the side of the cavity is a maximum of 20 µm, and expected to be less in future.

Reaching this accuracy needs components and cavities both to be aligned to local marks/fiducials (*Figure 12*). The processes of creating cavities in and marks on the substrate occur in different circumstances with different environments or temperatures. Stretching or deforming of the substrate is not an unfamiliar phenomenon and validates the use of local marking.

Reducing the inaccuracies formed by deformation or stretch requires multiple algorithms or enhanced measurement algorithms. The algorithm used by Assembléon divides the circuits into areas where stretch per area is taken into consideration. Increasing the number of marks to relate them to each individual circuit is also possible, but with possibly more than 1,500 circuits on one substrate, there could be over 3,000 to 6,000 marks (2 to 4 marks per circuit) to check. This would slow down the placement process. Experience shows that stretch of over 60 µm already occurs over

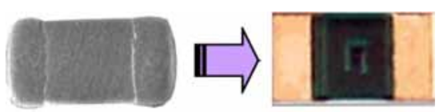


Figure 10. Terminations are changing from tin to copper.

Figure 9. For surface mounting, self alignment effects allow inaccuracies in pick & place equipment.

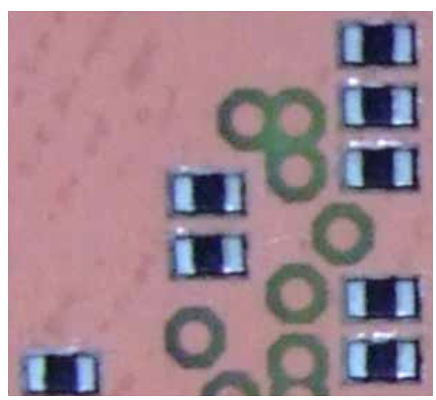


Figure 11. C0201 components embedded into the substrate, placed by the Assembléon AX-501, accuracy 40µ @ 3 sigma, CpK>1.

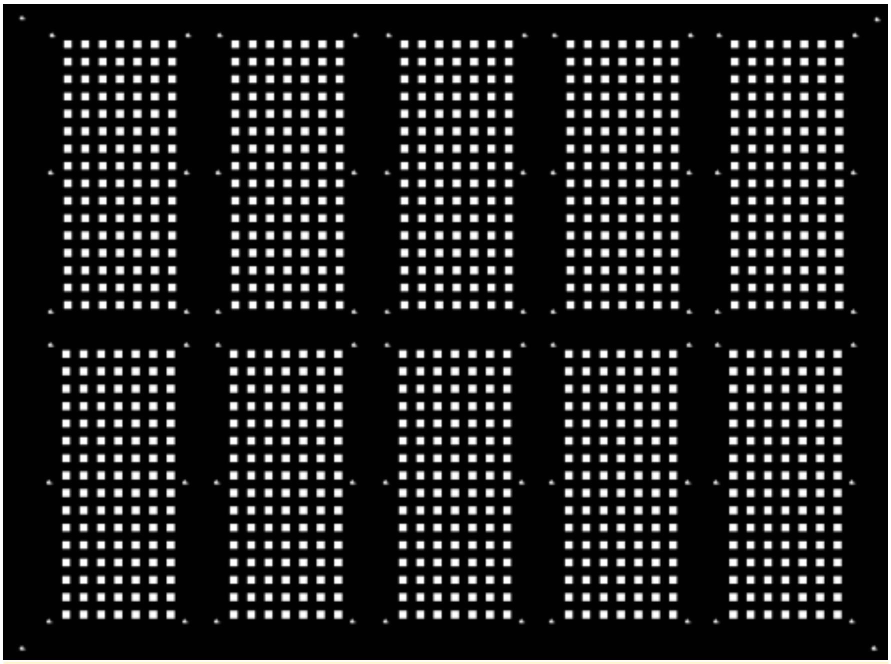


Figure 12. Circuits (each white spot embeds about 25 components) and fiducials.

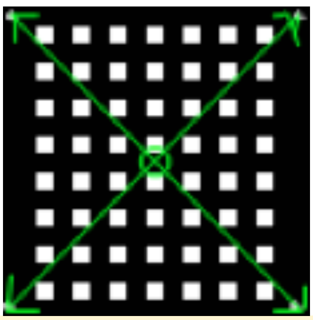


Figure 13. 4-point (all corners) or 3-point (2 opposite + 1) measurement calculates placement accuracy in any of the four triangular sections shown.

a distance of about 80 mm. Block marks/fiducials have so far also been sufficient to eliminate the influence of stretch (*Figure 13*). Depending of the size of a block, more than three marks might be required (in the example above, each block of 7 x 16 circuits has six marks to eliminate the effects of local stretch).

Preventing damaging of components: placement quality

High placement quality is a must because any undetected errors will eventually end up in the final substrate and, once embedded, there is no chance of repair. Besides the placement accuracy, the placement force is extremely important. In PCB Assembly the PCB still has some elasticity during component placement to reduce the impact, but this is certainly not true in embedded component manufacturing. Here, the substrate is flattened by a stiff rigid support frame, which eliminates all elasticity. It is therefore crucial to control the placement process, and especially the moment of contact between component and substrate. It is exactly this moment of impact that can damage the component most. The defects can range from component crushing to visible cracking and unnoticed micro-cracking. And as can be seen in *Figure 14*, especially the bottom right and left hand corners, components are becoming thinner and therefore more and more susceptible to damage during placement. Placement forces, impact and static, must be below 2 N (even down 0.5 N).

Many turret and array based machines already find standard 0402Metric (01005) components a challenge in standard applications, and they will find thinner components even more difficult. The turret-type pick & place equipment currently used in the embedded PCB industry simply cannot be adapted (usually using slower process speeds and special nozzles) to prevent component damage. The mechanical complexity of these machines and the high head mass of turret based systems limit their success in placing EPDs and EADs.

Assembléon's A-Series (*Figure 15*) is the only pick & place machine that can achieve single-figure defect per million figures—now in fact down to 5 dpm. Its unique parallel placement system, with all robots having a single head and a single nozzle, gives full process control for each component and speed.

Embedded components demand precise placement force

There are two parts to the placement force: the moment of impact, followed immediately by a dwell placement force (*Figure 16*). Placing components like 0402M or 0201M demands very low, accurate and stable placement force control. The smaller the area of contact between nozzle tip and component, the higher the stress on the component at the point of contact. The best placement force for small chips is 2 N or lower (but check component vendor specifications).

For a typical conventional placement action:

a. The nozzle with component moves downwards with a maximum allowed speed and decelerates when the bottom of the component reaches a defined "search" height, which is well defined above the surface of the board.

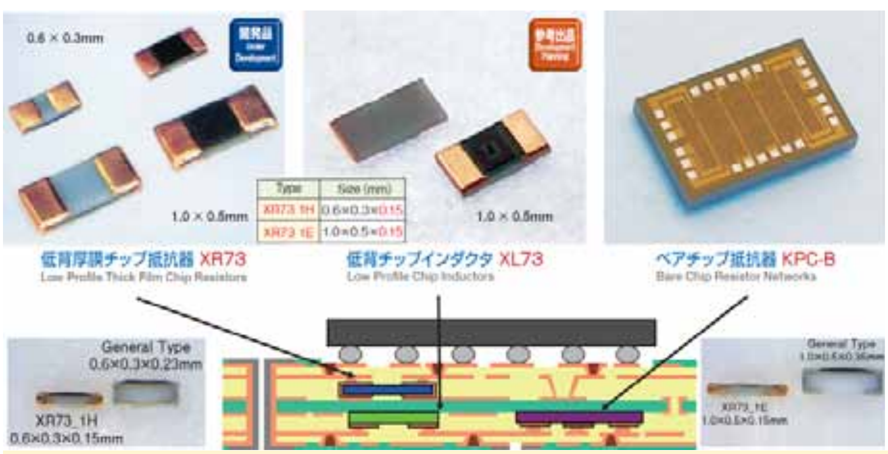


Figure 14. Low profile components: resistor thickness 0.15 mm. [Source: KOA]

Figure 15. Assembléon's AX-501.

b. The nozzle with the component then moves down at "search speed" until it has reached a position that is a little lower than the bottom surface of the substrate cavity ("over-travel") to ensure the component is placed.

c. The dwell force is controlled by a mechanical spring, which is compressed to the defined length (over-travel length). This is normally defined with reference to the assumed bottom level of the cavity (= height).

Most systems use this method, but it does not guarantee successful placement for thin and small components. For placement heads with a high moving mass it is very difficult to fully control the impact force and still maintain a high throughput. The A-Series placement process ensures that there is no impact force at all, with the force instead being built up towards the required dwell force (also known as static force), at a very high throughput.

Placement dwell force

On conventional systems, the length of the mechanical spring determines the placement dwell force according to:

$$F_{placement} = F_{retention} + zC$$

Where C is the spring factor (gr/mm) and z is the over-travel length (mm). For small embedded components, both the spring factor and over-travel length should be very small due to the required placement force and dwell force.

Advanced Z-servo mechanism

Instead of the conventional mechanical spring used by most pick & place vendors, Assembléon uses an advanced Z-servo mechanism.

Figure 17 shows the closed-loop active placement force control process of the A-Series. This achieves the required placement dwell and force regardless of component type, substrate type, condition of substrate, and transport system. The A-Series active force control dynamically monitors the placement force using the closed loop system integrated in the placement head.

Normal placement

During the first part of a placement action, the Z-axis of the placement head moves downwards at high speed. When it arrives at the 'search zone', the speed is reduced to the search speed (*Figure 18*). Then the downward motion continues until contact with the board is detected.

The advanced collision detection mechanism filters out any false collision signals but will always ensure that a component is placed, even if the bottom of the substrate cavity was lower than expected.

Additionally, throughout its lifetime it will record all placements and alert the operator if behavior may influence placement quality—a requirement when board quality is critical. And finally, the advanced collision detection mechanism records a surface map of the substrate, allowing all subsequent placements to be made at higher speed by reducing the search area.

For reliably low and stable placement forces, Assembléon's pick & place process not only measures the force using the real-time and closed loop placement mechanism, but also compares it against

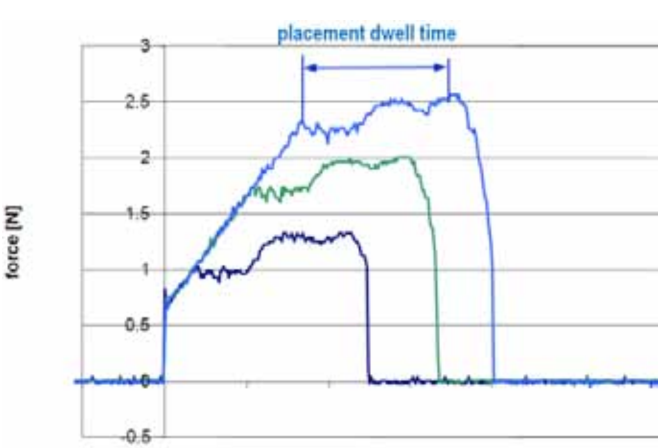


Figure 16. The moment of impact is followed by a dwell placement force.

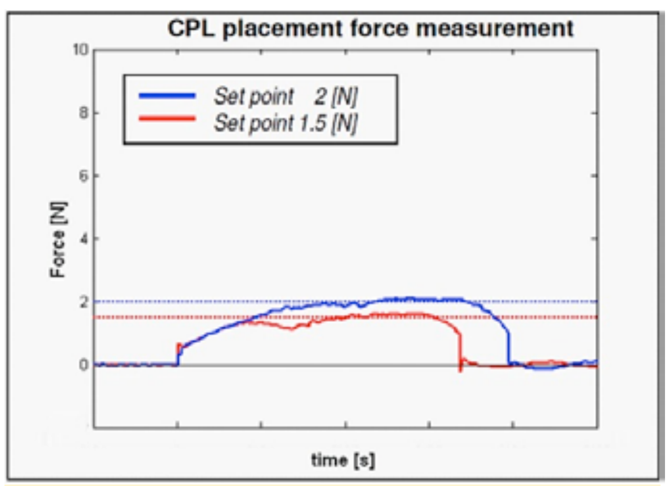


Figure 17. A-Series closed-loop active placement force control system diagram.

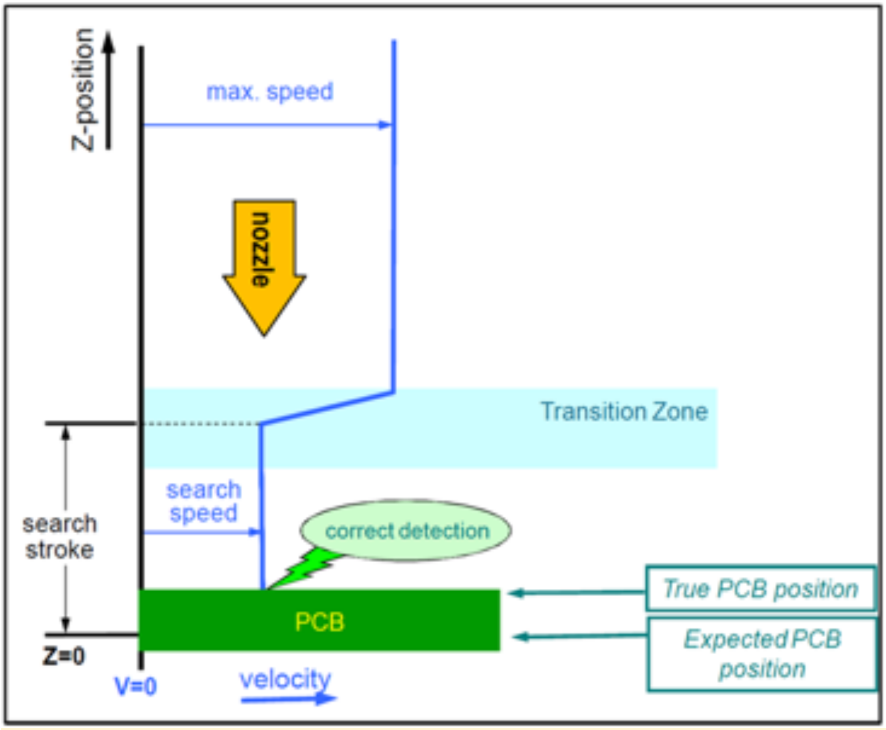


Figure 18. Correct detection of contact with the substrate.

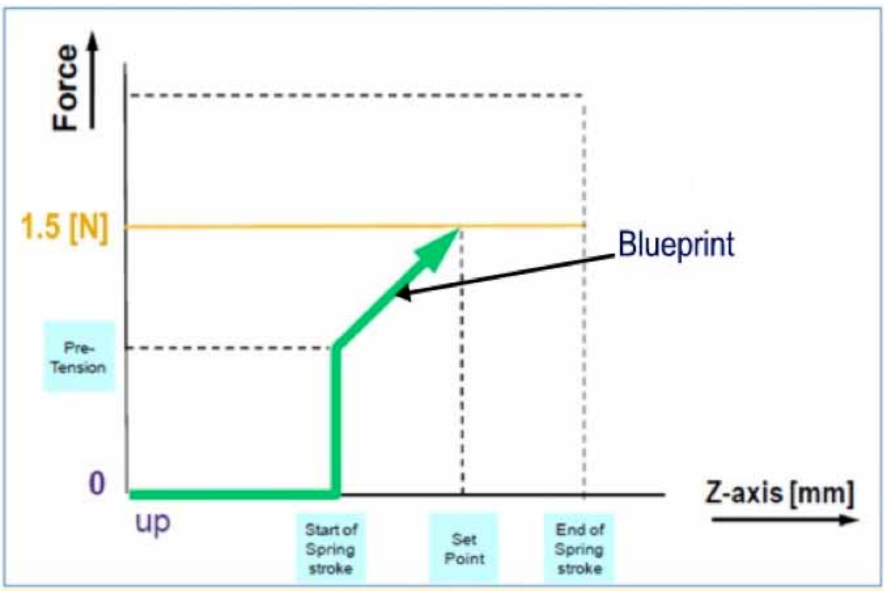


Figure 19. Comparing placement against a blueprint value.

a blueprint value—a placement profile description (*Figure 19*). Also, when the nozzle rises, the velocity is high enough to break the contact between nozzle tip and component to prevent components from being retained on the nozzle. Monitoring systems check whether the component has been detached from the nozzle tip immediately after placement. This quality check filters out any behavior that does not meet the blueprint value and warns the operator in time, avoiding possible costly board reworks throughout the machine's lifetime.

Assembléon's AX-301/501 pick & place system

Assembléon has since 2002 been working with thin substrates (backend modules) which demand excellent accuracy, and has pioneered 0402M (01005) component placement defect levels below 5 dpm. Since then, Assembléon has placed trillions of these components.

Assembléon is now very active at the world's leading electronics manufacturers, successfully placing embedded 0402M and 0201M components at very high yields within substrates (*Figure 20*). Substrates can have a variety of sizes and can hold up to 1600 circuits of 21 embedded components each (totaling 33,600 components per panel, soon to expand to above 60,000 embedded components per panel).

Cooperation between PCB and SMTA industry.

The substrate manufacturing and traditional SMT placement industries are worlds apart. It is clear that SMT pick & place equipment manufacturers still have a lot to learn about the processes of substrate manufacturing, and vice versa. For placing EPD and EAD into PCBs successfully, close cooperation between the two industries is essential.

Eric Klaver is senior product manager for Assembléon.

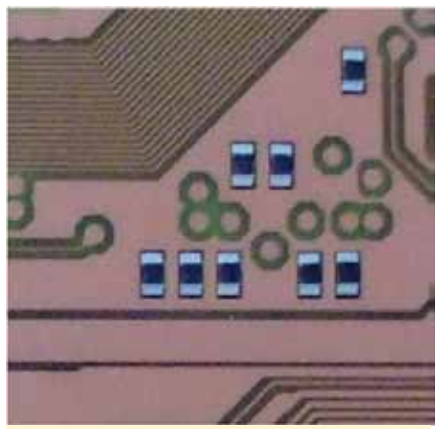


Figure 20. Embedded 0402M (EIA 0201) components placed by the AX-301.

