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SMT007 MAGAZINE


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SMT007 MAGAZINE

Automotive Electronics: The Driving Force

This month's issue of *SMT007 Magazine* looks into the latest developments, opportunities and challenges in automotive electronics, and why this market continues to drive the overall electronics manufacturing industry.

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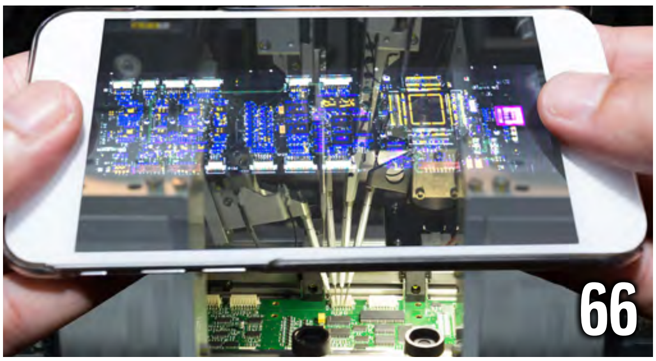

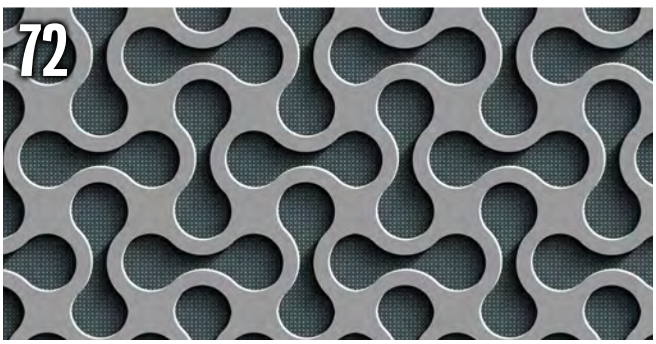

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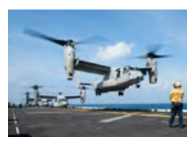

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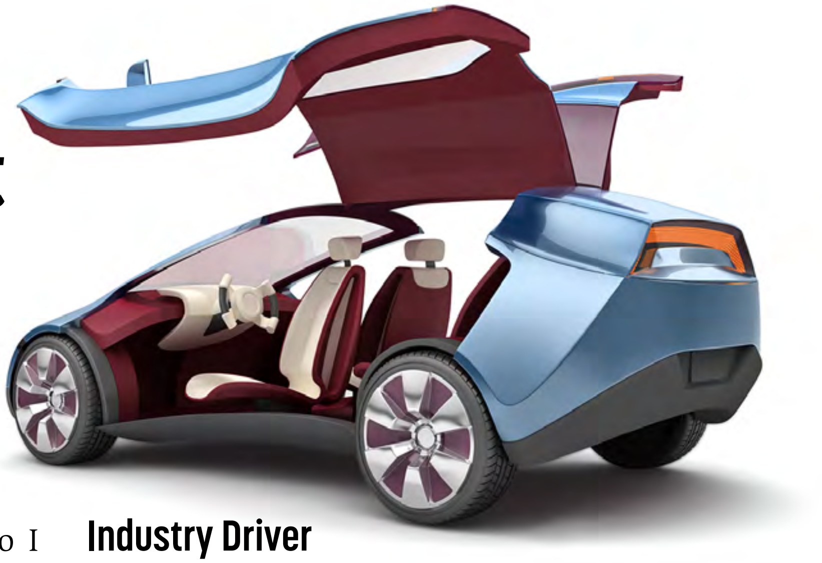
Automotive Electronics Still in the Driver's Seat

Editor's Note

by Stephen Las Marias, I-CONNECT007



The past few weeks had been hectic. In mid-February, I travelled to San Diego, California, to attend IPC APEX EXPO 2018. It was just my third year of attending the show but seemed bigger than the past two I have attended. This year's show highlighted new features, including the CFX demo, which I found interesting; it looks like Industry 4.0 is beginning to take shape and cement its presence in the roadmaps of every stakeholder in the industry. I talked to some of the participants in the demo, and you can read inside what they have to say about CFX.

By now you have probably seen our *Show & Tell* special edition (if not, click here), which is a comprehensive recap of the IPC APEX EXPO 2018 event, complete with our video coverage, interviews of award winners, as well as insights from our expert columnists and editors, among others.

Less than two weeks after arriving home, I travelled to chilly Shanghai, China, to attend the productronica and electronica China 2018 shows, as well as the CPCA 2018 show.

The productronica and electronica China shows were massive and, by all accounts, very busy. One exhibitor expressed to us that in the three days of the show, he had not had a chance to walk the show floor—it was that busy in his booth. The CPCA Show likewise was a big event, and Happy's presentations at the conference, on topics ranging from automation to Whelen's lights-out factory, were well attended. The shows were well-attended by engineers from Chinese PCB manufacturers.

Industry Driver

The past year was one of the strongest years that the PCB supply chain and the rest of the electronics manufacturing industry in general, has seen. Everyone we talked to at the shows, including the HKPCA & IPC Show 2017 event we attended last December in Shenzhen, China, were optimistic that the strong growth in the industry in 2017 will continue through 2018.

And most industry players point to one thing when it comes to what's driving this strong growth—automotive electronics. In fact, one of my RealTime with… interviews at IPC APEX EXPO 2018 show was with Henk Biemans, managing director of MEK Europe. During our discussion, he mentioned the increasing use of THT AOI systems in the wave-soldering process because most power electronics in cars still use through-hole devices—and most of these assemblies are manual.

All industry analysts are forecasting continued growth in the automotive electronics market. According to Global Market Insights, the global automotive electronics market will surpass $395.91 billion by 2024, up from $206.33 billion in 2016. The growth is attributed to the increasing automotive electronics adoption in cars to deliver safety features such as vehicle data recorder systems, emergency call systems and alcohol ignition interlocks, to name a few.

Infinium Global Research, meanwhile, expects the automotive electronics market to register a compound annual growth rate (CAGR) of 6.9% over the 2017 to 2023 period.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Another market analyst, Transparency Market Research (TMR), on the other hand predicts a CAGR of 7.4% between 2017 and 2022 for the global automotive electronics market. The market analyst firm expects the market to be valued at $5.05 billion by the end of 2022, up from $3.53 billion in 2017. Fueling the growth of the automotive electronics market include rising safety considerations, demand for high-end electronics for navigation, information, and entertainment, and the rising popularity of electric and hybrid vehicles due to environmental considerations, according to TMR.