The miniature component solder paste printing process

Mitch Holtzer and Tom Hunsinger, Cookson Electronics, and Joe Belmonte, ITM Consulting

The goal of any solder paste printing process is simple to understand: place the correct amount of solder paste in the hundreds to thousands of correct locations within a specific cycle time, 24 hours per day, seven days per week.

This goal may be simple to understand, but the execution of the goal requires the identification, understanding and optimization of numerous factors that all influence how well the solder paste printing process will perform. This goal is even more difficult when the product being produced includes miniature components such as 01005 passives and/or 0.3 mm pitch chip scale packages (CSPs), each requiring deposits as small as 0.007 inches (180 microns) across.

In the solder paste printing process, one or more of the following typically causes defects: poor alignment between the substrate and stencil, poor board and/or stencil design, poor board support, stencil aperture/paste friction, incorrect stencil snap-off speed, incorrect print speed, incorrect paste chemistry and/or powder size, or volumes of solder paste outside of the required upper and lower volume specification limits. To minimize defects, the capabilities of the printer and the materials selected (substrate, solder paste type, stencil design and squeegee type, as well as printer settings (squeegee speed, squeegee pressure, stencil snap off speed) need to be examined closely.

Introduction

As it is widely known and understood, the solder paste printing process accounts for the vast majority of *defect opportunities*. Most electronic manufacturing operations define a defect opportunity as one defect opportunity for each solder joint *plus* one defect opportunity for each component.

For example: a 256 pin quad flat pack (QFP):

> *256 solder joints + 1 for the component = 257 total defect opportunities*

Another example: any size chip resistor or capacitor:

> *2 solder joints + 1 for the component = 3 total defect opportunities*

Using this approach we can calculate that in excess of 80% of defect opportunities involve the application of solder, including all of the soldering related processes such as solder paste printing, wave soldering, selective soldering and hand soldering. The key to reducing the overall process defect rate is to optimize the soldering related processes, with the optimization of the solder paste printing process providing the most significant impact on minimizing overall process defects and maximizing first pass yield.

Since the inception of the SMT process there has been a massive amount of work done in the development and characterization of the solder paste printing process. The critical factors in the process, such as solder paste selection, stencil design and fabrication, squeegee speed, squeegee pressure, stencil snap off speed and squeegee blade angle, have been identified, quantified, and optimized through the use of or designed experiments (DOEs) and statistical studies.[1,2,3,4]

The natural progression in product design towards miniaturization is taking us past 0201 passives and 0.4 mm pitch chip scale packages (CSPs) into 01005 passive components and 0.3 mm pitch chip scale packages. Operating parameters that have been studied must again be evaluated to identify what material sets and process settings are required to provide high yields and lower cost of manufacturing as the "degree of difficulty" in the printing process is increased dramatically.

Area ratio has been identified as a strong indicator of the limit of a solder paste printing process capability. However, larger paste deposits remain on assemblies, which are also using the smallest available passive and active components. Having 100% yield on the fine features and getting insufficient solder on larger CSP or BGA packages could lead to head in pillow defects.

This leads to the concept of "broadband printing." It has often been asked if it's possible to develop a solder paste printing process for miniature components. The fist response is "what are the other components on the board?" If the printed circuit board only had miniature components, the solder paste printing process would be relatively easy since you could use a thin stencil and type 4 powder solder paste and achieve acceptable results. However there are no products that I am aware of with only miniature components, so we must consider all of the components on the printed circuit board, both large and small, when we design the solder paste printing process.

As we consider the significant changes to the printed circuit board assembly process during the past 20 years, we think about process changes and technology changes. Some of these changes are obvious, such as the introduction of SMT to mainstream electronic products in the late 1980's and early 1990's. This is clearly a technology change since it involved new process, new equipment, new components etc.

But what about other significant changes, such as the introduction of "fine pitch" (0.65 mm and 0.5 mm pitch quad flat packages)? These are process changes since they use the same technologies and equipment (with refinements) to introduce these fine pitch components onto the SMT process.

What about the introduction of lead free solder materials? This is a technology change since it involved new materials and significant process operating and process control changes.

Now what about the introduction of miniature components, such as 01005 passives and 0.3 mm CSPs? This a technology change since detailed stencil design and fabrication tests have to be conducted, as well as solder paste selection, printer settings DOEs and studies to understand and optimize the process.

The introduction of miniature components, especially when considering the "broadband" printing requirement, is a significant change to the SMT process and to understand and optimize it will require detailed engineering work and the experience and expertise and guidance of suppliers.

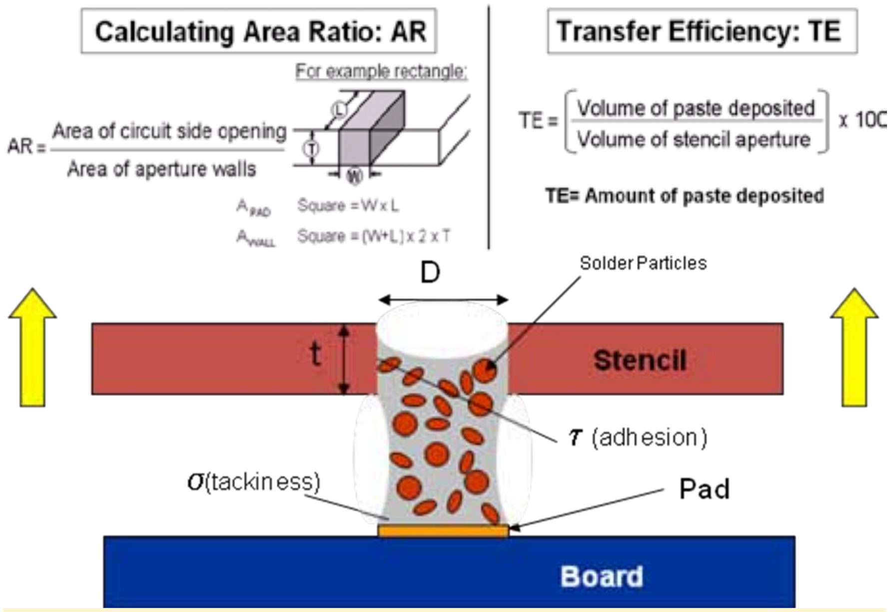


Figure 1. Calculating area ratio (AR).

Process considerations

Printing solder paste onto a substrate is a process. A process is defined as:

> "Sequence of interdependent and linked procedures which, at every stage, consume one or more resources (employee time, energy, machines, money) to convert inputs (data, material, parts, etc.) into outputs. These outputs then serve as inputs for the next stage until a known goal or end result is reached."

All the "linked procedure" or "inputs" of the process must be evaluated, understood, optimized, and controlled to maximize the "output."

In the solder paste printing process, the inputs consist of solder paste, stencil design and fabrication, support tooling, the substrate (printed circuit board), the printing equipment, squeegee material, squeegee angle and the squeegee thickness.[5,6,7] The operating parameters include squeegee speed, squeegee pressure, stencil board separation speed, stencil cleaning (both cleaning process and frequency), temperature and, in the case of water-soluble pastes, humidity. Operator training and discipline also are keys to a stable, high capability process. The outputs are good product and defects.

There is only one method to develop an efficient, high yield, stable electronic manufacturing process, and that is with the use of formal experimentation and statistical studies to identify and optimize the critical process inputs and operating parameters. Developing an electronic manufacturing process using trial and error will certainly result in a process that is statistically out of control. A process eloped using trial and error will have its good days and its bad days. No one can afford a process that hopefully will produce acceptable products on any given day.

Many aspects of designing and optimizing the process require efficient, accurate experimentation. Statistically designed experimentation is used to obtain maximum information at a minimum cost in time and resources. Conclusions drawn from experiments determine the best course of action in establishing the process. In this way, the controllable variables of the process can be set at optimum levels in an objective manner supported by data to produce the desired outcome. This approach must be used to understand and optimize the process inputs such as solder paste and stencils.

Once the process is "stable," it should be monitored using statistical process control (SPC). To achieve best in class performance, it is vital to monitor the process to prevent defects from occurring and not to inspect the product, attempting to find defects after they are created.

Every miniature component printing process is unique because each one has a different combination of inputs, operating parameters, and cycle time and yield goals. Only experimentation with that particular set of parameters will optimize that particular solder paste printing process. However, it is possible to offer some general guidance as a starting point for experimentation and process development.

Material considerations

Circuit board design

The printed circuit board itself should be as rigid (or well supported) as possible with a minimum of cutouts and routings. This can become a challenge in the world of accelerating miniaturization. Thinner substrates offer more design latitude for small hand held devices. At minimum, the printed circuit board should contain at least three fiducial marks that are on the copper etch pattern and not on the excess panel material if possible.

The printed circuit board design and the many materials of fabrication and methods used in circuit board construction should be examined first and can be broken down into three critical elements that directly affect the printing process: pad size, pad plating or finish, and solder mask type. Identifying these parameters will dictate the materials and equipment selected to complete the process.

Stencil design

Four main elements define the typical stencil design: stencil material, foil thickness, image pattern, and aperture size. A considerable amount of work has been done to identify the best choice for miniature component printing. Area ratio and choice of solder paste are among the two most criti-

Aperture Width ($1x10^{-3}$ inches)	Stencil Thickness ($1x10^{-3}$ inches)	Aspect Ratio
12	6	**2**
9	5	**1.8**
8	5	**1.6**
6	4	**1.5**

Table 1. Aspect ratio (1.5 or larger is recommended).

Aperture Shape	Opening Size ($1x10^{-3}$ inches)	Stencil Thickness ($1x10^{-3}$ inches)	Opening Area (LxW or πr^2)	Wall Area	Area Ratio
Square	15	5	225.0	300	**0.75**
Square	12	4	144.0	192	**0.75**
Square	12	5	144.0	240	**0.60**
Square	9	4	81.0	144	**0.56**
Square	7	3.5	49.0	98	**0.50**
Round	15	5	176.7	236	**0.75**
Round	12	4	113.1	151	**0.75**
Round	12	5	113.1	188	**0.60**
Round	9	4	63.6	113	**0.56**
Round	7	3.5	38.5	77	**0.50**

Table 2. Area Ratios.

cal factors; together they determine solder paste transfer efficiency.

Transfer efficiency (TE) is defined as the volume of solder paste volume deposited on the board, divided by the volume of the aperture being measured.

The proper stencil design will insure the forces that will attach the printed solder paste to the printed circuit board pad will overcome the forces that want to hold the solder paste in the stencil aperture. The two calculations that must be considered in stencil aperture design to maximize solder paste transfer efficiency are aspect ratio and area ratio.

Aspect ratio considers the ratio between the width of the aperture and the thickness of the stencil.

Area ratio is calculated by the ratio of the opening of the aperture (the area of the printed circuit board pad that will be covered with solder paste) and the total surface area of the aperture walls. For miniature components where the opening of the stencil is less than the area of the walls of the aperture, area ratio is a vital calculation to insure a stencil that will print well with minimum aperture clogging and maximum solder paste transfer efficiency.

In the past, an aspect ratio of 1.5 or greater and or an area ratio of 0.66 or greater had previously been used as rules of thumb for maximum solder paste transfer efficiency and minimum aperture clogging.

Today, many handheld devices are produced using area ratios well under 0.6 (See *Table 1* and *Table 2*).

However, calculating the area ratio for a 0.3 mm pitch CSP deposit, one must either use an extremely thin stencil, or delve into lower area ratio aperture/pad combinations. We'll stay metric through these calculations.

Assume 180-micron circular deposits are required for a 0.3 mm pitch CSP device. Using a 100-micron stencil would give an area ratio of 0.45. Making the stencil 90 microns thick increases the area ratio to 0.5, but this is still below many designers previous rule of thumb.

If one assumes that two 200 x 200 micron squares are needed to prevent tomb stoning or bridging with a 01005 chip, using a 100-micron stencil yields an area ratio of 0.5. Thinning the stencil to 90 microns brings the area ratio up to 0.56. These area ratios have become the next challenge in designing more capable solder pastes. As can be seen in *Table 2*, the 0.50 area ratio converts to a 7-mil (180 micron) square printed from a 3.5 mil (90 micron) stencil.

Paste selection

Two of the most critical factors that affect paste performance are rheology and solder particle size and shape. IPC type 3 solder powder (80% between 25 and 45 micron diameter) is widely used in paste to assemble 0.4 mm pitch QFP components. Type 3, and even standard type 4 powders (85% between 20 and 38 micron diameter) may not provide adequate properties for even 0.4 mm pitch CSPs. Examples of print volume and print volume repeatability for pastes containing type 3, type 4 and a modified type 4 powders, using the same flux vehicle, are shown in *Figures 2* through *5*.

Notice how the type 3 powder has a few prints with volumes below 200 cubic mils, whereas the type 4 powder produced no prints smaller than 275 cubic mils. The smallest measured paste deposit with the modified type 4 powder was about 300 cubic mils, and the mean deposit volume was nearly 10% greater than the type 3 deposits.

An additional process consideration that can be used to optimize the print volume of both the miniature and larger components on a PCB is the use of overprinting. If a 4 or 3.5 mil stencil is used to achieve the desired area ration for a 01005 chip capacitor, it may be possible to overprint the area for the larger components. Again, this is highly dependent on the properties of the solder paste, and solder mask, and whether the paste can "wick" back to the component without leaving random solder balls. Other considerations

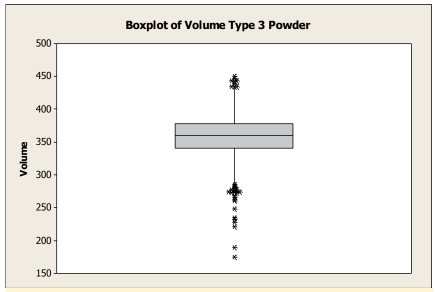


Figure 2. Type 3 powder. Area ratio 0.6.

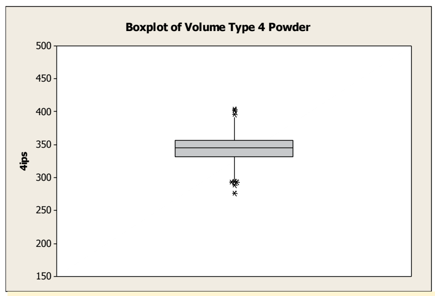


Figure 3. Type 4 powder. Area ratio 0.6.

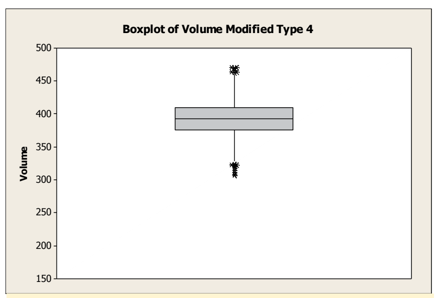


Figure 4. Modified type 4 powder. Area ratio 0.6.

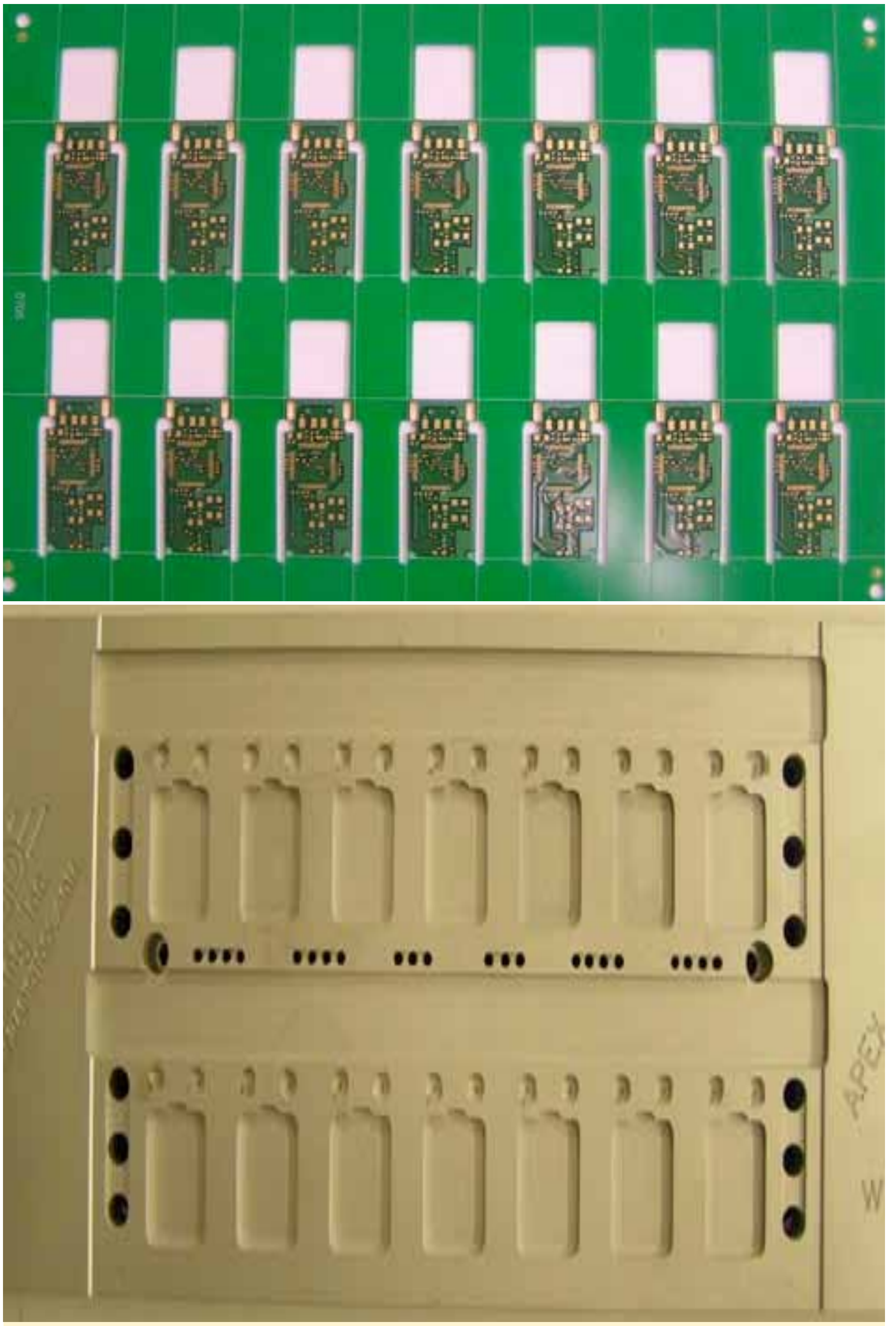


Figure 5. Example of support tooling (bottom) designed for a particular printed circuit board (top).

for overprinting include the board layout and proximity of other components.

Another option to consider when balancing the needs for ultra fine feature components and more standard components is the use of preforms to selectively add solder volumes on the larger apertures where needed.

Squeegee blades

Metal squeegee blades enable a more controlled and consistent print height across the entire board area and are widely used in almost all solder paste printing processes. There are numerous suppliers of metal squeegee blades that use a variety of materials, finishes, and designs. Squeegee blade design, finish, and material should be included in an experiment to optimize the miniature component solder paste printing process.

Squeegee pressure, speed & downstop level

Squeegee pressure is based on the length of blade and material. For metal blades, the starting pressure should be 1 lb./in. of squeegee. Based on the quality of the print, the pressure should then be adjusted to give complete fills of the apertures and clean wipes of the stencil surface. One simple method to use in dialing in the squeegee pressure is to reduce the pressure in the smallest increments allowed by the model of printer being used. As soon as the solder paste leaves streaks across the stencil, increase the pressure as little as possible until no measurable paste streaking is observed.

The solder paste rheology and stability are keys to the optimal squeegee speed. A range of 50 to 200 mm/sec (2 to 8 inches/sec) is typical. Pastes with higher viscosity, or low sheer thinning rheology require slower speeds to allow the paste to flow into the stencil openings. It is very important to follow the solder paste supplier's recommendation on squeegee speed. However, the solder paste supplier will provide a range of squeegee speeds and only formal experimentation can determine the optimum squeegee speed for your particular miniature component solder paste printing process.

Both pressure and speed can be used to control print viscosity. This is when the shear-thinning properties of the paste become critical. Consistent squeegee pressure is impossible to achieve without sufficient board support.

Downstop level is dependent on machine type with the major consideration being the design of the print head. Downstop controls the distance the print head travels beyond the substrate when the blades are not over the substrate. It prevents coining of the stencil. In general, the downstop should be set to a level that enables the squeegee to wipe the stencil clean and not over-deflect the stencil as the blades go beyond the substrate. For trailing-edge blades, a typical setting is 85 mils (2 mm).

Sufficient board support

Proper board support is essential to ensure consistent print results and higher yields. Without proper board support, the force applied to the board, across the entire width of the PCB, will vary and proper gasketing between the stencil and the board will not be achieved. Blade angle can also be affected and cause paste to be left on the stencil. Board supports should be distributed evenly across the width of the board, particularly with miniature components, to prevent bridging (sagging) and inconsistent paste deposition. In addition, board supports should be kept clean to ensure flatness and eliminate the potential for paste deposits on the underside of the board.

Figure 5 shows an example of a customized fixture offering excellent board support.

When printing on the back side of an assembly, a series of fixed pins, or an array of pins that conform to the z dimension of the front side of the board should be used to insure against board warpage and inconsistent gasketing. *Figure 6* shows an excellent example of this type of board support tooling. (Courtesy of WWW.DEK.com)

One typical result of inadequate board support is poor gasketing between the stencil and the printed circuit board, resulting in poor deposit resolution with the pad. Note how the paste deposits intended for a QFP package are misaligned, and very prone to bridging once the component is placed in the paste deposit. See *Figure 7*.

Optimal stencil/PCB separation

The critical factors in stencil/board separation are speed and distance. If the board is separated from the stencil too quickly, "bounce back" (fast, repeated contact between the stencil and PCB during board separation) or "Dog Ears may occur. Bounce back causes paste to stick to the bottom of the stencil and re-deposit on the board. The board will need to be cleaned and reprinted. Paste will remain on the bottom of the stencil, causing problems during the next print cycle unless thoroughly cleaned.

Dog Ears are edges of the paste deposit that are taller than the stencil thickness. This can interfere with automated optical inspection devices, giving the impression that too much paste was deposited. See *Figure 8*.

Snap-off distance is the measurement from the top of the board to the bottom of the stencil and applies only to contact printing. Lift height is the distance that the squeegee blade is raised from the stencil after the conclusion of the print. Both are application-dependent and it is recommended that material and equipment suppliers be consulted for optimal settings.

Inspection/SPC data collection

To have a reasonable grasp on true production fluctuations, inspection tools must be combined with active statistical process control (SPC) features. A good inspection system must be able to feed data back to enable process adjustments in real time so that the process engineer can take action to correct the situation before it becomes a true problem where defective product is made.

Many advances in high-speed, 3-dimensional paste volume inspection have been made in the past five years. Systems can now map each solder deposit in three dimensions, and report both the print volume and print volume repeatability for each deposit. *Figures 2*, *3*, and *4* are just a few examples of the output from a modern system.

3D inspection systems measure the amount of paste that is covering the target pad and compares that against the required coverage. For automated systems, the operator can elect to allow the printer to automatically initiate corrective action. Verifying the results of a freshly printed board is the optimal way to determine if the print process is in control and that acceptable boards are being produced. Inspecting a PCB immediately after printing verifies the printing operation itself to characterize the process. Correcting problems at this stage requires merely cleaning and reprinting the board, considerably less expensive than repair downstream.

Figure 6. Board support tooling for use when printing on the back side of an assembly. (Courtesy DEK.)

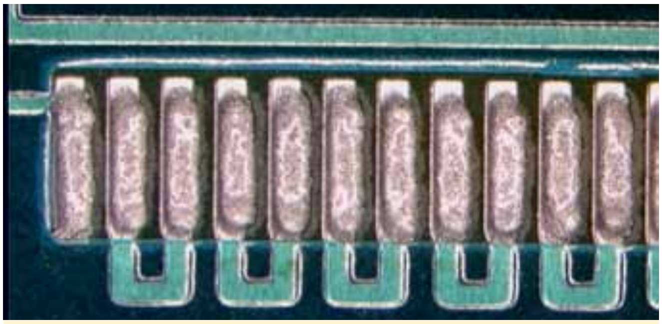


Figure 7. Poor board support causing poor stencil to board gasketing.

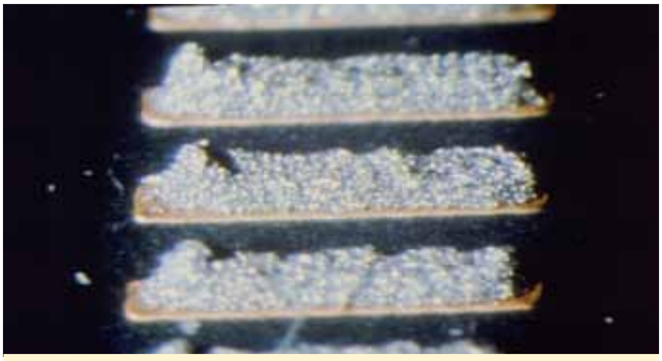


Figure 8. Dog Ears caused by excessive snap off speed.

Minimal operator intervention

Automated operations minimize the need for operator intervention, making set-up easier and ensuring a consistent and repeatable process. Some advanced stencil printers have features, such as a programmable printhead, which permits the operator to program squeegee pressure and downstop and to automatically level the blades before printing. Automatic paste dispensing systems add preprogrammed amounts of paste at preselected intervals, eliminating solder paste from being on the stencil for extended periods and constantly refreshing paste supply. An excess of paste on the stencil, or a paste bead that is too thick, can lead to drying of the solder paste. Automatic stencil wiping provides unassisted cleaning of the stencil, while a vacuum system cleans paste from clogged apertures.

Conclusion

To develop the optimum miniature component solder paste printing process, it is essential to consider all aspects of the process. The design of the board to be produced, the components to be placed, the materials used and the equipment selected to perform the process must all work in harmony with one another. We must not 'assume" that the materials, tools, and operating parameters that are providing

Continued on page 36

Solder paste residue corrosivity assessment: Bono test

Céline Puechagut, Anne-Marie Laügt, Emmanuelle Guéné and Richard Anisko, Inventec Performance Chemicals, Bry sur Marne, France

Lead-free soldering with no-clean solder pastes represents nowadays the most common process in electronic assembly. A solder paste is usually considered no-clean if it passes all IPC J-STD-004 corrosion tests: copper mirror, copper panel corrosion test, surface insulation resistance (SIR) and elecrochemical migration (ECM). Other SIR and ECM tests are described in Bellcore GR-78-CORE and JIS Z3197 standards.

Although SIR and ECM tests are recognized by all standards authorities to evaluate the solder paste residue corrosivity after reflow, a more selective method, the Bono test, has been developed and implemented in some French companies as a qualification criterion. It has been proven that compared to common corrosion tests, the Bono test better differentiates the nature of solder paste residues.

Introduction

In electronic assembly, boards have higher densities and narrower spacings between tracks and pads. Tracks can have a width down to 110 microns. Thus, dendritic growth can become a big issue. The purpose of the Bono test is to assess the corrosive nature of solder pastes and to quantify it by the corrosion factor (Fc). Over the duration of the test, a curve of data points is achieved that can be examined to give meaningful information. In addition to that, other visual parameters are taken into account: 1) whether or not mousebites (pitting) are present, and 2) the actual appearance of the residue (color, spread, etc.).

It has been proven that compared to common corrosion tests, the Bono test better differentiates the nature of solder paste residues. This can be attributed to many factors: the board design, the test conditions (temperature, humidity), and the applied bias.

In this paper, the methodology will be described: the material used (test board, stencil…), the specific test conditions (electrical measurements, power supply, applied bias during the test, and the climatic conditions), and the corrosion factor calculation.

Figure 1. Bono test board.

Figure 2. Solder paste after printing (left) and after reflow (right).

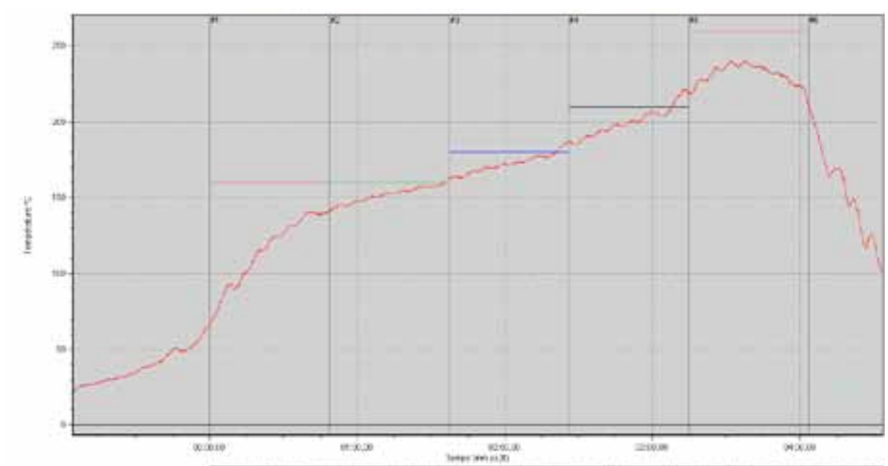


Figure 3. Thermal profile for boards reflow (Profile 1).

Standard	Test Method	Temperature (˚C)	Humidity (%RH)	Test Voltage (V)	Bias Voltage (V)	Test Duration (hrs)	Board
IPC J-STD-004B	IPC.TM.650, 2.6.3.3	85	85	-100	50	168	IPC B24
	IPC.TM.650, 2.6.3.7	40	93	Same as bias	25 V/mm	> 72	IPC B25A
	IPC.TM.650, 2.6.14.1	1) 40 2) 65 3) 85	1) 93 2) 88.5 3) 88.5	45-100	10	500	IPC B25A
Bellcore	SIR: 13.1.3	35	85	100	45-50	96	IPC B25A (D pattern)
	ECM: 13.1.4	65	85	45-100	10	500	IPC B25A (D pattern)
JIS Z 3197	SIR	A) 40 B) 85	A) 90 B) 85	100	0	168	IPC B24A (D pattern)
	ECM	A) 40 B) 85	A) 90 B) 85	100	45-50	1000	IPC B24A (D pattern)
BONO	Inventec: MO.SB.1002 9	85	85	12	20 V	360	Bono board

Table 1. SIR, ECM and Bono test conditions.

This paper will then focus on parameters like solder paste origin, solder paste chemistry (halogen or halogen-free), thermal profile (short and long profile), environment (air or nitrogen reflow), and conformal coating.

Bono test description

This method is based on an existing test that assesses the liquid soldering flux residue corrosivity after wave soldering. The test board has been modified to measure the solder paste residue corrosivity[1] (*Figure 1*) and is different from the one used in the SIR and ECM tests. It is composed of 10 electrolytic cells and is made of an FR4 epoxy substrate with a single copper layer having a very thin anode between two cathodes.

The solder paste is printed on cathodes through a 120 µm thickness stencil and reflowed according to the desired profile[2] (*Figure 2*). The thermal profile used for the tests is described below (*Figure 3*).

Twenty-four hours after reflow, the boards are submitted to ageing conditions; the samples must be then placed in a vertical position in the climatic chamber according to the temperature/humidity curve below (*Figure 4*). This is necessary to avoid any condensation on the test boards.

The samples are conditioned for 16 hours 85˚C/85% RH. Initial measurements (T0) are then taken. All measurements are made under temperature/humidity exposure, at a test potential of 12 VDC. The chamber is set at 85˚C/85% RH for a total exposure time of 360 hours (15 days), with 20 VDC bias voltage applied to all samples. Resistance measurements of the anode are taken daily and the corrosion factor (Fc) is calculated according to the equation below:

$$\mathrm{Fc} = \frac{R_d - R_0}{R_0} \times 100$$

where R_d is the resistance value at day "d" and R_0 is the resistance value at day "0". Fc is given in percentage (%).

SIR, ECM and Bono tests comparison

SIR and ECM tests lead to electrochemical migration, which is defined as the growth of conductive metal filaments on a printed wiring board (PWB) under the influence of a DC voltage bias. Dendrites are formed by electro-deposition from a solution containing metal ions, which are dissolved and re-deposited as a metal form[3].

The Bono test looks for electrochemical corrosion: The higher the amount of harmful residue, the greater the rate of attack on the metal in the circuit. The presence of an electrical potential greatly accelerates the corrosion process. At the anode, copper is dissolved forming mousebites[4]. These materials are only observed in the solder paste residue, which proves it is not a canodic anodic filament (CAF) phenomena.

The corrosion factor value is representative of the corrosion effect and of the leakage current, caused by the flux residue.

The test conditions between SIR/ECM and Bono differ also from one test to another[5,6,7,8] (*Table 1*).

Three lead-free SnAgCu solder pastes have been selected for the SIR and Bono tests: Solder pastes A, B and C. All the pastes are no clean, lead-free pastes. Solder pastes A and C are halide/halogen free, Solder paste B is equivalent to solder paste C but halogens were added. Results are shown in the table below (*Table 2*).

Solder pastes A and B passed all the SIR and ECM tests but not the Bono test. Solder paste C passed all the tests. It showed that the Bono test better differentiates the nature of solder paste residues.

Bono test: solder paste influence

Three other no-clean, lead-free pastes were tested in addition to the three solder pastes presented previously to assess their corrosive nature. The curve Time-Fc (*Figure 5*) shows the corrosion factor for each solder paste.

The curve of data points shows that solder pastes A, E and F exhibit a very high Fc value, and the three other solder pastes have low Fc values. Moreover, a visual inspection has been conducted (*Table 3*) to observe 1) whether or not mousebites are present, and 2) the actual appearance of the residue (color, spread, etc.).

This experiment showed that 1) even if the Fc value is low, copper dissolution may appear (solder pastes B and D): since there are no short circuits between anodes and cathodes, the Fc value can be low; 2) a high Fc value does not necessarily lead to mousebites (solder paste A). Since the

Standard	Test Method	Solder Paste A	Solder Paste B	Solder Paste C
IPC J-STD-004B	IPC.TM.650, 2.6.3.3	Pass $> 1.10^{8}\Omega$, No dendrites	Pass $> 1.10^{8}\Omega$, No dendrites	Pass $> 1.10^{8}\Omega$, No dendrites
	IPC.TM.650, 2.6.3.7	Pass $> 1.10^{8}\Omega$, No dendrites	Pass $> 1.10^{8}\Omega$, No dendrites	Pass $> 1.10^{8}\Omega$, No dendrites
	IPC.TM.650, 2.6.14.1	Pass No dendrites	Pass No dendrites	Pass No dendrites
Bellcore	SIR: 13.1.3	Pass $> 2.10^{10}\Omega$, No dendrites	Pass $> 2.10^{10}\Omega$, No dendrites	Pass $> 2.10^{10}\Omega$, No dendrites
	ECM: 13.1.4	Pass No dendrites	Pass No dendrites	Pass No dendrites
JIS Z 3197	SIR	Pass $> 1.10^{11}\Omega$, No dendrites	Pass $> 1.10^{11}\Omega$, No dendrites	Pass $> 1.10^{11}\Omega$, No dendrites
	ECM	Pass No dendrites	Pass No dendrites	Pass No dendrites
BONO	Inventec: MO.SB.1002 9	Fail Fc=8.1%, No copper dissolution	Fail Fc=1.7%, Copper dissolution	Fail Fc=1.8%, No copper dissolution

Table 2. SIR, ECM and Bono resuls.

residue can be conductive, the leakage current can then be measured through the Fc value. Residue spreading could also be a root cause for high Fc values; 3) halogen in the solder paste flux caused mousebites (Solder paste B); 4) some no clean solder pastes lead to a very high level of corrosion (solder pastes E and F).

Bono test: reflow environment influence

In this experience, two solder pastes have been selected for reflow under nitrogen: solder paste A and C[9]. The results are given in *Figure 6* and *Table 4*.

The first experiment (solder paste influence) seemed to show that the more the residue spreads, the higher the corrosion factor is. In spite of the fact that reflow under nitrogen leads to residue spreading, the corrosion factor is not affected compared to air reflow. In conclusion, residue spreading is only a cosmetic parameter which does not necessarily lead to a corrosion effect.

Bono test: thermal profile influence

In this experiment, a different profile is tested with solder pastes A and C. Profile 1 is the one described in *Figure 3*. Profile 2 is shorter, considered as easier and is described in *Figure 7* in comparison with Profile 1.