One trend in the automotive electronics sector is the shift to LED lighting. In an interview, Greg Marini, director of business development at EMS firm Vexos Inc., says the advent of LED lighting in cars—from headlights to tail lights to interior lighting—was one of the biggest game changers in the past decade. He also mentioned the prevalence of back-up cameras, rear-view mirror systems, entertainment systems, and the touchscreen, or just the display of information and content that is available for the driver. "There's so much information that you put down into these cars that I think there's actually a pull back now on what's going to be available for users, to keep them focused on driving the vehicle instead of being distracted by all the accessories that are available for them to tinker around with."

Safety is another trend that's driving innovation in automotive electronics, according to Future Market Insights. The research firm added that powertrains, wheels, parking assistance, and electrical suspensions are the major application areas most likely to spur the growth of the market, as well as increasing environmental sustainability plus rising demand of cutting edge infotainment systems. These, in turn, will fuel the demand for complex electronics systems. In line with this, protection of complex electronic systems from damaging electrical hazards and stringent government regulation regarding vehicle safety are some of the major challenges facing designers in the automotive electronics industry, FMI added.

While reliability continues to be one of the main challenges in automotive electronics, there are others. For instance, Marini mentioned lead time. "Materials are leading or extending out there like copper for PCBs or just simple components like resistors. I was having a conversation when I was in China a few weeks ago. There is a simple resistor there that seems everybody in the industry is using. Lead times are getting way out of the normal lead times, and it's a challenge to manage that for ourselves and our customers to understand that. People that are used to see an eight-week time for their products are now looking at two or three times that for some of these because of the components they've selected. So, we try to mitigate that by offering alternatives, or working with the customers to see if they can design with different components."

Aside from the challenges, the nice thing about the automotive electronics market is that when you land some programs, there's a bit of peace of mind, so to speak, because you typically land platforms that last three to five years, according to Marini: "It's nice from the new product development side; you can have some consistent income coming from programs and start to focus on others. In other industries, the program might be one, two, or three years, and you worry about replacement business. So, the downside is it takes a long time to get that business in the development side. But once you secured it, you are sure to have that for three to five years."

This month's issue of *SMT007 Magazine* looks at the challenges, opportunities, and new requirements from automotive electronics customers, and how these issues may be addressed. Enjoy!

Next month, I am travelling again to Shanghai, China, to attend NEPCON China. I hope to see you there! **SMT007**

Stephen Las Marias is managing editor of *SMT007 Magazine*. He has been a technology editor for more than 14 years covering electronics, components, and industrial automation systems.

Vehicle Electrification:
Disrupting the Automotive Industry and Beyond

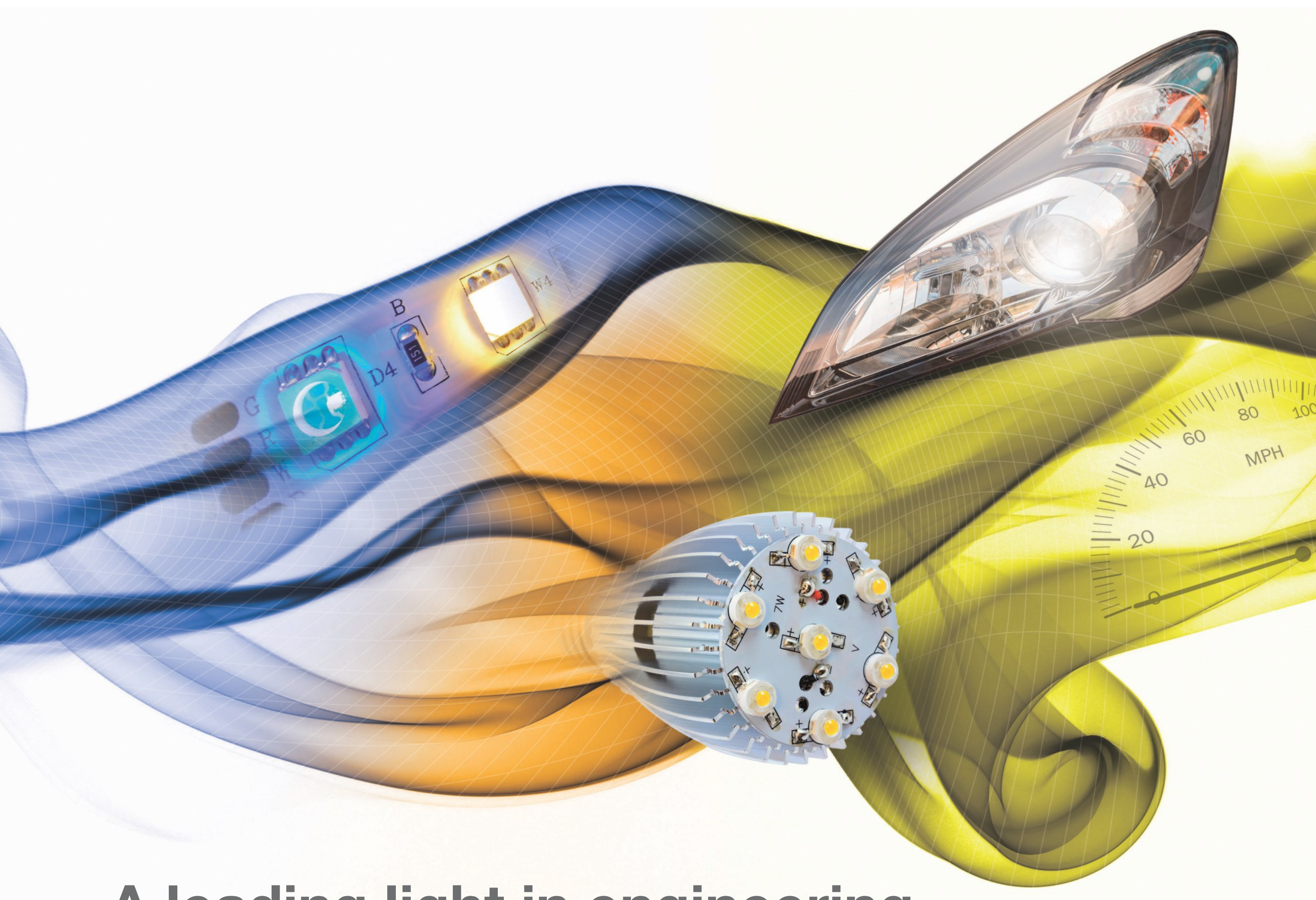
Feature by Chandran Nair
NATIONAL INSTRUMENTS

Around the globe, governments are announcing mandates that will bring about the demise of the internal combustion engine. China has led the charge by requiring 8% of new vehicles on the road to be "new energy" or zero emission vehicles in 2018, a huge growth over the current 2–3% on the road today. Similar strong government regulations limiting the future of the internal combustion engine have passed around the world, and the importance and growth of the hybrid and fully electric automobile industry can't be overstated. Volvo has possibly taken the strongest stance of the automotive manufacturers by pledging to make only hybrid or fully electric cars by 2019 and committing to sell more than 1 million electric vehicles by 2025. "This announcement marks the end of the solely combustion engine-powered car," said Hakan Samuelsson, president and CEO of Volvo, in a July 2017 statement.