After 15 days into the test, the boards were visually observed and neither mousebites nor short circuits were detected. Residue spreading was similar to the previous experiment (minimal spreading for A

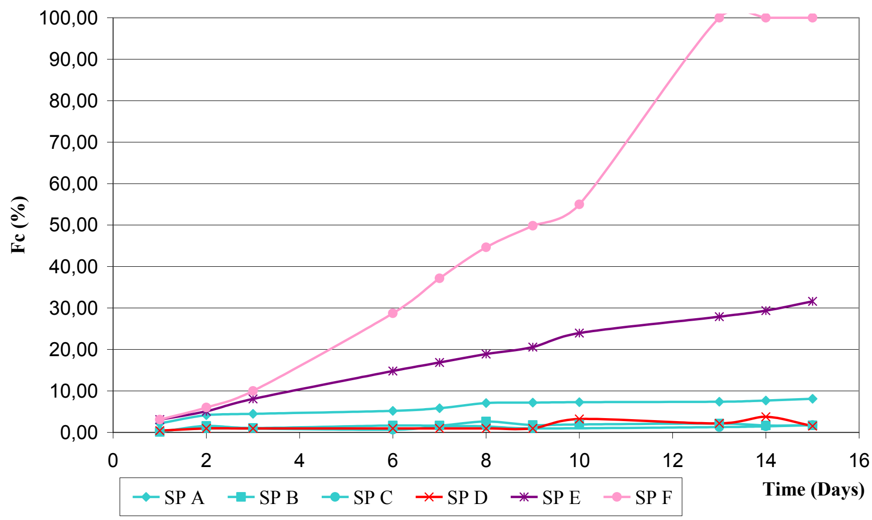


Figure 5. Solder paste influence.

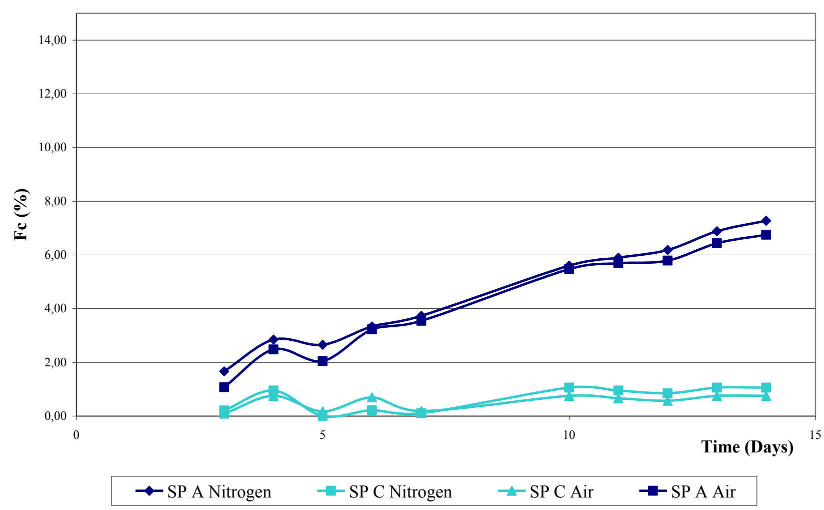
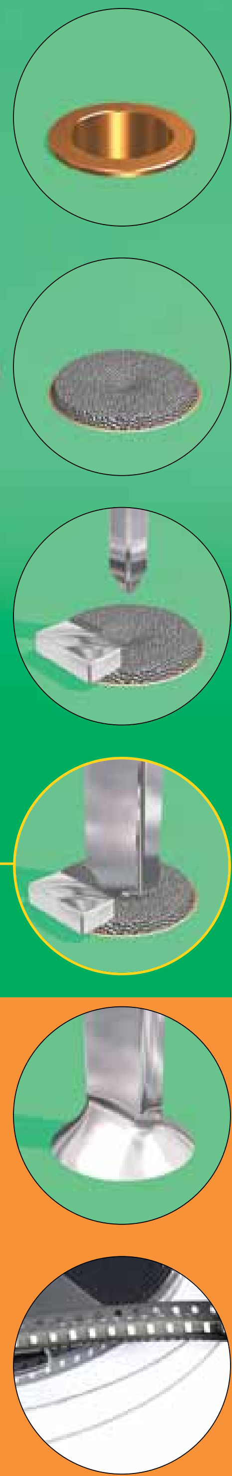


Figure 6. Bono test, reflow under nitrogen.



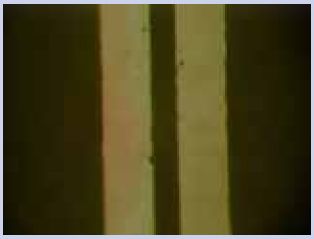
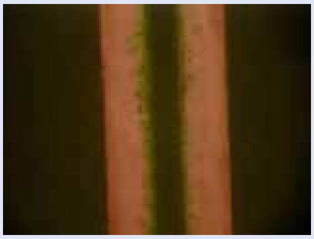
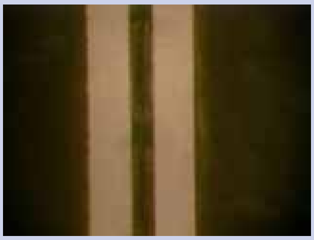
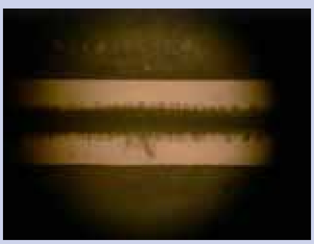
Solder Paste	Copper Dissolution	Short Circuit (over 9 tracks)	Residue Aspect
Solder Paste A		No	Greenish Small residue spreading
Solder Paste B		No	Brown No spreading
Solder Paste C		No	Light brown No spreading
Solder Paste D		No	Transparent No spreading
Solder Paste E		2	Greenish and minimal spreading
Solder Paste F		All	Green-brown No spreading

Table 3. Visual inspection, solder pastes from different origin.

and no spreading for C in air atmosphere). Fc value results are given in *Figure 8*.

This experiment showed that the thermal profile seemed to have an influence on solder paste A but not on solder paste C. Solder paste C is not corrosive at all, regardless of the thermal profile used. Solder paste A is more corrosive if the thermal profile is shorter (Fc=6.7% for Profile 1 and 11.5% for Profile 2). This can be explained by the fact that some activators remained on the board after reflow due to the shorter thermal profile. Thus a higher corrosion factor is observed for solder paste A.

Bono test: conformal coating influence

To protect the boards from environmental conditions (temperature, humidity), conformal coating is sometimes required. The Bono test is a very good technique for assessing the compatibility between the solder paste and the conformal coating. Solder pastes A and C were once again selected and reflowed according to the profile 1; the conformal coating used for this study is polyurethane (PU), cured according to its product data sheet. The SIR tests (IPC TM 650 method 2.6.3.3) passed for both solder pastes: the SIR values were above $10^8\Omega$ and no dendritic growth was observed.

However, the solder paste A with the PU conformal coating gave the lower SIR value (*Figure 9*).

The Bono test was then applied to the same solder pastes. Both solder pastes exhibited a higher Fc value when the conformal coating was applied (*Figure 10*). The corrosion factor for solder paste A increased more than the one for solder paste C, meaning that the solder paste A residue and the PU conformal coating were not totally compatible, even though the IPC SIR test passed. No mousebites were observed in either case.

Test consistency

When comparing the four (4) experiments for solder paste A and solder paste C, it was showed that this method is consistent (*Table 5*).

Conclusion

The Bono test differentiates the nature of solder paste residues better than other methods. Lead-free, no clean solder pastes have very different behaviours. Some can be very corrosive, as the Bono test proves even though common SIR and ECM tests fail to do so. Through the different experiments, it was shown that this method is consistent and repeatable.

Even if the Fc value is low, the start of dendrite creation may be seen (since there are no short circuits between anodes and cathodes, the Fc value can be low), and a high Fc value does not necessarily lead to mousebites. Residue spreading is only a cosmetic issue, and halogens in the solder paste flux can cause copper dissolution. The thermal profile will influence the solder paste residue corrosivity if the

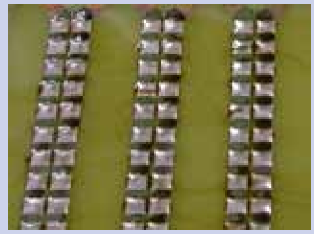
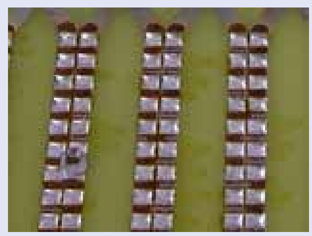
Solder Paste	Reflow Condition	Copper Dissolution	Short Circuit (over 9 tracks)	Residue Aspect	Residue Picture
Solder Paste A	Air	No	No	Greenish Small residue spreading	
	Nitrogen	No	No	Light green residue spreading all over the boards	
Solder Paste C	Air	No	No	Light brown No spreading	
	Nitrogen	No	No	Light brown No spreading	

Table 4. Visual inspection, reflow under nitrogen.

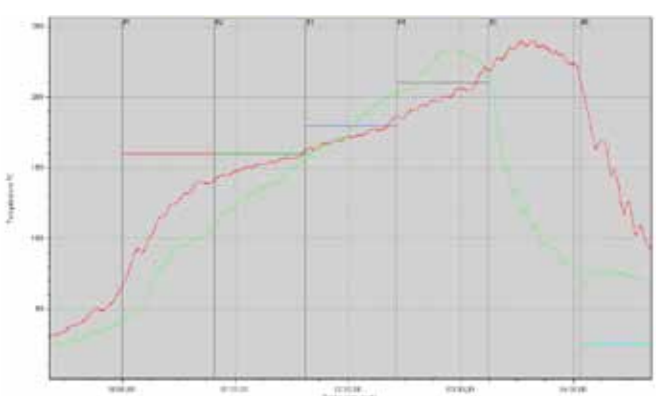


Figure 7. Profile 1 (red) and 2 (green) on the same graph.

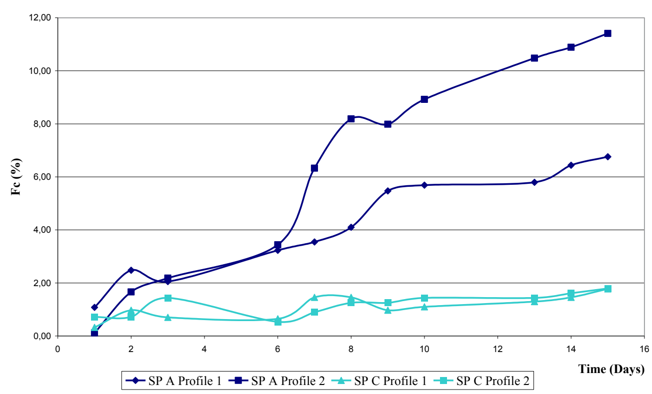


Figure 8. Thermal profile influence on solder paste.

solder paste tends to be corrosive, however the reflow environment does not seem to have any influence. This test is also a good way to check the compatibility between solder pastes and conformal coatings, as it increases the difficulty to pass the test.

It should be noted that the Bono test procedure does not specify any real critical value above which a solder paste is considered to be corrosive. However, from the different experiments, a solder paste residue corrosivity assessment can be taken into account using the following guidelines: corrosivity does not exist in solder paste residue when the Fc value is under 2% (which can due to measurement precision), the solder paste residue corrosivity is acceptable when the Fc value is between 2 and 8%, and the solder paste residue starts to be corrosive when the Fc is above 8%.

In addition to characterizing solder

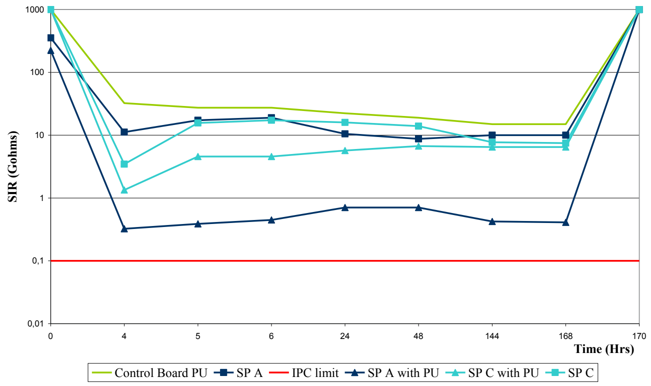


Figure 9. SIR results for solder pastes A and C with and without PU conformal coating.

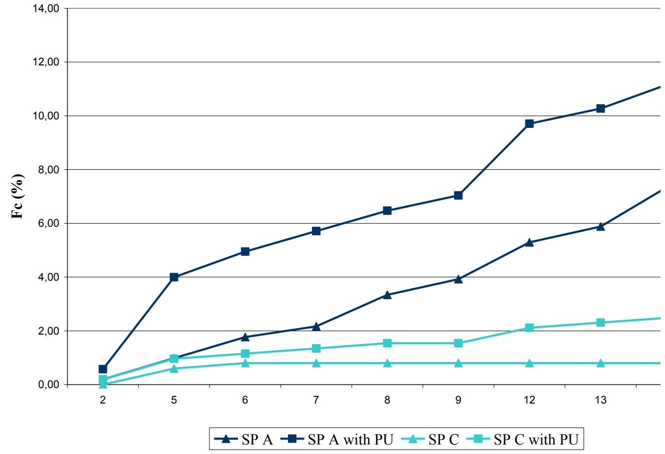


Figure 10. Bono results for pastes A and C with and without PU conformal coating.

Experiment #	1 Solder Paste Influence	2 Reflow Environment	3 Thermal Profile	4 Conformal Coating
SP A—Fc Value (after 15 days) %	8.1	6.8	6.7	8.2
SP C—Fc Value (after 15 days) %	1.8	1	1.1	1.2

Table 5. Fc values from the diverse experiments.

paste residues, the Bono test can be performed for wave soldering fluxes, repair fluxes, and tacky fluxes using the same method and the same board.

Acknowledgments

The authors would like to thank Dr David Bono for his help in developing and implementing the test, which bears now his name.

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The miniature component solder paste printing process—Continued from page 29

acceptable results in our current solder paste pritng process will be correct in optimizing the miniature component solder paste printing process. Numerous experiments by solder paste suppliers, stencils suppliers, printing equipment suppliers, academic institutions, and users have identified several significant process modifications that must be considered in the development and optimization of the miniature component assembly process. More so than ever before, it is important to work with your suppliers to develop recommended process parameters in order to satisfy the process cycle time and quality goals.

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Post-earthquake thoughts

**Walt Custer
and Jon Custer-Topai**

Following a very strong recovery year in 2010, this year began with projections of "historically normal" growth rates for the electronic supply chain in 2011. However political unrest in N Africa (higher oil prices) and the tragic Japanese earthquake/tsunami/nuclear radiation situation (loss of life & property and supply disruptions) have detoured most short term forecasts.

A timely leading indicator, Japan's Purchasing Managers' Index (Chart 1), plunged in April as Japan struggled to resume operations. Charts 2 & 3 were created for my "Global Business Outlook" keynote talk at the IPC Expo/APEX tradeshow in Las Vegas April 12-14. Hopefully as you read this article conditions have improved in Japan but it is likely that many assembly operations worldwide will be hampered by the limited availability of unique, Japan-made materials and components.

Higher oil prices are another major concern. Per Chart 4 the electronics industry "outgrew" oil prices from the mid 1990s through mid 2000s. However in periods of Mideast unrest oil prices have spiked and they are certainly doing so today.

High energy and petrochemical costs, skyrocketing metal prices, rising wage rates in China and key component shortages are combining to fuel significant inflation in the electronic supply chain.

Globally the effects of the Japanese situation were not that evident in electronic equipment and component sales available through mid-April. Actual Japanese electronic equipment production (www.jeita.or.jp/) is released almost 3 months after month close (Chart 5). We won't see the earthquake effect in the Japan equipment data until the March information is released in late May.

Other countries' equipment shipment data are timelier. Electronic equipment production plummeted in February in Taiwan/China due to a combination of normal seasonality, Lunar New Year shutdowns and production delays due to Intel chip set issues. However March rebounded.

Printed circuit boards are following as similar monthly pattern as electronic equipment. February dropped but March rebounded (Chart 8). Since Japan only produces about 20% of the world's PCBs and because much of its production was not affected by the earthquake, global PCB production should not be impacted that much in 2011.

End Markets

Global PC shipments are forecast to grow 10.5% y/y to 387.8 million units in 2011.—Gartner

Media tablet shipments reached nearly 18 million units in 2010 with Apple capturing 83% market share. E-book reader shipments quadrupled to more than 12 million units.—IDC

Smartphones are expected to grow 50% y/y to over 450 million units in 2011.—IDC

Worldwide camera phone sales are forecast to grow 21% from 918 million units in 2010 to 1114 million units in 2011.—Strategy Analytics

Femtocell shipments reached over 1.2 million units in 2010.—Infonetics Research

EMS, ODM & related assembly activity

Worldwide EMS industry revenue will grow from $233 billion in 2009 to $400 billion by the end of 2014.—IDC

North American EMS aerospace and defense market revenues are expected to grow from over $5.52 billion in 2009 to $8.42 billion in 2014.—Frost & Sullivan

Advanced Manufacturing Service moved

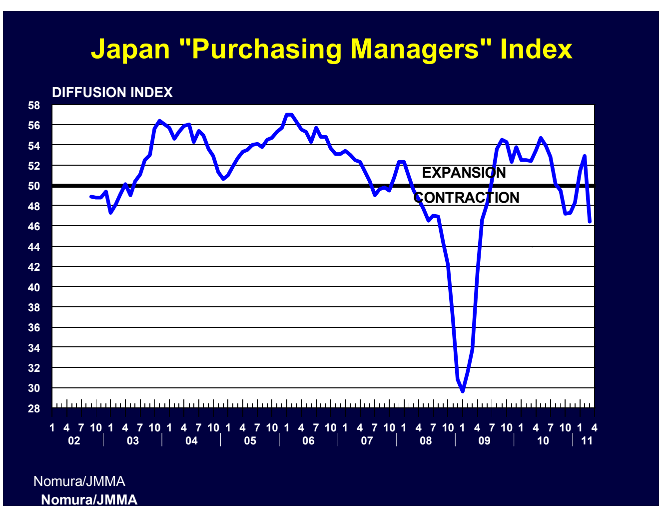


Chart 1.