Although we have yet to witness such bold and aggressive challenges in Southeast Asia, the region is home to a fairly strong automotive industry. For instance, Thailand is the base country for many automotive OEMs, while the Philippines and Malaysia are the go-to destinations for supply chain vendors including component designers and manufacturers as well as semiconductors. This signals tremendous opportunities for the automotive industry in terms of autonomous vehicles and electrification.

More than Electric Vehicles

The move from internal combustion to hybrid and then fully electric power plants represents only the most visible portion of the aggressive growth of power electronics systems in vehicles. Electrification applies just as significantly

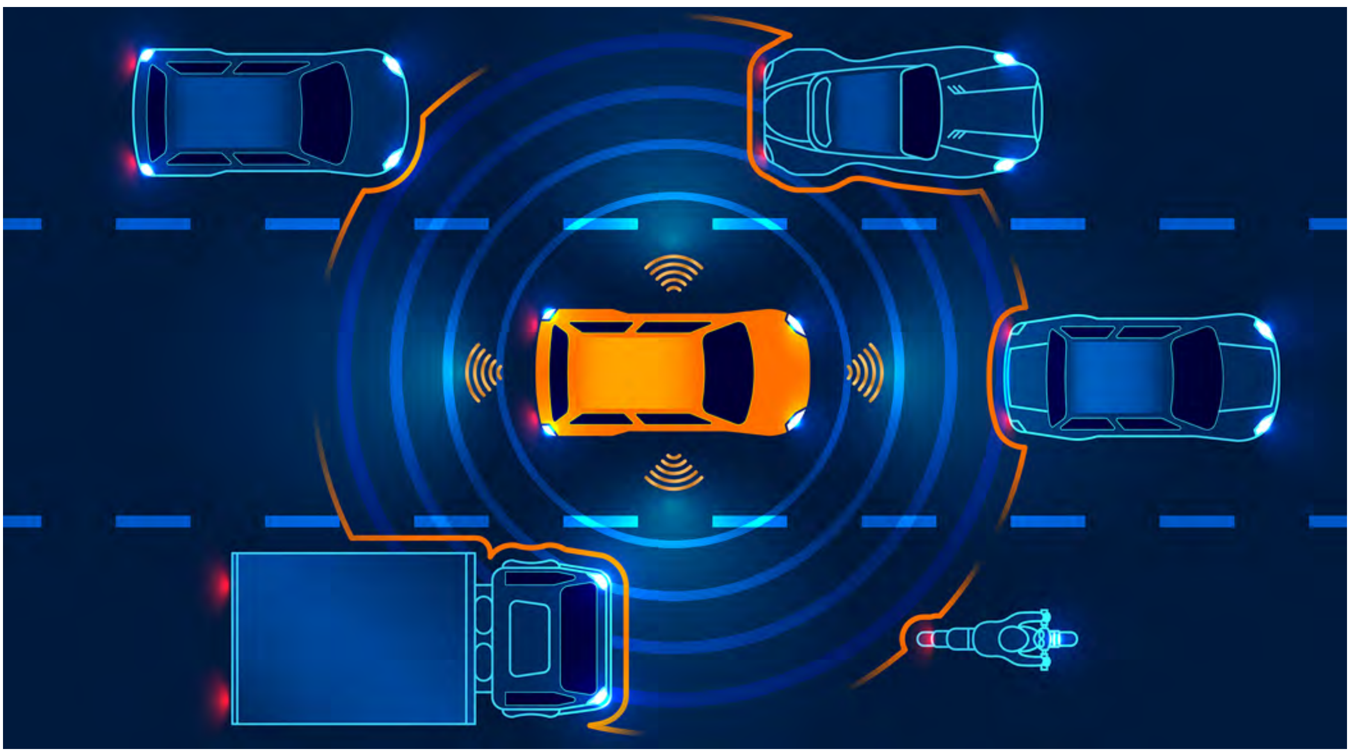


to vehicle subsystems. As recently as 10 years ago, a fully mechanical coupling between the steering wheel and the front wheels was not unusual. The steering wheel connected to a shaft that connected to a rack-and-pinion system that turned the wheels, and even a more efficient hydraulic version of the system still maintained a mechanical coupling between the steering wheel and the tires. The story is similar for the accelerator pedal and manual transmission.

The explosion of drive-by-wire technology throughout the modern vehicle has changed this paradigm. A sensor, a remote actuator, and multiple control systems have replaced the mechanical linkage. Instead of a direct connection between the steering wheel and the front tires, a sensor on the steering column now measures the angle of the wheel. An embedded controller then translates that measurement into an angle and sends the value to the vehicle's communication bus. Elsewhere on the communication bus, another controller picks up the value, translates that into an angle of the wheel potentially based on vehicle speed and driver settings, and then commands an actuator to move the wheel to a desired angle. In many vehicles, a safety system sits in the middle of this drive-by-wire steering system to make sure the vehicle stays in the traffic lane and avoids obstacles in the roadway. As the number of power electronics subsystems in the vehicle grows, the automobile itself begins to look like an electrical microgrid with a common power bus connecting a growing list of sources and sinks of power, each managed by an independent embedded control system.

The Broader Impact–Challenges

Taking a slightly broader look at the implications of government automotive mandates, the exponential growth in electrification and the impending end of internal combustion engines represent a radical change in the infrastructure required to support the shift in vehicle power plants. A car with an internal combustion engine requires roughly 10 minutes at nearly any petrol station to fill up its tank for another 300 miles of driving. However, even with a dedicated supercharger, a similar pit stop requires at least an hour for a fully electric vehicle to charge. Even for the slow recharge associated with a daily commute, the required charging hardware



In many vehicles, a safety system sits in the middle of this drive-by-wire steering system to make sure the vehicle stays in the traffic lane and avoids obstacles in the roadway.

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needs some thought. For homeowners, installing an overnight charging station might be as simple as putting in a high-current circuit in the garage, but this becomes more complicated for a renter in a house or an apartment. If a car owner happens to live in a city and parks on the street, the concept of a home-charging station might be completely impossible.

The future of vehicle electrification from the prospective of the electrical utility, the cyclic demands based on the daily workforce schedule combined with the high-load demands of fast charging present significant new challenges for the electrical grid as well. If an entire workforce returns home at 5:00 p.m. and plugs in its electric vehicles around the same time, this shifts the timing of the typical peak demand on the grid and refocuses the regional peak consumption from heating or cooling toward transportation. On the larger scale of a gas station, a collection of the superchargers for fast charging will require an amount of energy like that of a medium-sized neighborhood.

Indeed, the infrastructure required to enable or support autonomous and electric vehicles is a challenge. For autonomous vehicles, developing the V2X applications and infrastructure and ensuring they can co-exist with existing infrastructure and vehicles presents other challenges when it comes to scaling autonomous vehicles with a very low margin of error.

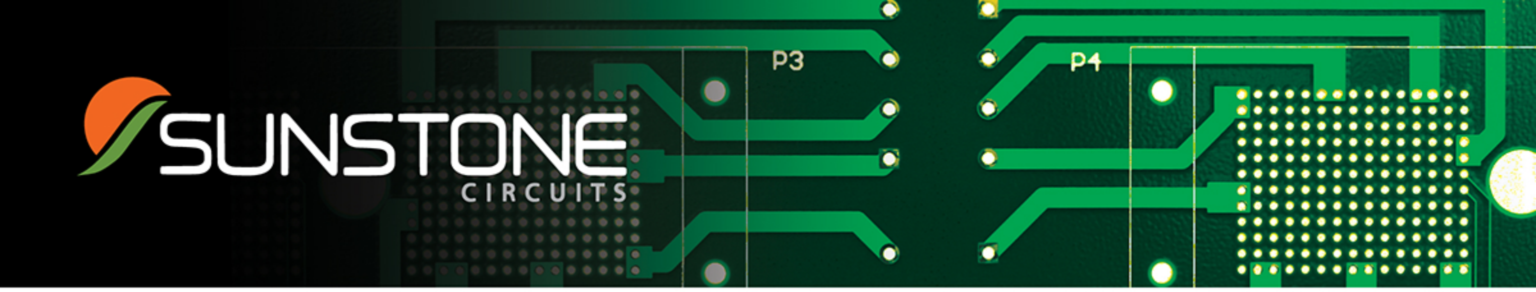
Looking Ahead

The government-mandated trend of electric vehicles directly leads to growth in the complexity of vehicles and indirectly leads to an immediate need for growth in infrastructure. The next-generation automotive industry will drive the future of the grid, which will require smarter control systems. Turning this into reality represents a truly interdisciplinary challenge to build safe and reliable control systems among other needs. To get this to market quickly would require an increased reliance on real-time test, production test, and ecosystem partners who have vertical expertise building tools on top of an industry-leading, flexible, and open platform. With the right tools, engineers can adapt to the disruptive technologies vehicle electrification will require.

Additionally, given the advancements in smart manufacturing that we are seeing taking place as well as increased R&D investments in Southeast Asian markets, the outlook for the automotive industry is, without a doubt, positive. Engineers are developing applications ranging from new vehicle technologies and capabilities for infotainment systems, in-vehicle networks and sensor fusion, to fully autonomous driving, and V2X communications and infrastructure. Organizations as well are looking at addressing market needs and opportunities from smart grid, to management and distribution of power (the charging stations), to the electric car itself. For instance, many NI Alliance Partners enabled by NI technologies are helping to make autonomous driving and the electrification of vehicles a reality, faster, such as the test bed project NI is working with the Advanced Remanufacturing and Technology Centre in Singapore on.

The shift to electrification certainly creates many new applications and those with a strong and keen focus on Industry 4.0 and smart cities would therefore be placing themselves in an advantageous position. Electrification of the automotive industry also means an increase in productivity as consumers could spend time doing things rather than driving. That is the smart future we are heading towards. **SMT007**

Chandran Nair is the vice president for Asia Pacific at National Instruments.



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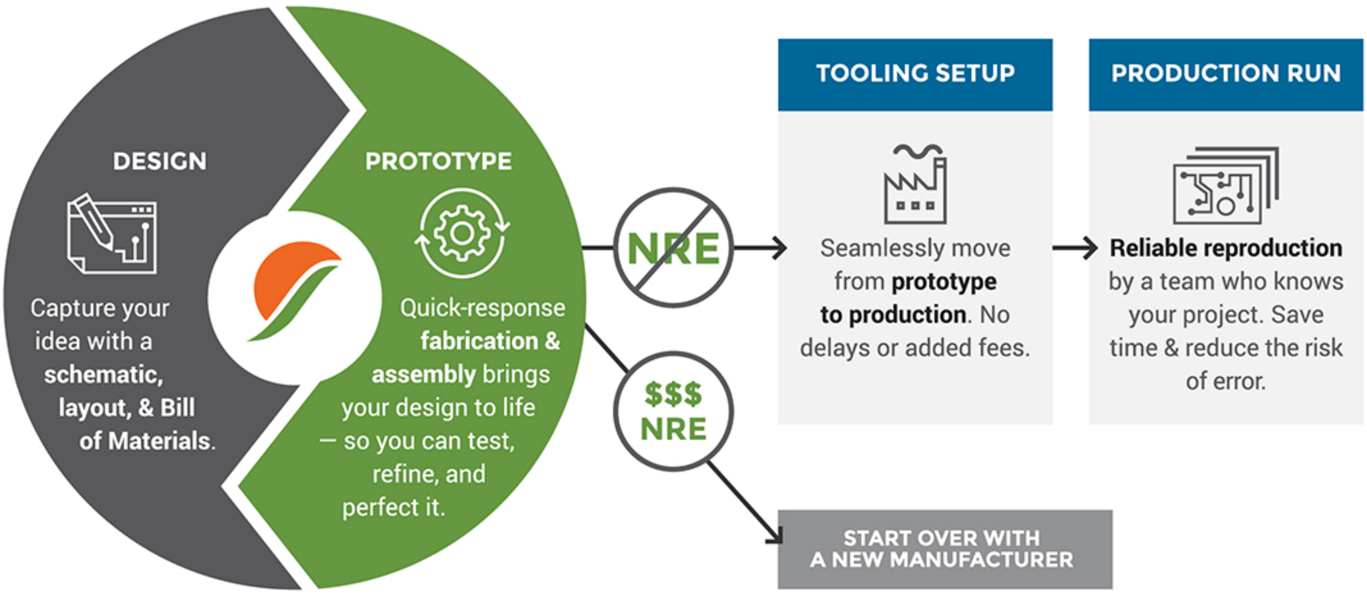

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MilAero Highlights

Kitron Posts Strong Growth in Q4 2017 ►
Kitron has reported improved revenue, order backlog and profitability for the fourth quarter and full year 2017.