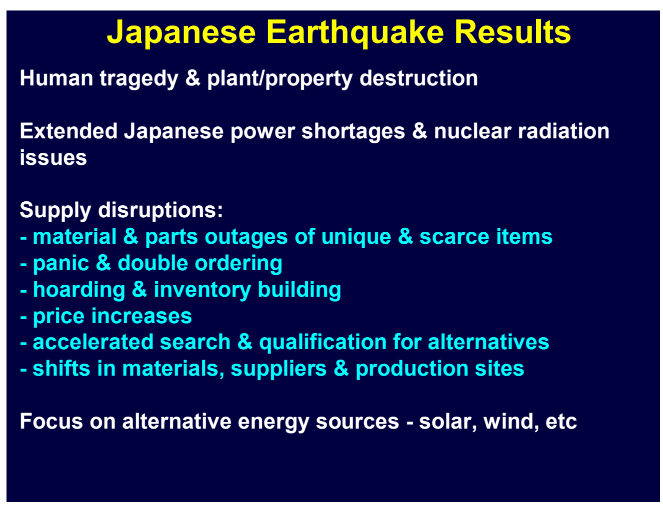


Chart 2.

to a 13,000 SF facility in Ronkonkoma, NY.

Brush Engineered Materials changed its name to Materion Corporation.

Celestica is closing its Kladno, Czech Republic, manufacturing unit.

Cimar added a MY100 Synergy production line from MYDATA.

ControlTek added a Juki FX-3 SMT system.

Creation Technologies purchased a Universal Instruments Advantis 3 Platform for its Markham Ontario, Canada, facility.

Deswell Industries appointed Herman C.W. Wong CFO.

Distron began construction of a 13,000 SF addition to its corporate headquarters in Attleboro Falls, Massachusetts.

Flextronics:

- is setting-up a facility in Senai, Johor, to house its Flextronics Global Services operations.
- plans to hire more than 7,000 people to support its growing Malaysian operations.

Foxconn:

- is opening a manufacturing plant in Jundiai, Brazil.
- began operation at its R&D center in Changsha, China.
- is spending US$200 million to construct an 89 million handset/year factory in Vinh Phuc Province, Vietnam.
- plans to establish 10 subsidiaries and list them on the TSE within 5 years.
- increased iPad 2 shipments to over 4 million units/month.

Hadler added a Siplace SX1 in Felsberg, Germany.

Jabil:

- plans to lay off around 90 staff in St. Petersburg, Florida.
- received 200 MW solar panel assembly contract from JA Solar Holdings.

Kitron received a five-year manufacturing agreement for naval strike missile electronics from Kongsberg.

LaBarge:

- was acquired by Ducommun for $19.25/ share.
- received a $4.5 million cable harness contracts for Raytheon's Tactical Tomahawk program.

Legacy Electronics moved from San Clemente, California, to Sioux Falls, South Dakota.

LG Electronics set up LCD TV production line in Shenyang, China.

Nortech Systems named Mark Nordquist GM of Aerospace Systems Operations.

Oakwest Corporation acquired 8,541,987 common shares of Firan Technology Group.

PartnerTech laid off 37 workers in Vellinge, Sweden.

PC Partner added a Track, Trace and Control system from Cogiscan in Dongguan, China.

PPI/Time Zero is opened 340,000 SF facility in Waynesboro, Virginia.

Rocket EMS purchased a Trident duo high-yield automatic defluxing and cleanliness testing system from Aqueous Technologies.

Ryder Industries is opening a 70,000 sq m manufacturing campus in China's Jiangxi province.

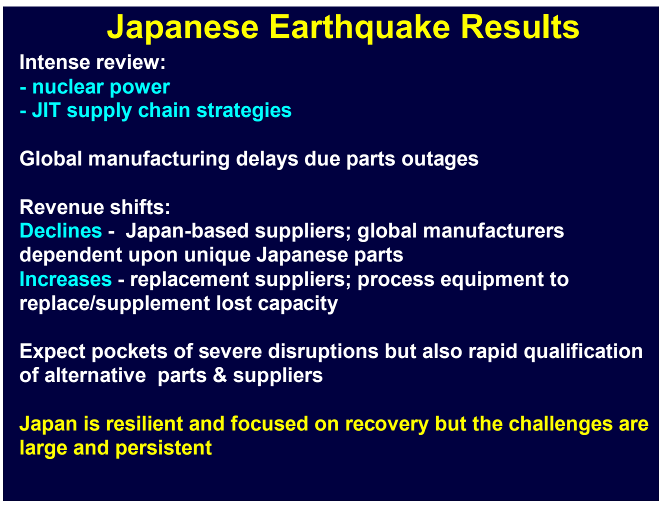


Chart 3.

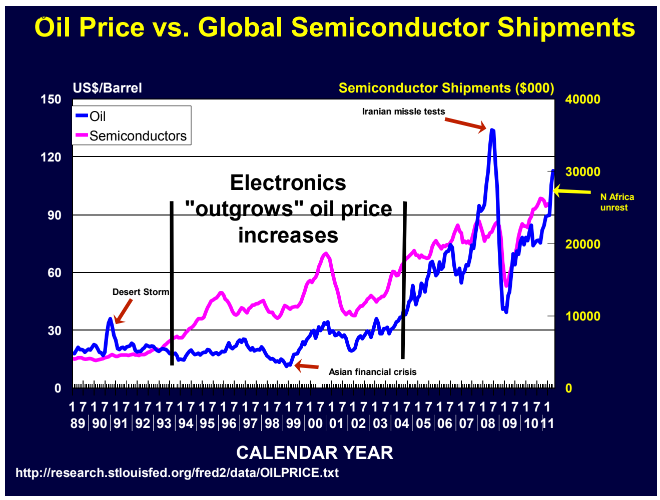


Chart 4.

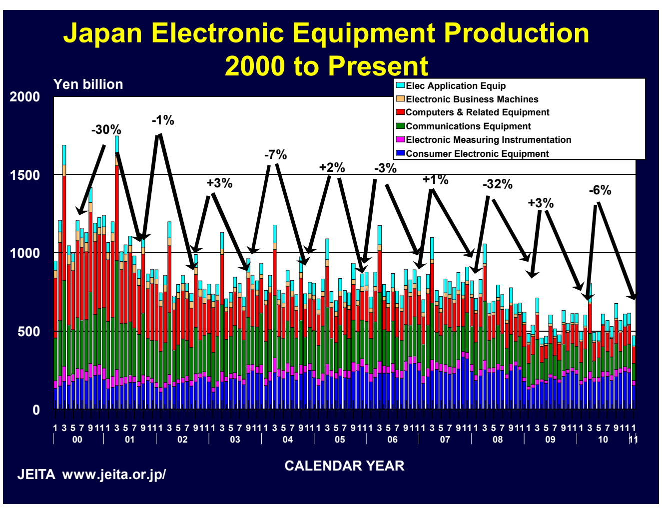


Chart 5.

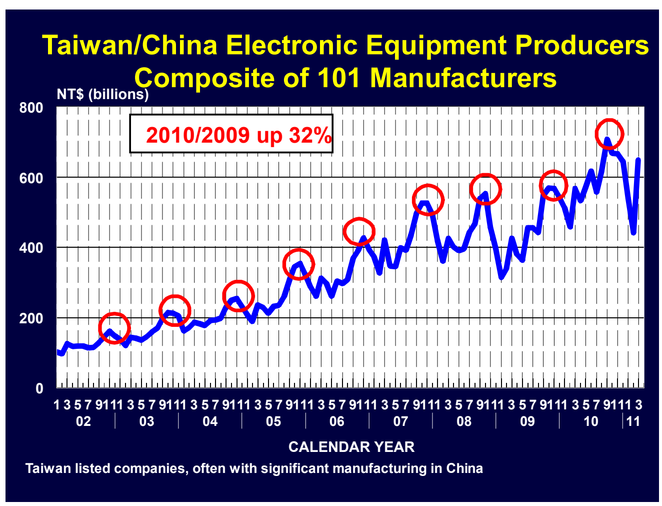


Chart 6.

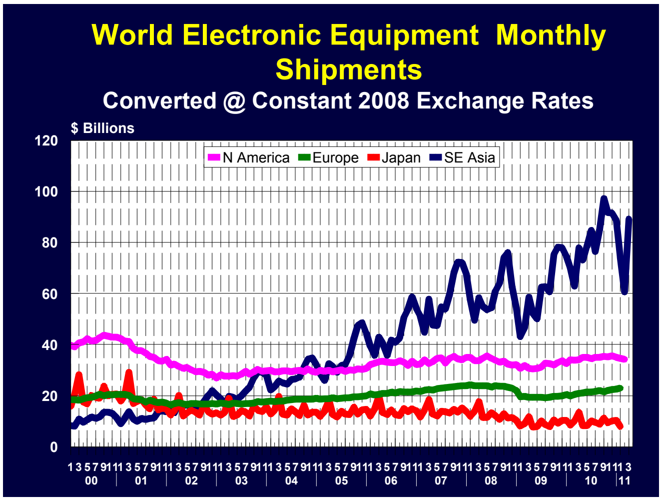


Chart 7.

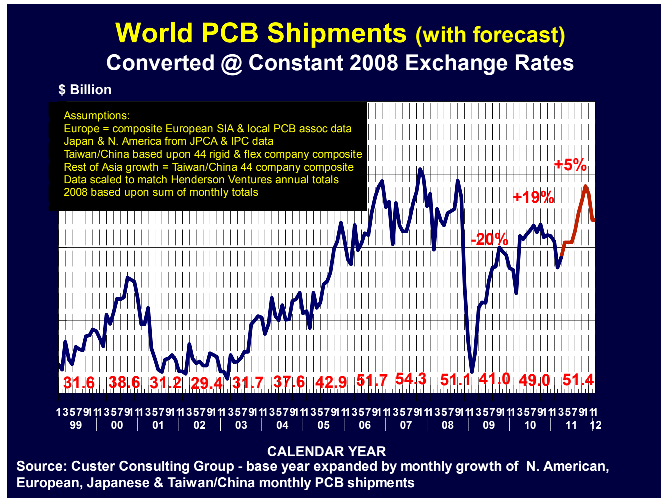


Chart 8.

Samsung Electronics switched its entire stencil requirement in Jaszfenyszaru, Hungary, to ALPHA TetraBond, a new frameless, stencil technology by Alpha, Cookson Electronics.

Sanmina-SCI:

- Magyarország Kft is hiring 150 new staff to meet rising demand.
- President and COO Hari Pillai resigned but continued in consulting role.

Season Group:

- appointed Steve Wilks Business development director for Europe.
- signed a memo of understanding with Logatec GmbH Logistik Technologie.

SMT Hautes added Universal Instruments Genesis Series 2 Platforms in Montreal, Canada.

SMTC appointed Alex Walker chair of the board.

PCB fabrication

EDA industry revenue increased 19.4% for 4Q'10 to $1508 million; PCB & MCM revenue grew 26% y/y to $166 million.—EDA Consortium

Arc-Tronics began manufacturing printed circuit boards in Empalme, Sonora, Mexico, for Offshore Group.

Canon Components re-started its printed circuit business with new products such as TAB, flexible circuits with heat sink and low cost D/S circuits.

Colonial Circuits appointed Mike Tucker director of engineering.

Eltek appointed Erez Meltzer chairman of the board of directors.

Faraday installed a Microcraft MJP 6151 Inkjet legend printer, Microcraft Emma roving probe tester, Orc 5kW exposure unit and a Hakuto cut sheet laminator in Washington, Tyne & Wear, UK.

Garner Osborne Circuits, Newbury UK added a MicroCraft Emma ELX6146 tester from Viking Test Services.

GSPK Circuits installed two flying probe test machines in Knaresborough, UK.

Integral Technology named former Sanmina-SCI VP of business development, Jim Ryan VP of business development.

Lenthor Engineering installed an ESI Flex5530 UV laser drilling system.

MFLEX appointed Philippe Lemaitre chairman and elected Kheng-Joo Khaw to its board.

Nippon Mektron resumed full operation at its Okubara plant.

Schneider Electric began using RFID to identify and track the production of every PCB it manufactures.

U.S. Circuits installed Maskless Lithography direct-write imaging systems at its Southern California facility.

Semiconductor & other components

Global semiconductor materials sales increased 25% y/y to US$43.55 billion in 2010.—SEMI

Semiconductor equipment spending grew 143% to almost $41 billion in 2010.—Gartner

Worldwide semiconductor manufacturing equipment sales expanded 148% y/y to US$39.5 billion in 2010.—SEMI

Worldwide semiconductor photomask market is forecast to grow from $3.0 billion in 2010 to $3.2 billion in 2012.—SEMI

Materials & process equipment

Direct imaging equipment installations will increase to 1000 units in operation in 2011.—Dr. Hayao Nakahara

Thin glass yarn prices have risen 3-5% every month since the beginning of 2011.—Dr. Hayao Nakahara

3M is investing US$10 million to build a R&D center In Taiwan.

Assembléon is developing pick & place machines that will cut energy consumption and other operating costs by at least 30%.

Cobar BV hired Marshal Jusmal as business manager for South East Asia.

Essemtec established a SMT equipment subsidiary in Warsaw, Poland.

Fujitsu integrated its SignalAdviser-SI analysis system with Zuken's CR-5000/BD-Viewer Advance system and CR-5000/Board Designer.

HumiSeal appointed Keith Waryold, global business unit director.

Indium:

- named Ron Hunadi, Ph.D., market development manager for semiconductor and advanced materials.
- appointed AdoptSMT Europe GmbH as its newest sales channel partner in Austria.

Intrinsiq introduced prototype, stable, 80wt% copper screen print ink for photonic curing at room temperature in air.

JSR developed an optically isotropic transparent film that has a maximum operating temperature of 260°C or higher.

Juki is shifting production of component feeders from Japan to China to reduce manufacturing costs by 30%.

Kyzen promoted Debbie Carboni to national electronics sales manager.

LPKF headquarters invested 5 million euros to purchase a neighboring building and add additional 32,000 SF for product development and production.

Mitsubishi Gas Chemical resumed BT-resin based laminate production to pre-earthquake volume for IC substrate

Continued on page 53

Interview—
Suresh Nair, Leaptech Corp.

In an exclusive with Global SMT & Packaging's technical editor, Pradeep Chakraborty, Suresh Nair, director of Leaptech, elaborates on what India should do, as far as electronics manufacturing is concerned. He especially highlghts support for the Indian electronics hardware industry, and specifically calls upon the government to impose higher duties on imports of fully finished electronic products and completely removing duties on import of components and raw materials.

How is Leaptech helping the electronics, semiconductor and automotive manufacturing companies in India?

Leaptech Corp, was established to help electronics, semiconductor and automotive manufacturing companies in India achieve global standards by adopting the latest technologies available worldwide, especially on the automation front.

Elaborate on your service contracts. What kind of after-sales service do you provide?

We supply machines from all of our principals with full warranty and service support. The initial installation, commissioning & training to customers are provided by us. Subsequent service support during the warranty period is also provided by us. In most of the cases, all of these services are provided free of any cost to the customer as part of the machine supply. Post-warranty, we offer an annual maintenance contract for all our products, which includes preventive maintenance visits as well as breakdown visits.

You also provide audit and reconditioning services to enable customers improve productivity and uptime on their exist-

ing automated through hole and SMT assembly machines. Please elaborate. Do these services also include machines not sold by/through your company?

Yes, we do provide auditing and reconditioning services to all products that are part of our portfolio; that is, machines that are sold by our principals, whether they were sold by us or not. We don't offer this service to products that are not part of any of our principals.

What kind of training do you provide on operational and maintenance aspects of through hole insertion and SMT machines?

We provide complete training to the operators and engineers of the customer, including machine operation, routine maintenance and troubleshooting activities.

Our training support also covers production support to the customer for the initial few days, since operational issues are encountered in the beginning of any automation.

Elaborate on the consultancy services that enable customers meet global standards in PCB assembly.

We offer consultancy services for set-up of any new facility or for new product introduction. The methods followed by us are as laid out by the IPC and documentation are as per the ISO regulations.

What is your take and position regarding connected mobile devices? How do you see this segment growing in the years to come?

Mobile devices are the future as far as gadgets are concerned. Currently, this segment will grow continuously for many years to come.

Since this is a mass volume product, the automation requirement is also high and we see good potential for our products.

What is Leaptech doing with regard to driving automotive electronics toward energy efficiency?

Many of the products offered by us are energy efficient compared to our competitors and also compared to our own products, which were in offer few years ago.

For example, the reflow ovens once available were power guzzlers consuming anything like 40-50 kW depending on the number of zones. Today, the same reflow oven consume only 5-10 kW depending on the number of zones. The same is true with many other equipment.

What is your take on the Indian electronics scenario in 2011 and beyond?

The Indian electronics industry is poised for reasonably good growth in 2011 and beyond, mainly on good GDP growth and market sentiment. Though the export market is still sluggish, the domestic market is doing good and growing rapidly.

What, according to you, should be done to boost electronics manufacturing in India?

Similar to the material and policy support extended by the central and various state governments towards the software industry, we need to have such support for electronics hardware industry as well. This is a long standing request of the industry. Though some improvement is seen by way of SEZs coming up in Chennai, we need many more such initiatives.

Also, the government should look at imposing higher duties on import of fully finished electronic products and completely removing duties on import of components and raw materials.

Have you been affected at all by the Japanese earthquake? How are you managing the business?

Fortunately, our principals are all located in the southern part of Japan and hence, there is no disruption in factory activities. Some of the component suppliers located in the northern Japan did get affected, but our principals could arrange for alternate sources from other parts of Japan. So, in general, we don't have any problems as of now.

Lastly, do you think that nanotechnology will emerge as a disruption in India?

It is not true that nanotechnology will have a disruptive effect in India. It can co-exist with all of the other technologies as the industry is vast and in fact, different technologies will benefit the industry in general.

Thank you, Mr. Nair.