IPC Honors Rockwell Collins and Northrop Grumman with Corporate Recognition Awards ►
IPC bestowed its highest corporate honors on two member-companies, Rockwell Collins and Northrop Grumman Corp. during a luncheon at IPC APEX EXPO 2018. The Peter Sarmanian Corporate Recognition Award was presented to Northrop Grumman and the Stan Plzak Corporate Recognition Award was presented to Rockwell Collins.

NASA's Robert Cooke Wins IPC President's Award ►
In recognition of his significant contributions of time, talent and ongoing leadership in IPC and the electronics industry, long-time IPC volunteer Robert Cooke of NASA Johnson Space Center was presented with the IPC President's Award at IPC APEX EXPO 2018.

Neways Electronics Expands Production Facility at German Site ►
EMS firm Neways Electronics International is expanding its German site in Neunkirchen.

Nortech's Intercon 1 Group Expands Existing Manufacturing in China ►
Nortech Systems Incorporated announced today that it has expanded capabilities at its manufacturing facility in Suzhou, Jiangsu, China, to support its regional machine vision technology customers.

Plexus Announces Revised Capital Allocation Plan, Employee Bonus ►
Plexus Corp. announced that recent U.S. tax reform will enable it to tax-efficiently repatriate approximately $500 million of offshore cash into the United States.

Dynamic Manufacturing Celebrates 11,000th Inspection Machine Installation with Koh Young ►
Dynamic Manufacturing, a Matric Group Company, recently installed a new Zenith AOI platform from Koh Young Technology to help them deliver the highest quality products to its growing customer base.

Sypris Lands Additional Contracts with Harris ►
Sypris Electronics LLC, a subsidiary of Sypris Solutions Inc., has recently received multiple contract awards from Harris Corp. to manufacture a variety of mission-critical electronic assemblies for a number of government programs.

Rockwell Collins' Dave Hillman Inducted into IPC Hall of Fame ►
In recognition and acknowledgement of his extraordinary contributions to IPC and the electronics industry, Dave Hillman, Rockwell Collins, was presented with the IPC Raymond E. Pritchard Hall of Fame Award at IPC APEX EXPO.

Solving Reliability and Thermal Management Challenges in Automotive Electronics

Feature Interview by Stephen Las Marias
I-CONNECT007

Paul Salerno is the Global Portfolio Manager for SMT Assembly Solutions at Alpha Assembly Solutions. He has more than a decade of experience in the electronics assembly industry in roles such as application engineering, project management, and product management. Paul is responsible for developing and executing strategies for the automotive and consumer electronics market segments, ensuring Alpha's products continue to meet the evolving needs of their global customers.

In this interview with *SMT007 Magazine,* Paul discusses the growing automotive electronics industry, its impact on the soldering materials business, and how Alpha helps customers address the new challenges and requirements in the automotive market.

Stephen Las Marias: The automotive electronics market has been one of the driving forces of the electronics manufacturing industry. What is the impact of this on your business?

Paul Salerno: The solder market continues to flourish, and we see an upward demand for automotive electronics from OEMs due to the sophistication required for modern vehicles. The continual adoption of the HEV/EV powertrain, advanced driver-assist systems (ADAS), and in-cabin electronics is driving the need for more sophisticated assembly solutions. For example, advanced detection systems such as lane departure warning, adaptive cruise control, LIDAR, RADAR, and vision systems that were once reserved for luxury vehicles are now becoming more common in the average consumer vehicle. Each one of these technologies presents itself with unique challenges that require customized solutions.

Las Marias: What are some of these "unique challenges"?

Salerno: Reliability, of course, is a major driving factor to the successful implementation of an assembly material in automotive electronics. Specifically, exposure to high-temperature and high-vibrational environments for

powertrain and advanced detection devices creates a need for assembly materials that exhibit excellent creep resistance. The combination of the end product's performance requirements as well as exposure to environmental stresses is driving increased reliability demands on the assembly materials.

Thermal management is critical from both application and processing perspectives. In powertrain applications facing high-operating temperatures, the ability to develop creep resistant alloys capable of facing temperature ranges from -40°C to 150°C is driving the need for high-reliability alloys such as InnoLot. Thermal management from a processing perspective is driving the need to develop low-temperature alloys capable of high reliability to prevent component warpage during reflow. Alpha's HRL1 alloy exhibits excellent mechanical reliability relative to SAC305 while reducing processing temperatures by 50°C. This has proven to have a profound impact on reduction of component warpage leading to increased yields and enhanced product performance.


Paul Salerno

Las Marias: How do you help ensure the reliability of electronics assemblies for cars?

Salerno: The answer to this question really begins with the relationship we maintain with our customers. Maintaining a strong voice of customer enables Alpha to develop next generation products to meet the upcoming needs of the marketplace. Having a global R&D and technical service footprint allows Alpha the flexibility to quickly address customer needs, albeit on a production line or in the lab. We maintain a cutting edge analytical and diagnostic lab capable of characterizing assembly performance through use of equipment such as SEM/FEM, as well as conducting field tests such as thermal cycling and surface insulation resistance to qualify the performance of our products in a given application. For example, the ability to measure electrochemical migration and corrosion resistance of our solder pastes on fine-pitch components ensures the reliability of our products in advanced detection devices.

Las Marias: Are there new requirements being placed upon you by your customers dealing with automotive electronics?

Salerno: As always, demands are unique to the given application. The need for assembly materials capable of meeting operating temperatures above 120°C is commonplace for devices located closest to heat-generating sources of the vehicle. We are seeing thermal cycling demands of -40°C/150°C with requirements above 2,000 cycles for these powertrain applications. For advanced safety detection systems, not only are thermal cycling requirements increasing, but there is a growing need for fine pitched electrochemical reliability. It is not uncommon to see power density increasing and component sizes shrinking as these advanced detection devices become more sophisticated and miniaturized. Finally, for in-cabin electronics, a focus on total cost of ownership is driving the need for low-temperature, high-reliability alloys.

Las Marias: What new technologies from Alpha target these issues?

Salerno: Alpha is committed to the development of next-generation solder alloy and pastes chemistries to meet the current and future needs of our customers. For high temperature and vibrational applications such as powertrain and advanced detection devices, highly creep-resistant alloys, such as our InnoLot alloy, is key to meeting the reliability requirements of our automotive customers. Additionally, our CVP-390 solder paste chemistry delivers

world-class electrochemical reliability down to 100 µm spacing on fine-pitch components.

Our newest solder paste, Alpha OM-550 HRL1, is a revolutionary advancement in low-temperature soldering that also aids in increasing performance while helping to reduce warranty failures. The HRL1 alloy requires a soldering temperature of 50°C below SAC305 while maintaining a similar reliability to SAC305. This results in a highly reliable and energy-efficient soldering process.

Las Marias: What latest trends or developments in automotive electronics are changing the way electronics assemblies are being manufactured?

Salerno: The continual trend towards the development of autonomous vehicles are forcing manufacturers to rethink electronics assemblies and once again push the reliability demands on assembly materials. Advanced detection systems are one of the key elements to building a safe and reliable vehicle capable of predicting behavior of the three-dimensional images it is sensing. To achieve this, electronics need to embody artificial intelligence, processing advanced algorithms to enable the vehicle to quickly and automatically adapt to changing circumstances. There's also IoT considerations as onboard systems need to support machine-to-machine communications to learn from other vehicles and adjust for weather changes and shifting road conditions. As package sizes decrease, demands to maintain thermal and electrical performance of assembly materials will increase.

Las Marias: What are the key considerations for success in automotive electronics assembly?

Salerno: The ability to meet reliability requirements and reduce total cost of ownership are critical to success in automotive electronics. The balance between product warranty cost and the implementation of more advanced alloys that enhance long term reliability will continue to be a challenge for design and manufacturing engineers alike.

Las Marias: What can you say about the future of automotive electronics assembly industry? How do you position Alpha in this market?

Salerno: Alpha is well positioned to meet the current and future demands of the automotive industry. The continual adoption of HEV/EV powertrain, advanced detection systems, and enhanced in-cabin electronics are three significant trends in the automotive electronics industry for which Alpha has well-established, proven products to meet the most stringent design demands. Alpha can provide product solutions to the automotive electronics market where the technology is rapidly changing and becoming more complex. Alpha's strong partnership with leading Tier 1 automotive suppliers is fostered through delivering high quality products, superior technical support, and having a deep understanding of their next generation needs.

Las Marias: Thank you, Paul.

Salerno: Thank you. **SMT007**

MEK Sees Increasing Demand for THT AOI Systems

Henk Biemans, managing director of MEK (Marantz Electronics) Europe, speaks with I-Connect007 Managing Editor Stephen Las Marias about why the growing automotive electronics market is driving the increasing demand for THT AOI systems. Other topics discussed include reliability issues, artificial intelligence, and machine learning in inspection systems.

To watch the interview, click here.

Supply Line Highlights

Siemens Addresses Digital Enterprise with Valor IoT Manufacturing Tool

Siemens today announced the Valor IoT Manufacturing Analytics product, a new comprehensive big data and business intelligence platform that monitors and manages global electronics manufacturing operations for accurate, real-time manufacturing utilization and overall equipment effectiveness (OEE).

RTW IPC APEX EXPO: How Smart Factories Will Revolutionize Electronics Manufacturing

KIC president Bjorn Dahle discusses the smart manufacturing trend in the electronics assembly industry, and how KIC can help their customers with smart manufacturing transitions.

Flextron Unveils New X-ray Inspection, Failure Analysis Capability

Flextron Circuit Assembly announces the availability of 3D X-ray imaging capability, through the acquisition of a Nikon XTV-160 system that provides Flextron with a powerful quality assurance and diagnostic tool.

The IoT Event of The Decade

The IPC APEX EXPO tradeshow at the end of this month is set to rock the manufacturing world in a way that has not been seen for many years.

RTW IPC APEX EXPO: Indium Discusses Fighting Solder Voids

Voiding has increasingly become one of the most critical challenges in the soldering process. In this interview, Christopher Nash, product manager for the PCB assembly solder paste business of Indium, speaks about how the company is helping customers address the voiding challenge.

Cirtronics Invests in Additional Pillarhouse Selective Soldering System

Pillarhouse is pleased to announce that Cirtronics has today placed an order for a 4th Pillarhouse selective soldering system, for their manufacturing facility.

RTW IPC APEX EXPO: Addressing Challenges in Automotive Electronics

Paul Salerno explains how Alpha Assembly Solutions have addressed the challenges of the exponential growth in automotive electronics, with specific reference to soldering in power train, ADAS, and infotainment applications.

RTW IPC APEX EXPO: Developments and Reliability Improvements in Solder Alloys

Tim O'Neill of AIM Solder explains developments in solder alloys for cost-sensitive applications, and improvements in the reliability of alloys subjected to sustained high temperatures.

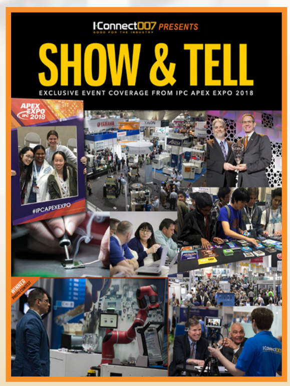
RTW IPC APEX EXPO: COMET Technologies Highlights Product Range and New Facility

Craig Arcuri of COMET Technologies details the numerous ways his company's technology is employed to manufacture and inspect a wide range of products, from chips to jet engine turbine blades. He also speaks about Lab One, the company's new technology and application center in Silicon Valley.

Another year of great conversations!

We would like to thank everyone who stopped by for a chat during this year's **IPC APEX EXPO**.

I-Connect007's ***Real Time with...*** has been covering the industry's most important events for more than 15 years and we look forward to seeing–and maybe talking with–YOU at an event soon!



Download our post-show coverage magazine!

REAL *TIME* *with...* *IPC APEX EXPO 2018*

System-Driven Approach Ensures Automotive Electronics Assembly Success

Feature Interview by Stephen Las Marias
I-CONNECT007

Based in Neuilly-Plaisance, France, Asteelflash Group is an EMS firm offering services from NPI to mass production within a broad range of markets, including defense, military and aerospace, automotive, medical, industrial, telecommunications, and consumer electronics.

The automotive electronics and systems market accounts for nearly 20% of the company's global revenue. It is spread out around the key sub-segments (or end applications) including, but not limited to, infotainment, battery management system, power electronic modules, gateway and communication electronics, door controls, smart-lighting modules, and new technologies targeted towards the autonomous or self-driving cars such as vehicle to grid or V2X integration systems.

According to Mathieu Kury, business development manager at Asteelflash USA Corp., in Fremont, California, growth has been pretty aggressive over the past year and they expect it to continue with new technologies and strong players in the industry coming up with new vehicles and/or technology breakthroughs.

To successfully support its customers and capture new business in this segment, Asteelflash has developed its automotive-specific footprint, including Tijuana, Mexico; Suzhou, China; Bad Herzfeld, Germany, and coming soon, La Soukra, Tunisia.