Pradeep Chakraborty

Integrating cleaning agent and cleaning equipment for maximum performance

Serge Tuerlings, Kyzen Europe, Maldegem, Belgium

Continuous Innovation

Over the last 20 years the electronic assembly industry has changed dramatically. Not only has the amount of electronic equipment used in our day-to-day life increased, the requirements from the general public have become more demanding.

Indeed nowadays everybody has a mobile phone that can do a lot more than just make or receive a call. If we add mobile navigation systems, portable game consoles, smart mp3 players and the other gadgets we carry in our pocket, this gives us a nice collection of items that we want to be trustworthy and dependable. Traditionally, industries such as the military, medical, aircraft, space and automotive had reliability and performance as high-ranking requirements on their wish list. In the ever-continuing quest for miniaturization, the challenge to achieve reliability and performance becomes bigger and bigger. These industries came to the conclusion a long time ago that cleaning the electronics assemblies after reflow, wave soldering and/or manual rework process does increase reliability.

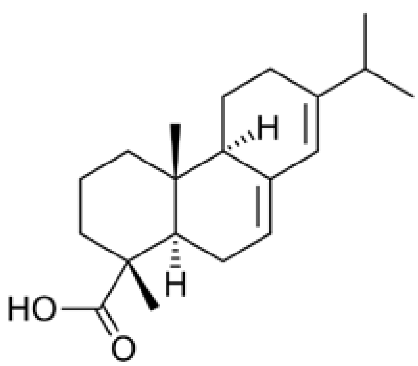
Since the introduction of no-clean flux technology, now more than 20 years ago, the discussion about the influence of the flux residues after the soldering process is still ongoing. Obviously manufacturers of the soldering materials claim that these residues are inconsequential and should be left on the assembly. The segment of the electronics industry that is manufacturing items with lower reliability demands agree about no-clean fluxes being irrelevant. On the other hand, industries requiring high reliability from their assemblies have concerns about the no-clean fluxes reacting with moisture, temperature changes, voltage and aging, and prefer to remove these residues. The introduction of lead-free alloys, now 10 years ago, have contributed to the no-clean debate, as these alloys require adapted flux technology contributing to wetting and solder joint formation.

Innovative cleaning liquids

In order to remove the no-clean flux residues, innovative cleaning liquids are being introduced. These are innovative in the sense that they have the ability to remove the no-clean lead-free flux residues from high-density designs and from underneath low-stand-off components. An added innovation with the new cleaning fluids is that these are environmentally friendly. These fluids are used diluted with water, which reduces the volatile organic compound concentration dramatically.

The no-clean (lead-free) fluxes are a mixture of natural rosins and/or synthetic resins regulating the viscosity and tackiness of the solder paste, organic acids and halogens are used to promote wetting and towards dissolving oxides. Solvents and rheological additives complete the formulation. The cleaning chemistry must be able to remove this mixture of chemicals with their own cleaning particularities.

Some of the latest solder pastes formulations are combining synthetic resins and natural rosins. Synthetic resins with their aromatic structure and polar covalency are harder to clean and will require a higher solvency of the cleaning medium. The natural rosins have a carboxylic structure and are easier to clean due to hydrogen bonding and polarity.

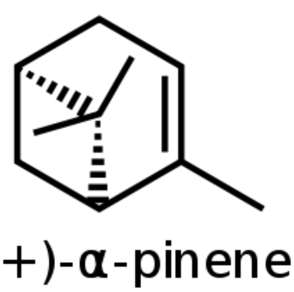


Natural rosin.

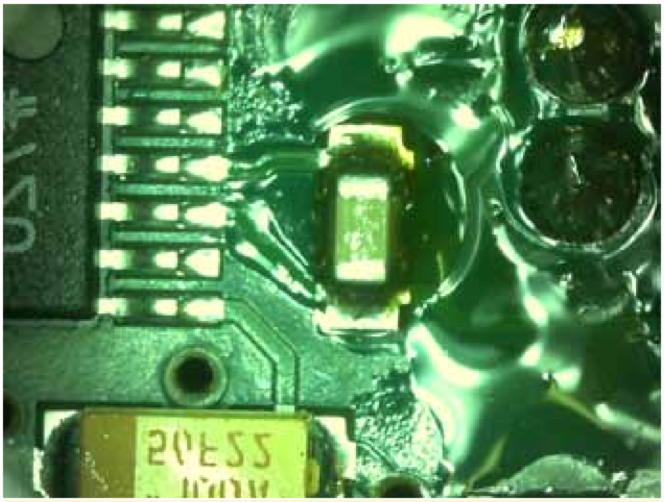
Another parameter contributing to cleaning issues is the choice of reflow profiles during the SMT assembly process. The ramp-soak-spike profiles result in harder to clean residues because of the higher exhaustion of the fluxes making them hard and more bonded to the surface of the solder joint. A ramp-to-spike profile maintains the flux vehicle during the entire profile, resulting in an easier to clean residue.

With the increased usage of low-stand-off components, the challenge is to clean away the residues underneath these components. The innovative aqueous cleaners are capable of penetrating the low gaps between boards and components in order to remove the flux residues. Due to the lowered surface tension, the rinsing water is equally able to get under the components and is displacing the cleaning fluids with great success.

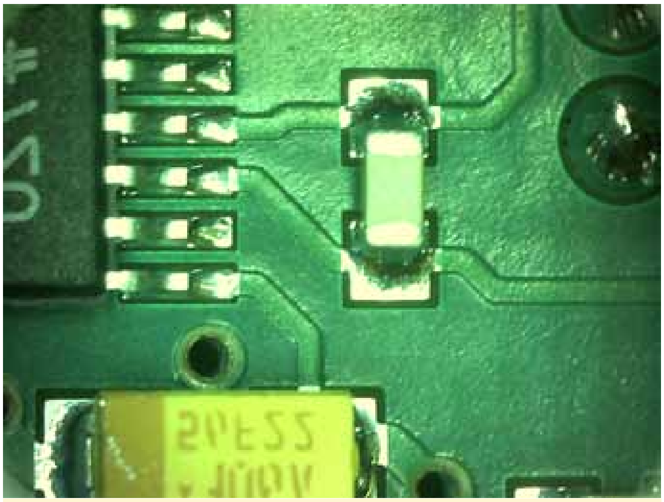
Innovative cleaning fluids have several ingredients in their formulation; each ingredient contributes to the performance of the end product. A primary ingredient is a solvent or a blend of solvents used. This solvency basis will determine which type of residue the cleaning fluid can tackle. It will also determine the static cleaning rate as it will dissolve the contaminants. Activators are used to help the solvents dissolve the contaminants and remove them from the surface. This avoids having white residues after the cleaning process. Buffers are there to keep a stable pH environment,



Synthetic resin.



Assembly before cleaning



Assembly after cleaning

which is important for the functionality of the cleaning medium. Surfactants help to reduce the surface tension for better penetration of the cleaning fluid and rinse medium underneath low-stand-off components. Inhibitors are incorporated in the cleaning chemistry keeping metallic surfaces safe from any discoloration during the cleaning process.

Process cleaning rate

Cleaning of electronic assemblies is an exact science in which it is important to understand which residue needs to be cleaned from which surface. Each cleaning fluid has an internal cleaning power also called the Static cleaning rate (R_s). This is the rate at which the cleaning material dissolves flux residue in the absence of an outside energy source.

The Dynamic cleaning rate (R_d) is the energy applied from the machine and its fluid delivery system. The process cleaning rate (R_p) is the sum of the static and dynamic cleaning rate.

$$R_p = R_s + R_d$$

This equation teaches us that the cleaning chemistry on its own will contribute to a certain cleaning level but will not be able to fully remove the residues. It also shows us that the cleaning equipment on its own is without any use. The combination of the right cleaning fluid in the right cleaning equipment will assure a performing cleaning process.

Equipment requirements

Each cleaning process is influenced by five parameters: time, temperature, product type, product concentration and mechanical energy. Four out of these five parameters can or should be controlled by the equipment. Additionally, rinsing and drying of the electronic assembly after the cleaning process in itself will contribute to the end results.

Time: The cleaning fluid needs a certain contact time with the contaminants to dissolve them and to remove them from the surface. The equipment should have the ability to control this feature. Flexibility towards having different timings for the cleaning, rinse and drying cycles is a prime feature of the equipment.

Temperature: Adding thermal energy to the cleaning process will assist the cleaning fluid to dissolve the residues from the assembly surface as temperatures between 40˚C and 60˚C will soften the resin/rosins used in the fluxes.

Concentration: Aqueous cleaning fluids have to be diluted with water to the ideal concentration. This ideal concentration will depend on the residues, cleaning time targeted and temperature used. Mostly a concentration of between 20 and 30% is common practice. The equipment should ideally be able to maintain the exact concentration during the entire bath life.

Mechanical energy: The dynamic cleaning rate is influenced by the energy that the equipment will deliver to the cleaning process. Regardless of the type of energy supplied by the machine (ultrasonic, spray under immersion, spray in air) having the right amount of energy and wash flow delivered to the correct destination will influence the end result as much as the static cleaning rate. Having the flexibility to supply different energy levels to the equipment that needs to be cleaned will benefit the entire process.

Product type: Choosing the right chemistry for your cleaning process will be influenced by the residue type and by the equipment selected. Your chemistry and equipment suppliers will be able to assist you.

Rinsing: The rinsing process is as important as the cleaning cycle. Rinsing will ensure that all residues are removed together with the cleaning chemistry itself. Especially under low-stand-off components, a good rinsing process is of the utmost importance. The reduced surface tension provided by the cleaning chemistry and the appropriate rinse medium volume delivery and energy level supplied by the equipment will guarantee full removal of residues and chemistry.

Drying: With high-density assemblies and low-stand-off components, a performing drying process is required. A combination of temperature and hot air movement will guarantee a dry and safe board.

Conclusions

Cleaning electronics assemblies will require the right cleaning fluid in combination with the right cleaning equipment. Critical elements for the cleaning fluid are the static cleaning rate and the ability to remove a wide range of residues. The cleaning equipment will require the ability to deliver the right amount of energy and wash flow. Thermal energy and appropriate contact time will all contribute to a clean assembly.

Process validation and standards compliance

Bjarne Møller and Henry Jurgens, Ph.D., P.Eng., Valor Division of Mentor Graphics Corp.

Failing a customer process audit is something no organization wants to be faced with. Ensuring that your manufacturing site continuously receives high marks in such audits is critical to retaining the business of key accounts.

Keywords: Process Validation, Standards Compliance, Manufacturing Process Definition, Build Record, Material Management, Resource Management

Introduction

Manufacturers of printed circuit boards and electromechanical systems are continually challenged with validating their assembly and test processes. Aside from the fact that it is good practice to assure that their manufacturing plants are running in an optimal manner and that they are producing high quality products for the market, a manufacturing operation has other drivers, such as compliance with industry standards and passing regular process audits run by their customers. The ability to prove that a site is certified to a plethora of different standards, such as quality management system standards like ISO 9001 and the industry specific versions such as AS 9000 for aerospace, ISO/TS 16949 for automotive, TL 9000 for the telecom industry, and ISO 13485 for the medical industry, can differentiate a manufacturer from the competition and can be key in opening up potential new markets for their services. Failing a customer process audit is something no organization wants to be faced with. Ensuring that your manufacturing site continuously receives high marks in such audits is critical to retaining the business of key accounts.

In today's dynamic world of electronic manufacturing, which is challenged by an ever increasing level of complexity, it is

Figure 1. An MES system needs to be able to present data and controls in real time.

becoming more and more important that companies have the latest systems in place to help insure that they can fully validate their manufacturing processes. Having such systems in place can greatly aid in helping a company to get certified as being compliant to a number of industry standards, and, when implemented well, can ensure high marks are received after a customer process audit. This article will outline a number of areas in which the latest manufacturing execution systems (MES) systems, which are designed specifically for the electronics manufacturing industry, can aid in validating key manufacturing processes providing an infrastructure ideal for maintaining compliance with both industry standards and customer expectations.

The MPD and build record

When discussing process validation, we find it useful to refer to a couple of key concepts.

The first is the manufacturing process definition or MPD. The MPD defines the exact set of operations that a product must flow through in manufacturing as it is being assembled, tested, and packaged. Along with this definition of the 'route' the product takes through manufacturing it also includes the complete set of programs needed by equipment in manufacturing, information about required fixtures, detailed instructions for operators related to equipment setup, and, for manual assembly or inspection operations, a full set of instructions outlining exactly what the operator needs to assemble and/or inspect.

The second concept is the build record. the build record is a complete history of exactly what has happened to any unit that has been produced by the operation. It contains:

- a complete record of every operation and equipment that the product went through during production
- detailed traceability information identifying what material was added to the product at each operation
- information concerning what operator was working on the product at each operation
- data concerning key process parameters collected from the equipment that was used in assembling and testing the product
- all measurement results from every test and inspection operation
- additional quality information such as a full defect and repair history for the product

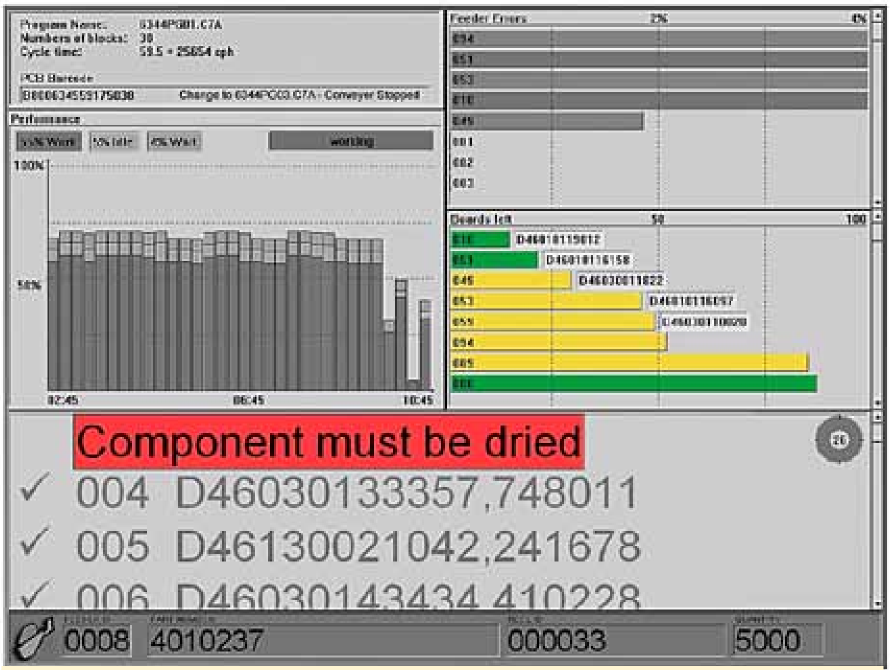


Figure 2. Powerful material management systems identify when a moisture sensitive component must be dried, increasing overall quality.

Process validation and control

The definition of the MPD is a prerequisite for an MES system and is the basis for enabling good process validation, and more importantly, control. This starts from the basis of having a system in place that enforces that the product follows the proper MPD. That is, the system needs to have the capability to ensure that a product follows the exact routing that is defined in the MPD. If, during manufacturing, the product moves to an operation that it is not supposed to be at (because it is not part of the MPD, or earlier operations in the MPD have not been passed successfully) the system should alert the operator that this unit should not be at this operation and let them know where it should be.

The most advanced systems provide additional capabilities such as:

- interlocking automated assembly equipment such as SMT placement machines when a unit is not properly following the MPD
- verification that the proper NC programs are loaded on automated assembly/test equipment and that key settings on the equipment are within required tolerances
- verification that all fixtures and material (components, sub assemblies, and consumables) are correct for the particular operation and unit
- automated, paperless, delivery of the correct revision of assembly and inspection instructions to operators

To provide a comprehensive set of process validation and controls in the operation, the MES system needs to have coverage of all key operations and equipment in the factory from screen printers, through SMT placement machines, reflow ovens, manual assembly stations, wave solder machines, AOI, ICT, and functional testers, manual inspection locations, system assembly locations, etc.

A site's operators are a key part of its manufacturing capabilities, and ensuring that they have the proper skills and training to perform key assembly and test related tasks on specifics product can be challenging. More importantly, it is key that a manufacturer has the ability to validate that all operators working on a product have the proper training to perform their assigned tasks when manufacturing a product. A good MES system will have the ability to manage the details of all the operators in a site along with their skills and qualifications. If during production, an operator is found to not have the prerequisites to perform a given task assigned to them, the system needs to alert the operator in question, and when possible interlock the particular equipment until an operator with the proper qualifications logs into the

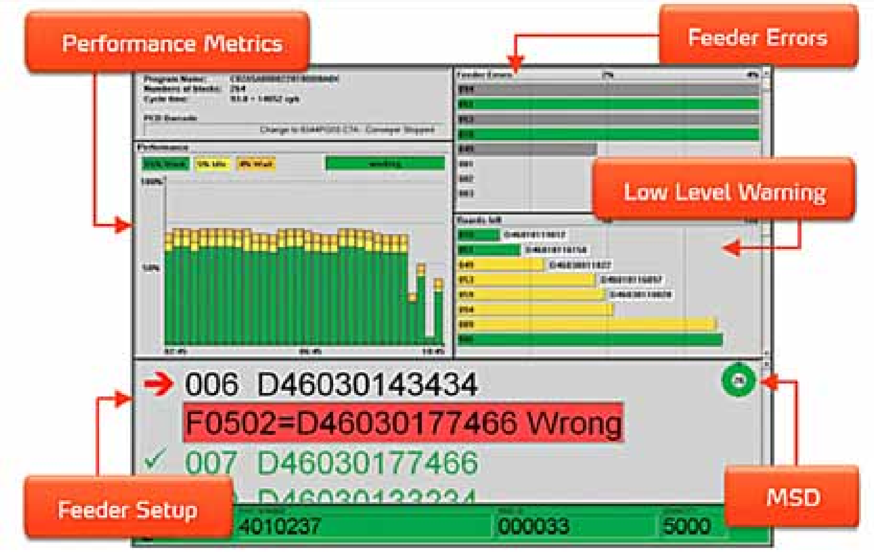


Figure 3. The entire manufacturing process can be monitored using a powerful MES system.

operation.

Material and resource management

The management of material as it pertains to the assembly of products, as well as their repair when issues are detected during test and inspection is also critically important in ensuring that a manufacturer can validate and control its processes. It is important to ensure that the proper components, sub¬assemblies, and consumables are being used at each assembly and repair operation. That is, that the material properly matches the specifications found in the product's Bill of Materials such as part number and revision information. Also, the material being used needs to meet detailed requirements related to hazardous material content, and constraints regarding from which vendors the materials can be acquired.

To ensure that the process is being followed properly, the MES system needs to provide full support for verifying that all material being used in every operation is correct, and if any discrepancies are found, that it will alert the operator or interlock any automated equipment. The most advanced systems also provide the ability to manage advanced operational practices such as the verification of material in offline setup locations, the management of material on trolleys, the verification of family setups, and the ability to quarantine (or block) the use of specific components at assembly operations due to quality issues.

Of specific importance to printed circuit assembly manufacturing is a comprehensive solution for managing moisture sensitive devices (MSD). This is a key process in such a manufacturing environment and providing validation that the operation is properly managing MSD components is critical to maintaining industry specific certifications and passing customer based process audits. Any MES system implemented in such an environment must have the ability to manage the processes associated with MSD components including:

- identification of MSD components and their classification based on IPC/JEDEC standards
- management of the time a component can be exposed to moisture in the environment before they need to be dried
- alerting operators and interlocking of placement machines when a component has been exposed to the environment for too long and there is an attempt to assemble it into a product
- management of components when placed in dry stock or dry ovens to properly account for exposure time to the environment

Some manufacturers have even more specialized needs when it comes to ensuring that their operation is following the proper process for assembling their products. One example is related to the automotive industry where a dashboard assembler needs to ensure that all the LEDs are the same brightness. Given the fact that LEDs come in different light classes (that is, they will shine at a different level of brightness), the manufacturers will compensate for this by adjusting the value of other components (such as resistors) placed on the printed circuit board to ensure that all LEDs shine at a consistent brightness level. This complex scenario can result in many different variants of component sets, related to LED light classes, being required for a single printed circuit assembly. Validating that the proper components are set up on assembly equipment, and managing this when material is replenished to the manufacturing line during a production run, is almost impossible to do unless an automated set up verification system that understands all the variants is in place.

Making sure that other required resources are at particular operations during assembly and product testing are the correct ones is also important in ensuring that an MPD is being properly executed. This includes the ability to verify that the proper paste or glue stencil is being used at a screen printer and that procedures are being followed concerning proper stencil cleaning. The most advanced MES systems manage a closed loop process between the stencil cleaning and screen printer operations and will interlock the printer if the process is not being followed. Other fixtures are equally important, such as partial wave solder fixtures, ICT fixtures, and others.

Properly maintaining fixtures and other resources needed in the manufacturing process is also critical to ensure full validation of adherence to the manufacturing process. As an example, ensuring that all the feeders used in a operation are properly maintained can not only improve the overall throughput of the manufacturing lines, but can have a significant impact on the overall quality of the SMT placement process and can help to reduce material waste. A comprehensive MES system for the electronics manufacturing industry provides a full feeder maintenance management system which includes logging of feeder usage and related errors, the ability to block feeder usage and recall them for maintenance, and comprehensive tools for managing preventative maintenance on feeders.

Quality management

The quality levels of the products being produced at a manufacturing site are a cornerstone of measuring the overall compliance to an optimized manufacturing process. This includes making sure that all inspections and tests are carried out correctly on a unit during production, that all measurements are being logged, and when any measurements are outside of specified tolerances these symptoms are analyzed to

determine the underlying defects so that the unit can be properly repaired. Along with the logging of information concerning the testing and repair of units, an MES system that provides full quality management must also work with the MPD control aspects of the solution to ensure that no product can ever move through the manufacturing process unless all tests have been passed. If a test has been failed, the system must guide the operators to bring the unit to the correct repair location. The bottom line being that no product must ever be packaged and shipped unless all required tests and inspection steps identified in the MPD have been passed.

The most advanced MES systems in the electronics industry also provides comprehensive solutions for automatically connecting to and collecting measurement and symptom information from automated test platforms including easily extensible solutions that allow the system to communicate with customized functional test equipment. Advanced systems also provide comprehensive guidance to the analysis and repair technicians which will aid them in quickly finding the root cause of symptoms to identify the exact defect in the unit and what repair actions need to be taken. All of these capabilities help to ensure that an operation will easily be able to meet the most stringent of quality management standards, and pass the most picky customer quality process audits.

Figure 4. A comprehensive report system provides data in multiple ways to allow thorough analysis and implementation of efficiency-improving changes.

Reporting and Analysis

A site must be able to easily produce all the required reports to prove that they are manufacturing products according to the MPD. That is, that they can validate they have been running the proper manufacturing processes. The basis for this reporting is the collection of a comprehensive build record. An MES system must provide the capabilities to provide an extensive set of reports about the manufacturing process, or about any particular unit that had been manufactured. This includes, but is not limited to, reports related to:

- the proper completion of the MPD identifying every operation that was successfully completed, as well as test operations that may have been failed and the number of times a repair attempt was made
- detailed traceability reports identifying all material used in a product along with key information about the material such as the manufacturer, lot and date code information, and details such as hazardous chemical content
- key process parameters collected from the equipment that was used in assembling and testing the product
- quality reports based on yield and defect information

The reporting engine needs to be able to summarize the data in different ways such as based on specific units or work orders, from different time frames, and for different parts of a production operation all the way down to a specific piece of equipment.

The most advanced MES systems provide comprehensive analysis capability that goes beyond basic reporting to 'validate' that the proper processes have been followed. This allows advanced users to do detailed analysis of the data being collected in the manufacturing operation by on the fly modification of the underlying information being displayed in the reports along with the ability to drill down to ever greater levels of detail. This capability allows an operation to identify processes that are open for further optimization allowing a site to implement an effective methodology for continuous improvement.

Conclusion

Given the complexity of the number of processes that are involved in manufacturing printed circuit assemblies and electromechanical systems it is becoming a greater and greater challenge for sites to maintain their certification to industry standards and to achieve high marks in customer based process audits. Investing in the implementation of an advanced MES solution that is tailored for the specific needs of electronics manufacturers can form the basis for a sustainable infrastructure that enables full process validation and control across the entire manufacturing site. Coupled with advanced reporting and analysis capabilities, such a solution can aid a site in maintaining their existing certifications, allow them to extend their capabilities to the needs of additional market segments, and continue to maintain and add to their list of customers.

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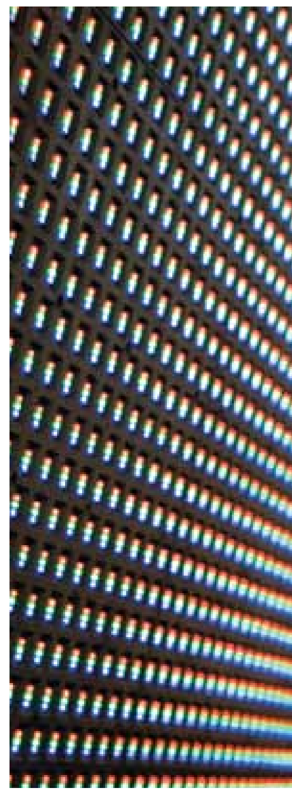

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  • LED/OLED applications, such as illumination and displays
  • LED/OLED manufacturing and processing equipment
- Connect with 1,500+ LED/OLED suppliers from 22+ countries and regions.
- Leading international players include: BridgeLux (USA), Citizen (Japan), CREE (USA), Delta (Taiwan), Epistar (Taiwan), Everlight (Taiwan), Foxsemicon (Taiwan), Infineon (Singapore), Lextar (Taiwan), Macroblock (Taiwan), Nichia (Japan), Osram (Germany), Panasonic (Japan), Philips (The Netherlands), Rohm (Japan), Seoul Semiconductor (Korea), Toshiba (Japan) and many more.
- Get the latest LED/OLED technology and product trends through pavilion exhibitors – Taiwan, Japan and Hong Kong.
- Drive dialogue with influential industrial associations through the forums of AGROA, Lighting Design Gallery and the Asia LED Lighting Summit, which presents the latest marketing intelligence for Asia's LED lighting industry.

Contact:
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Interview—

Chan Pin Chong, Everett Charles Technologies

Everett Charles Technologies is a subsidiary of Dover Corporation, a leading manufacturer of electrical test products and services, including Pogo® test contacts, semiconductor test products, bare-board automatic test systems, and bare and loaded PCB test fixtures. ECT manufacturing, service and support facilities are ISO registered with locations throughout the United States, Europe and Asia. The company has been awarded numerous patents and participates actively in developing industry standards.

Chan Pin, you recently joined Everett Charles Technologies. Please describe the recent changes that have taken place within ECT's management team.

A. There have not been any changes in the management team recently; however, there have been numerous synergy discussions between the staff because we are working to synergize the team and leverage each of the businesses. For example, the head of research and development (R&D) has begun developing strategic roadmaps with each of the business heads and leveraging the broad-based technologies to further focus our innovative advantages over the competition.

Can you give us any indication of new developments or directions for ECT's Electrical Test (ET) business?

In line with Dover's growth target, ECT will continue developing strategies to grow at a similar rate. Some of the current directions include increasing our customer intimacy, optimizing our overall resources, and leveraging synergies to increase ECT's innovation and products. My vision is to continue the company's dedication to product excellence through innovative technology and fulfillment of customer expectations through superior service.

Who is your primary customer base and where are you seeing the majority of growth?

A significant part of our customer base is in Asia because our end-users are high-volume manufacturers in Asia. Our strategies are threefold: (1) To engage strategically with our OEMs and IDMs in R&D and leverage the success into high-volume space. (2) To increase customer intimacy through strategic collaboration of new product introduction (NPI) for future customer requirements. The majority of the growth will be due to consumer application of smart phones, tablets and some initial investigations into adjacent markets. (3) Increase R & D spending to be in the forefront of technology roadmap requirements

What products will drive the growth of the ET business? Do you have anything new in the pipelines at the moment?

On the bare board test side, our "S" technology probers continue to thrust into the high-value HDI, PCB packaging market with special measurements focusing on Kelvin and Latent test with the highest throughput. The high-volume production grid testers continue to meet tighter pitch requirements on octal density with requirements for two- and four-wire test. On the fixture and services side, we are working closely with another tester resource to develop high-quality results for loaded board fixtures with the highest quality results and speed. The Pure ZOOM™, a unique test/fixturing system, is the ATE industry's first in-circuit test solution to provide a low-cost, fine-pitch fixturing solution with the high coverage test for both NPI, high-mix, low-to medium-volume production test applications, particularly for large node count boards.

For contact products, the Edge™ provides an economical, sharp, aggressive and shallow angle blade tip for reliable via probing on PCBs by incorporating ECT's patented ZIP® flat technology manufacturing cost advantages. It is fully replaceable in current fixtures with 100 mil receptacles installed. ECT has been able to develop a low-cost, interchangeable alternative to the expensive round, steel-bladed plungers that are requested increasingly by customers worldwide in test fixtures. Other new products include the new long-travel Z3 addition to the ZIP®

"ECT will play a greater role in Asia because we already have a manufacturing presence there as well as a customer interfacing team."

family of "flat" technology Pogo® pins with various semiconductor applications.

As Asia continues to grow, what role does the ET Group play in Asian market growth?

ECT will play a greater role in Asia because we already have a manufacturing presence there as well as a customer interfacing team. The ECT corporate office will be identified in Asia and will continue to grow as the customer base in Asia grows. However, the R&D efforts and sales resources in North America and Europe will continue to interface and collaborate closely with the OEMs and IDMs to influence their high-volume decisions in Asia. ECT's involvement in the full spectrum of test creates a unique synergy that is unmatched in the industry. Because of the unique fixture technology requirements of bare board and loaded board test, the company can apply both hardware and software innovations initially developed for one application to the other. For example, the contact-related issues presented by the fine-pitch and high-density requirements of bare board result in unique probing capabilities in the loaded board application area. Similarly, the company's test probe products benefit from the range of loaded board test fixture application requirements supported by ECT. As a result of this integrated engineering, the company becomes better at all facets of test while developing products and technologies for specific applications.

Please describe the ET Group's core technology and roadmap.

ECT is the leading manufacturer of electrical test products and services, including Pogo® test contacts, semiconductor test products, bare-board automatic test systems, and bare and loaded PCB test fixtures. ECT's manufacturing, service and support facilities are ISO registered with locations throughout the United States, Europe and Asia. The company has been awarded numerous patents and participates actively in developing industry standards.

As a solutions-based company, ECT has set standards with such patented technologies as the biasing ball Pogo® Contact for achieving the most consistent electrical contact and the "S" family of flying probers for high-speed board testing. Committed to quality, ECT manufacturing facilities use our ProWorks work instruction software tool to ensure quality with maximum flexibility. With manufacturing sites in China (Shenzhen), Germany (Wertheim) and the United States (California and New York), we serve a global customer base. Fueled by a talented engineering team and a management philosophy that encourages creativity and R&D commitment, ECT continues to develop technology and products to improve contacts on a product under test, board test and loaded board test, as well as develop turnkey solutions for functional test.

Thank you, Chan Pin.

Trevor Galbraith

Post-earthquake thoughts—

Continued from page 40

manufacturing.

Nordson:

- MARCH promoted Leo Li to GM in China.
- MARCH and Semblant entered a partnership to develop plasma systems for electronics deposition.

Orbotech received "2010 Best Vendor Award" from AU Optronics.

Panasonic:

- introduced Next Production Modular Wide platform for processing PCBs up to 750 x 550mm in size.
- increased selling prices of glass/epoxy laminates by 5-10% due of the cost up of the raw materials.

Rogers developed proprietary technology to thermally bond Victrex APTIV® film directly to metal foils or other materials in both roll to roll and flat panel laminate structures without the need for adhesives.

Schmid Group delivered its 1000th wet processing system made in China.

Technic named Felix Schwager R&D director.

Teledyne acquired minority stake in Optech.

Torrey Hills Technologies and KIC formed a strategic business alliance to speed up optimal thermal process setup on THT belt furnaces.

Viscom and CyberOptics entered 3-D solder paste inspection sensor technology cooperation.

VJ Electronix appointed InterCEM as Its exclusive distributor in Korea and FHP Reps as its sales representative for Colorado, Utah and Wyoming.

Walt Custer is an independent consultant who monitors and offers a daily news service and market reports on the PCB and assembly automation and semiconductor industries. He can be contacted at walt@custerconsulting.com or visit www.custerconsulting.com.

Jon Custer-Topai is vice president of Custer Consulting Group and responsible for the corporation's market research and news analysis activities. Jon is a member of the IPC and active in the Technology Marketing Research Council. He can be contacted at jon@custerconsulting.com.

New products

Nordson ASYMTEK fluid dispensers jet precisely into narrow cavities to improve side-view LED manufacturing process

Nordson ASYMTEK introduces jet dispensing for manufacturing side-view LEDs. The system jets 0.1 to 0.2 mm dots through windows as small as 0.4 mm into the LED cavities. Side-view LEDs illuminate the displays in devices such as tablet computers, smart phones, and e-readers. Nordson ASYMTEK's Spectrum™ S-920N jetting system automatically maintains a consistent shot weight with software-managed dispense parameters. Closed-loop dispensing eliminates the need for time-consuming operator adjustment. *www.nordsonasymtek.com*

EBSO introduces the next generation Ebso Selective Solder platform

The Ebso SPA-NC Series is highly flexible, automatic selective soldering cell with manual load/unload. The EBSO SPA-NC Selective Solder platform overcomes the soldering challenges by automatically transporting the PCB to each critical soldering step via an XYZ-axis carrier—Microdrop fluxer, bottom-side preheater and soldering modules. The final result: Perfect solder joints and a reliable and repeatable process. *www.ebso.com*

Aegis Software and MetricStream partner to deliver total enterprise quality management

Aegis Software is partnering with MetricStream Inc. to deliver a unique and comprehensive solution for total quality management across a manufacturing enterprise. The solution combines Aegis' shop-floor and process-level quality system with MetricStream's solutions for CAPA, regulatory compliance, supplier quality and enterprise-wide quality management and assurance. *www.aiscorp.com*, *www.metricstream.com*

Seika debuts the Ecobrid SC-AH100 low-VOC stencil cleaner

Seika Machinery, Inc. introduces the new Sawa Ecobrid SC-AH100 fully automatic low-VOC stencil cleaner. The Ecobrid stencil cleaner provides a 66 percent reduction in CO2 emissions and energy consumption over the previously fully automatic cleaning system, as well as a significant reduction in running costs. Additionally, the system cleans and dries in five minutes. The fully automatic cleaner features easy-to-use touch panel operation and uses a low-VOC solvent, making it environmentally-friendly and resulting in little to no flash point concerns. *www.seikausa.com*

Specialty Coating Systems introduces SCS Parylene C-UVF™ conformal coating

At Avionics and Defence Europe 2011, Specialty Coating Systems introduced a new technology, SCS Parylene C-UVF™. The coating is ultra-thin, optically clear, and maintains the same electrical, mechanical and physical properties of SCS Parylene C, but it fluoresces under UV light, a characteristic that companies in the military, defense and aerospace industries rely on to ensure their components are protected. *www.scscoatings.com*

Attain consistent syringe dispensing with Micro-Dot™

The Micro-Dot™ manual syringe dispenser from DYMAX combines a precise, infinitely variable and repetitive, hand-held dispenser with a readily available, inexpensive syringe fluid reservoir. The Micro-Dot functions as a complete dispensing system for machine-ready 3, 5, and 10 mL syringes, allowing users to dispense a wide variety of materials with repeatability and precision. Because the Micro-Dot is a manual device, it is wireless and cordless enabling users to move freely to wherever their tasks may be. *www.dymax.com*

Christopher Associates adds a new high-resolution measurement system to its lineup

Christopher Associates Inc. introduces the Tagarno Milli inspection system. The new system combines Tagarno's industry-leading MAGNUS HD benchtop inspection system with a precision measurement capability at magnifications from 4 to 105X. The inspection system allows multiple viewers to see the same image on 42" monitors. Traceability and data recording software also are available to meet a range of industrial and technical requirements. *www.christopherweb.com*