In an interview with *SMT007 Magazine,* Kury talks about the new challenges and customer requirements when it comes to automotive electroics assembly, trends driving the growth of

the market, and where the industry is headed.

Stephen Las Marias: Have you seen an increase in automotive electronics assembly jobs over the past two to three years? What are the main drivers for this?

Mathieu Kury: We have indeed. These assembly jobs are mostly focused on PCB assemblies and sub-assemblies, including the full array of testing services and conformal coating, among other steps of the manufacturing process. This is a trend we expect to see again this year, along with higher volumes for customers/projects we started to support only recently and for which we have very strong and positive outlooks within the next few months.

Mathieu Kury

Las Marias: What are the greatest challenges when it comes to electronics assembly for automotive electronics?

Kury: More than the assembly itself, I would say the main challenges reside in the level of quality processes, procedures, and containment/contingency plans you need to have in place. This is something we're not new to, of course, and therefore have mastered over time. Traceability is another one. With the increasing level of electronics in cars on the market, a lot of EMS/CM players are attracted to penetrate this industry. However, not all of them are able to provide the quality commitments and results needed to succeed on the long run.

On another note, dealing with new technologies can also be a challenge and the self-driving vehicle sub-segment will change the way we assemble automotive products as the liability on the field will be even higher—but this is something we're ready to tackle.

Las Marias: What new requirements or demands are being placed upon you by your automotive electronics customers?

Kury: More than new demands or sub-applications, our customers require shorter and shorter lead times, which is something we can help with by engaging at the early stage of the project—most specifically during the design stage. This will allow us to guide and support the customer in keeping the mass production context in mind, which is something overlooked too often.

Las Marias: How are you helping customers address their challenges?

Kury: We've integrated design for excellence (DFE) and design for manufacturability (DFM) principles into our processes. That helps us in providing our customers with design support services, with the right tools, at the right time. Qualifying alternate parts, identifying possible roadblocks to volume production, among others, are services we provide more and more to our customers to make sure lead time is optimized, component selection is relevant and in line with customer's requirements, and allows mass production ramps up smoothly. Testing strategy is another area where we're investing additional resources, supporting our customers in defining the right testing strategy according to their specific use case, and supporting the associated tooling development.

Las Marias: What recent trends or developments in automotive electronics are changing the way electronics assemblies are being manufactured?

Kury: Not sure if these latest developments are changing the way products are assembled, however we do see a lot more opportunities to bring our expertise inside a vehicle. From sensors to infotainment and an ever-increasing role of the screens and touchpads for interior control, we are regularly consulted to support these types of assembly, in addition to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historical applications such as lighting or door controls. In addition, green technologies and the overall Smart City ecosystem is bringing additional opportunities to support the electric vehicle industry especially the charging infrastructure, for example.

Las Marias: What are the key considerations for success in automotive electronics assembly/manufacturing?

Kury: While I believe that most CM or EMS companies can place components on a board, it is usually another story to make it successful for high-volume production without compromising on quality. To reach this goal of < 20 PPM, which we have and is below industry standards for this specific segment, I really think you first need to have a system-driven quality approach. This will ensure your processes are system driven and properly documented. The second contributor is people. I'm proud to be working at an EMS company where everybody is accountable for quality. As Ron Williams, our quality manager in Fremont, California, (one of our automotive certified facilities) repeatedly mentions, we have 350 quality managers in the plant; each and anyone of us can raise our hand and hold the line in case of an issue. That mindset is key to succeed in this very demanding industry.

I'm proud to be working at an EMS company where everybody is accountable for quality.

Las Marias: What can you say about the future of automotive electronics assembly industry? What factors will drive its growth?

Kury: It all comes down to mass adoption on the market and the readiness of the infrastructure for these companies to succeed, therefore boosting demand for assembly services. I do believe the self-driving car will play a greater role to making this happen, in addition to increasing electronic content on-board any vehicle. This will imply having capacity available and capabilities in line with automotive requirements. I also believe new sensing technologies and Lidars, with new comers in this very field, will boost demand for assembly services, such as box-build and finished product assembly.

Las Marias: One of the biggest issues in the automotive industry is reliability. How do you ensure the reliability of your assemblies?

Kury: This is also a challenge for any new comer in this industry. Reliability is key and we have integrated this into our processes and follow industry best practices such as ISO 16949 and becoming IATF compliant. Our traceability system is one of the most advanced for electronic manufacturing services, allowing Level 3 traceability; in other words, it gives us the ability to go back to the component level. This very aspect is critical to us and to our customers.

We've had our traceability system and manufacturing execution system (MES) linked to our ERP and other tools such as incoming inspection/receiving software, etc. These tools, being connected, allows us to always keep monitoring every step of our processes. Being system-driven allows us to go back to the component level with our suppliers, on behalf of our customers, but also to structure our own engineering and manufacturing process through forced routing, for example. A good example would be the possibility for us to avoid human mistake at revision level or making sure a specific assembly has been going through each step it was supposed to. Such features are priceless to our customers and therefore to us.

Las Marias: Thank you very much, Mathieu.

Kury: Thank you, Stephen. SMT007

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SMTA, INEMI, and MEPTEC have joined forces to again host this international conference, focusing on advances in electronic technologies and advanced manufacturing, specifically targeting medical and bioscience applications. Our last conference attracted about 200 attendees and more than 30 exhibitors. In prior years, MEPTEC's and SMTA's conferences were held in Phoenix, AZ and Milpitas, CA, respectively, drawing technology experts, entrepreneurs and service providers that work in this niche technology space. Typical applications within this space involve implantable defibrillators, neurostimulators and drug delivery, interventional catheters, pillcams, ultrasound transducers, hearing aids, biosensors, microfluidics, wireless communications, as well as future diagnostic and treatment solutions that may use stretchable electronics, microelectromechanical systems (MEMS) or nanoelectromechanical systems (NEMS). ◆

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Annual IT Spending by Western European Healthcare Providers to Reach $14B in 2021 ▶

According to an International Data Corporation (IDC) Health Insights IT spending forecast report, IT spending by the Western European healthcare sector is forecast grow from $12.9 billion in 2016 to $14.1 billion in 2021.

IDC New Zealand: Smartphone Shipments, the Beginning of the End? ▶

According to International Data Corporation's (IDC) recently published fourth-quarter mobile phone shipment results, tracked from October to December 2017, the New Zealand smartphone market has observed a full year on year shipment decline.

Under the Hood: Solder Joint Reliability

A look into the effects of substrate material and package pad design on solder joint reliability of 0.8 mm pitch BGA

Feature by Burton Carpenter
NXP SEMICONDUCTORS INC.