Etek Europe launch replacement for retired Selecta Spray Fluxing System

ETEK Europe are pleased to announce that they have developed a 'drop in' replacement for the Selecta Spray—the eSpray Fluxing System! The eSpray Fluxing System has been developed in the UK and equals the performance and quality of the Selecta Spray at a very competitive price. *www.etek-europe.com*

Universal's Innova feeder delivers high-speed bare die to mainstream manufacturing

Universal Instruments is embracing the convergence era of electronics assembly with the introduction of the Innova and Innova + direct die feeders. This revolutionary technology enables the presentation of wafer-level devices to Universal's GenesisSC Platform without incurring costly packaging charges. *www.uic.com*

Optically clear, highly flexible epoxy cures at room temperature and withstands cryogenic conditions

For demanding applications where highly flexible, impact resistant bonds are required, Master Bond developed Polymer System EP37-3FLF. This optically clear, two component epoxy has exceptional resistance to cryogenic temperatures and severe thermal cycling. Its unique combination of properties allows it to cure without stressing delicate electronic components. EP37-3FLF is sold in pint, quart, gallon and 5 gallon container kits and has a 6 month shelf life if unopened and stored at room temperature. *www.masterbond.com*

Viscom S3088 flex: improved AOI inspection

Viscom is now offering the S3088 flex system as an enhanced model to the S3088-III. Like its predecessors, the S3088 flex is distinguished by a highly effective electronics assembly inspection, but also offers important advancements for future viability, system performance and operation. The intel core i7 computer and Touch Screen monitor are now included with every S3088 flex machine. This results in higher computing power, faster inspection speed and ease-of-use capability with optional operation of vVision, Viscom's new inspection software. *www.viscom.com*

Manncorp pick-and-place assembles 4-foot long LED light panels

The continued popularity of LEDs has caused Manncorp to roll out another LED-enabled pick and place system. The MC-392LED is ideally suited for populating extra-long LED panel assemblies in a single pass. Through the use of the low-cost optional CT-150 Conveyor Extension Unit, the machine becomes capable of two-stage assembly of oversized LED boards of up to 1.2 m (47.25") long. *www.manncorp.com*

ASYS INSIGNUM 1000 laser marker

Customers searching for a small footprint, flexible laser marking solution need to look no further than the new INSIGNUM 1000 Laser Marker from ASYS. At a mere width of 21", the machine can be configured as a manually-loaded version or as an in-line system. The INSIGNUM 1000 Laser Marker is available with a CO2 or Fiber laser source for precise and fast marking on any material. The in-line version of the machine handles boards up to 18"x18" and has a maximum marking area of 5.5"x5.5". *www.ASYS-group.com*

Count On Tools introduces replacement Pace pre-filters

Count On Tools Inc. announces the release of Pace Replacement Pre-Filters (OEM Part Number 8883-0111-P5) for Arm-Evac and Lab-Evac 105/200/250 fume extraction filtration systems. The replacement pre-filters provide up to 30 percent savings over original Pace Pre-Filters, making production more affordable. Count On Tools Pace Replacement Pre-Filters are available in packs of five for $70. The Count On Tools Pacer Replacement Pre-Filters are low-efficiency particle filters used to protect the primary HEPA filter from large, coarse particles. *www.cotinc.com*

Mentor Graphics transforms SoC integration and functional verification with next generation Questa platform

Mentor Graphics Corp. has embarked on a corporate-wide strategy aimed at transforming the integration and functional verification of complex System on Chip (SoC) designs. The strategy targets both near-term and long-range challenges with a blend of tools and methodologies that span the efforts of conventional ESL and RTL functions. *www.mentor.com*

Multitest'sMT2168 shows best jam performance in the field

Multitest's MT2168 has proven its high production performance in the field. Best jam rate statistics are evidence of the successful new design concept. The design concept of the MT2168 is optimized for a minimum number of handling steps. The result is a non-complex architecture that ensures the best material flow. Whereas traditional pick-and-place handlers need up to 10 handling steps, the MT2168 is optimized with just five handling steps. *www.multitest.com*

APS Novastar offers expanded suite of soldering products for low volume, high mix applications

APS Novastar, LLC has expanded its suite of soldering products to specifically address the needs of low volume, high mix soldering applications. The recent introductions of ESS Selective Soldering Machines, EWS-500 Wave Soldering Machines, and ERO-500 Reflow Ovens are specifically designed for low volume, high mix assemblers providing new easy to operate options at cost-effective entry points for batch soldering applications. *www.apsgold.com*

New stencil printer for large PCBs

The SD 903 stencil printer by FRITSCH GmbH in Kastl has been extended to a new size. This new type enables the incorporation of clamping frames up to 784 x 590 mm in size. The new stencil printer includes the same features as the stencil printer of the previous SD 903 series. The new version can also be equipped with a motor-driven feed and vision system, of course. *www.fritsch-smt.de*

Sunstone Circuits® adds new and improved schematic editor to CAD tool PCB123®

Sunstone Circuits® has enhanced their circuit board design software, PCB123®. Sunstone's newest version of their advanced CAD tool now makes the prototyping process faster, easier and more accurate, from project concept to PCB delivery. With version 4.1, the new seamless synchronization of layout and schematic views allows the engineer even more flexibility and reliability during the PCB design process. Also new to the CAD software are optimized graphics, which allow the engineer to create faster and cleaner drawings. *www.Sunstone.com*

Multi-drop sealed connector and cable system for harsh environments

Molex Incorporated announced the availability of the Multi-Drop Sealed Connector and Cable System, a sealed, modular, cable connector system for the transfer of both power and data/signal in a multi-drop configuration. The Multi-Drop Sealed Connector and Cable System is fully sealed to IP66 and IP67 ratings, and can be customized to meet any requirements for internal and external data/signal and power applications. *www.molex.com*

New RoHS compliant VCO from Z-Communications

Z-Communications, Inc. announces a new RoHS compliant Voltage-Controlled Oscillator (VCO) model SMV5320A-LF in C-band. The SMV5320A-LF operates at 5245-5395 MHz with a tuning voltage range of 1-4 Vdc. This VCO features a typical phase noise of -81 dBc/Hz @ 10 KHz offset and a typical tuning sensitivity of 170 MHz/V. SMV5320A-LF is well suited for digital radio and fixed wireless applications that require low phase noise performance. *www.zcomm.com*

E-Switch's TL3700 ultra-miniature tact switch measures 2.6mm x 3.0mm

E-Switch announces the tiniest tact switch they have ever offered: The TL3700 series tact switch. The TL3700 series ultra miniature micro tact switch is a mere 3.0mm x 2.6mm x 0.65mm! The smallest tact switch in our product line, this tactile switch features a 100,000 cycle life expectancy and 2 different gram force options. Markets for this micro tactile switch include audio/visual, computer peripherals, consumer electronics, handheld devices, medical equipment, telecommunications and more. *www.e-switch.com*

New frameless stencil foil available on-line

Alpha® TetraBond™, the new 'frameless' stencil foil from Cookson Electronics, is available to order on-line through the Solder Connection. Described as the 'evolution of frameless stencil technology' the new Alpha® TetraBond™ uses an innovative and proprietary process to Direct Bond the stencil foil to a thin, safe and easy to handle, round cornered sub-frame, ready for loading in any existing TETRA™, Vector™ or VectorGuard™ frame. Alpha® TetraBond™ foils are available for all Cookson's stencil technologies (Alpha® Cut™, Alpha® Form™ and Alpha® Nickel-Cut™) to suit all frame sizes. *www.solderconnection.co.uk*

FumeCube—enhanced fume extractor hits the market

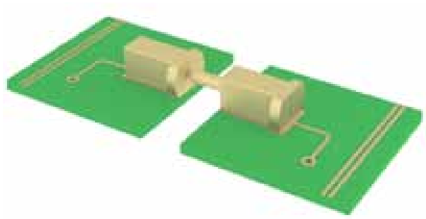
To protect workers from hazardous fumes and to help ensure the employer complies with health & safety regulations, Purex have released the enhanced FumeCube Fume Extraction System. The FumeCube can be connected to either one or two flexible extraction arms. The arms can be attached to a bench using clamp brackets and the integrated airflow valve supplied.
The FumeCube features a powerful blower to draw contaminated fumes away and pass them through a 3-stage filter system. *www.purex.co.uk*

New software options for Mantis Elite-Cam

Vision Engineering has introduced two new software options for their Mantis Elite-Cam, Stereo Microscope with instant digital image capture. The intuitive ViFox software allows you to easily set key parameters whilst viewing the live image, providing fast, precise imaging of your samples and components. ViAxos is an alternative software option for the Mantis Elite-Cam, providing advanced 2D measurement options such as feature to feature measurement. ViAxos also provides a digital zoom option so individual features can be inspected in greater detail. *www.visioneng.com*

IMS introduces HVI series high voltage surface mount chip resistors to 3kV

International Manufacturing Services, Inc. (IMS) introduces their line of HVI Series chip resistors especially suited for high voltage applications. The HVI Series are offered in sizes 0402 to 2512, values to 1Gohm and tolerances to 1%. These resistors feature a nickel barrier layer for excellent solder leach resistance and proprietary thick film architecture allowing the 2512 size to withstand a continuous 3kV and overload of 4kV. Samples are available by contacting the factory or visiting their website. *www.ims-resistors.com*



Mill-Max offers horizontal SMT spring pin and target pin mate

Mill-Max's 0967 is a low profile, horizontal, surface mount spring pin designed for edge board interface applications: board-to-board or device-to-board. Whereas most spring pins are designed to mount vertically on a pc board, the 0967 mounts parallel to the pc board so that the plunger travel is horizontal to the board surface. The above board height of .100" (2.54 mm) provides a low profile for tight packaging requirements. *www.mill-max/PR616*

Polyonics introduces XF-604, a flame retardant polyester label material

Polyonics introduces the XF-604, a 2 mil white polyester, halogen free label material designed and recognized by Underwriters Laboratories to meet the VTM-1 level of flame retardants per the UL94 standard. The addition of the XF-604 to the FLAMEGARDTM product family provides customers with a lower cost alternative to the XF-603 (polyimide) while still exhibiting flame retardant properties. The XF-604 is coated with a semi-gloss white topcoat specifically designed for flexographic and thermal transfer printing. *www.polyonics.com*

Questar enhances, streamlines design of automatic wire bonders

Questar Products International has further refined and enhanced the design of its fine-pitch, fine-wire (17 µ-75 µ), Al/Au automatic wedge and ball bonders to better meet the production challenges associated with smaller lot sizes, multiple product variations and frequent set-up changes. The new Q7000 Series has updated hardware and software, delivering a more tightly integrated assembly package, with approximately 30 percent fewer components and 50 percent less wiring than the Q2100 Series,. *www.questarproducts.com*

Inside Market:

China market is key to the global market for two Korean companies

Global companies, such as Panasonic, Fuji and Yamaha, based in Japan, and Siemens in Germany, are leading the advanced chip mounter markets. In meantime, Samsung Techwin and Mirae Corporation have grown to be big Korean players in the worldwide mounter market. Now, Both of them are setting their sites on an aggressive takeover of the market in China.

Chip mounter market trends

The LED industry played an important role in leading the chip mounter market in 2010. As Korean companies had successfully gone to LED TV markets in the world in 2009, a mood to have a good influence on the SMT market was created in 2010. 2011 is a different situation.

"Although there are not any new items to lead the market this year, I think the mounter market for 2011 is not bad," says Hansu Choi (漢洙 崔), general manager, domestic sales division/SMT&LED at Mirae Corporation. "It's expected the chip mounter market for this year will be 70 percent of the level of 2010."

Samsung Techwin had made big sales due to the explosive growth of LED TV markets related to the World Cup before Q1 2010. "After Q1 2010, the industries for mobile phones, displays and consumer electronics have been our general sales area," says Eunyoung Park, leader of Marketing Group 1, Strategic Marketing Team at Samsung Techwin. As 2010 was prosperous for smart phones, the company was in full flourish, getting flooded with orders after March 2010. However, the company has a different point of view for 2011: "Although it's difficult to expect last year's sales level because this year's market is lacking of major product items or key drivers of growth, replacement demand will be steadily expected."

Mirae, on the other hand, has a good outlook for 2011. Mr. Choi says, "Apple has big influence on the global market due to the explosive demands of iPad and Mac Book. Therefore, display demands are increasing. I think demand for small LCDs will grow because 10-inch tablet PCs and smartphones have been continuously manufactured. It's expected to result in the mounter market going to the small displays."

Contract manufacturers for LED backlight units (BLU) first asked the board dimension range, not capabilities or features, when they purchased a chip mounter for manufacturing LED BLU. A mounter's board dimension was a key issue in the LED mounter market last year because Korean SMT machines had already ensured high-level capabilities and features. In response, chip mounter makers have introduced upgraded equipment applicable to the super-large board dimension or announced a totally new LED mounter.

Target is China market

China makes up 60 percent of the worldwide chip mounter market. Korea makes up 5 percent, and Japan compromises 5 percent. The Americas and Europe make up the rest of the market. Therefore, China market provides tremendous opportunities. "The LED lighting market for China is expanding to more than the level of the last year's market," says Mr. Choi.

China is still a home for manufacturing consumer electronics and low-end/high-end electronics. Therefore, OEMs, ODMs and contract manufactures need middle-/high-speed mounters, and the markets are wide open to chip mounter makers. Mr. Choi says, "The trend of this year's market is the customization. We can provide the best customized services and high-quality, cost-effective mounters to the clients as requested." The company established China/Taiwan business development department in Shenzhen in January 2011 in order to actively to go to the China market.

Samsung Techwin is also planning to aggressively move to the China market. Samsung's middle-speed mounters, as well as the world's first launched LED mounters, target the China market. "We have reinforced the localized sales and marketing capability in China through Samsung Techwin China, established two years ago in order to aggressively move to China market," says Mr. Park. "The business networks at Shanghai, Shenzhen and Tianjin have been reorganized, and sales and services have been also reinforced."

Nepcon Shanghai offers entry

Mirae showed two concepts at NEPCON Shangahi, which was held in May. The first was their SMT machine and applications dedicated to LED, including LED packaging solutions, including the Mx200LED, a cost-effective LED mounter that provides a super large LED board size—up to 1,200 mm long—and the Mx400LD, a high-speed mounter for LED BLU applications. The second was their dual-lane systems.

Samsung Techwin introduced SLM100 Series, high-speed LED mounters with reinforced convenience function dedicated to LED.

—Amy Kim
Global SMT & Packaging—Korea

Show preview:
NEPCON Malaysia 2011

Photo: Les Chang

NEPCON Malaysia, the country's most respected electronics assembly/manufacturing event, takes place 14-16 June 2011 at the Penang International Sports Arena (PISA) in Penang. The event puts visitors in touch with the latest technologies at the exhibition, gives them the opportunity to receive expert advice on their technical challenges, discover cost-effective solutions to their sourcing needs, network with more than 5,000 industry players from over 30 countries, and meet face-to-face with key suppliers.

The show floor features six segments this year:

- Active & Passive Components, showcasing active and passive parts and assemblies used in electronics manufacturing and assembly.
- Light Emitting Diode (LED)s: With the presence of three of the world's top five LED makers, Penang is set to become the LED hub in the region. NEPCON Malaysia will be featuring "The Next Wave LED" at this year's event, which will offer LED components, LED inspection/measurement/test/evaluation equipment, LED manufacturing equipment, LED packaging materials and equipment, lighting devices, optical related products and technologies and products, technologies and services for lighting systems.
- PCB Assembly & SMT Equipment, showcasing the latest materials, equipment and services for PCB production, assembly and packaging, SMT and fine-pitch technology.
- Semiconductor, showcasing semiconductor-related capabilities and featuring equipment manufacturers, facility control and facilities providers, manufacturing service providers and consultants, manufacturing materials, software providers, sub-systems, components and parts, and support products.
- Testing & Measurement Equipment, showcasing the latest test and measurement equipment that help to reduce wastage and improve production efficiency. Key products and services in this segment include the full range of inspection, test and measurement equipment.
- Metal Stamping, Rubber Molding, Contract Manufacturing & Other Related Services, including conventional PCB assemblies, die casting and die-cast mold metal stamping, electomechanical assemblies, packaging, OEM and computer peripherals, SMT board assemblies, tools and dies, turnkey assembly services, and more.

The event also offers a comprehensive NEPCON Workshop Series, which brings together five international authorities to impart their expertise covering a range of current topics in thirteen different workshops. The Workshop Series, organized by Knowledge Group, takes place at the Equatorial Hotel, 14-16 June.

For more information on NEPCON Malaysia, visit *www.nepcon.com.my*. For more information on the NEPCON Workshop Series, visit *www.knowledgegroupco.com*.

International Diary

NEPCON Malaysia
June 15-17
Penang, Malaysia
nepcon.com.my

NEPCON Thailand
June 23-26
Bangkok, Thailand
nepconthailand.com

electronica India +
productronica India
September 13-16
Bangalore, India
electronica-india.com

NEPCON Vietnam
October 6-8
Hanoi, Vietnam
nepconvietnam.com

electronicAsia
October 13-16
Hong Kong
electronicasia.com

EPTC Electronics Packaging
Technology
December 7-9
Singapore
www.eptc-ieee.net

India Telecom
New Delhi, India
December 7-9
www.indiatelecom.org

Hong Kong Electronics
April 13-16, 2012
Hong Kong
hkelectronicsfairse.com

New for 2010: "Contract Services" has been broken into two categories: > $100 million and < $100 million.

Presenting...

The 2010 GLOBAL Technology Awards

The ONLY global awards program in the industry

A GLOBAL Technology Award sends the message that your product or service is an innovation and quality leader in an industry crowded with competing products.

Sponsored by Global SMT & Packaging magazine, the GLOBAL Technology Awards are now in their sixth year of recognizing and celebrating innovation in the electronics manufacturing industry. Entries are being accepted now through July 31st.

Entries are invited from equipment, materials and EMS companies of all sizes.

In addition to the award statue, winners receive publicity in a special awards issue of each of Global SMT & Packaging magazine's five editions (US, Europe, China, Korea & South East Asia) as well as on the Global SMT & Packaging and GLOBAL Technology Award websites and in the Global SMT & Packaging email newsletters. Winners also receive a small poster for use at trade shows and an image and logo for use in advertising, websites and other promotional materials.

Enter now: http://awards.globalsmt.net

GLOBAL SMT & PACKAGING