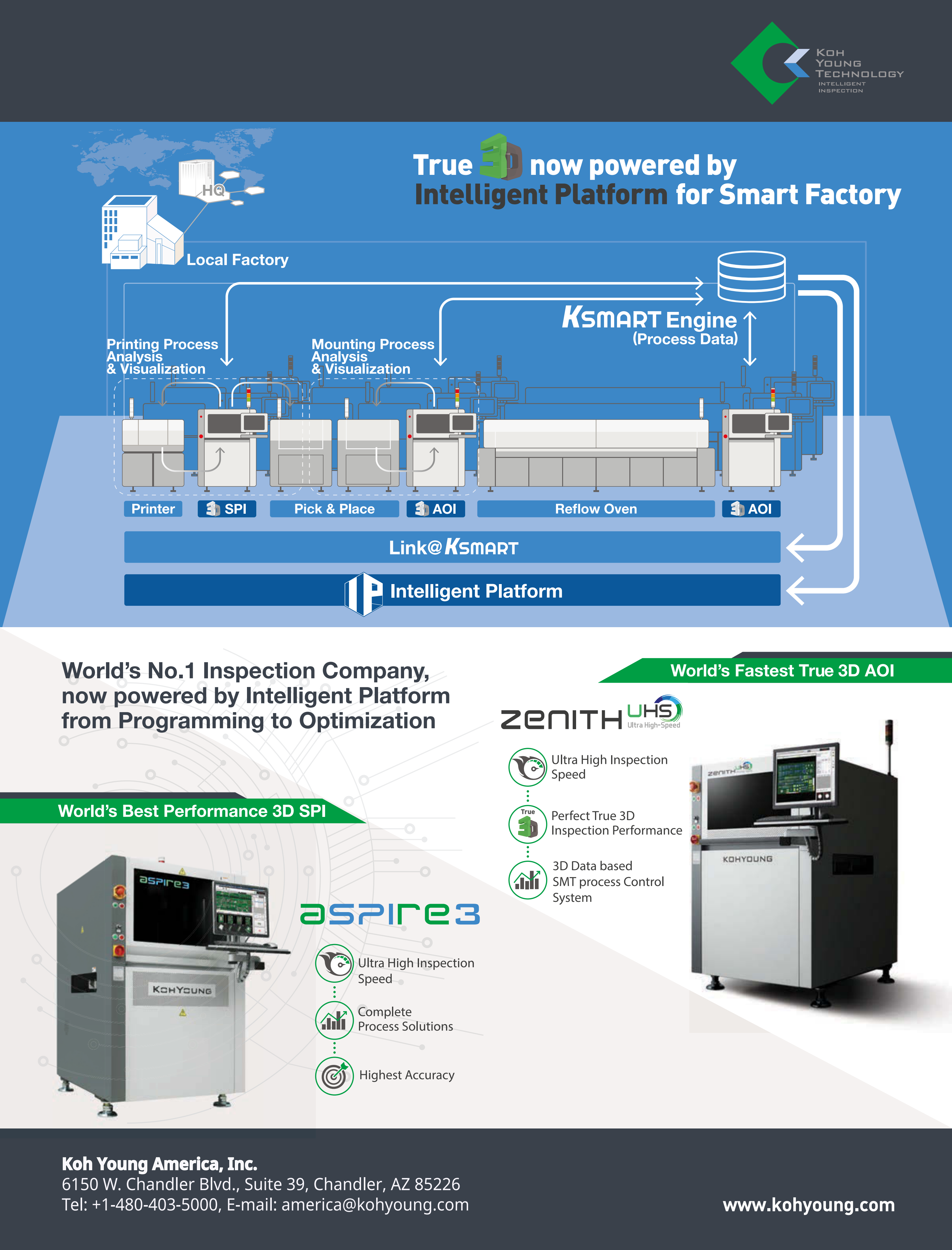
The automotive industry continues to drive increased solder joint reliability (SJR) for under-the-hood applications. One aspect of SJR, temperature cycle on board (TCoB) assesses thermal fatigue resistance of solder interconnection between component and PCB during temperature excursions. In some instances, requirements on number of cycles to first failure have increased 2x over previous product generations.

It has been long established that packages using NSMD BGA pads were more resilient than ones with SMD pads to fatigue induced solder joint cracks [1, 2]. However, NSMD pads in our previous investigations on 292MAPBGA and 416PBGA packages failed sooner in AATS testing due to an alternate failure mode: substrate Cu trace cracks [3].

Detailed failure analysis revealed that these cracks occurred exclusively on BGA pads in the die shadow. This led to the idea that a mixed design—NSMD pads outside the die shadow, while maintaining SMD pads under the die—could perform better than a pure SMD design.

Separately, lower CTE substrate dielectric materials were under investigation as a means to reduce package warpage. Below Tg, the mold compound CTE is 9ppm/°C. The standard substrate dielectric CTE is 16ppm/°C, resulting in considerable package warpage at lower temperatures. It was hypothesized that lowering the substrate dielectric material CTE to 11ppm/°C would reduce package warpage which in turn should reduce solder joint strain thereby increasing solder joint lifetime.

A six-cell experimental matrix was run to study the impact of these two variables (substrate dielectric material and package pad design type.) These experiments used standard daisy-chain temperature cycle testing methodology. Assemblies were monitored in situ to detect failures as they occurred, and 2-parameter Weibull failure distributions were fit to the data. Various metrics derived from the Weibull fits were regressed against the DOE variables to determine which had significant impact on solder joint lifetime, and to what degree.



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Crack growth was assessed using cross-section and dye-and-pry techniques on unmonitored assemblies that were removed from the chambers at fixed readpoints. Conclusions on the impact of the parameters were determined based on the totality of electrical test and crack growth data.

EXPERIMENTAL:

Design

The package attributes are summarized in Table 1. Those highlighted in yellow were varied in the experiment. The substrate dielectric details are in Table 2. BGA arrays are shown in Figure 1. The baseline SMD design in Figure 1a contained only SMD pads. Hybrid-A in Figure 1b used the same footprint, but the outer four rings were substituted with NSMD pads, while the pads at the die edge were maintained as SMD. By contrast, the outer six rings were NSMD for Hybrid-B, encompassing the die edge. In all cases, the SMD pad SRO (solder resist opening) was 0.45mm. To compensate for solder wetting down the pad sidewall, the NSMD pads on the hybrid designs were slightly smaller to produce a similar ball height.

These packages were daisy-chain test vehicles with pairs of solder joints electrically connected as illustrated in Figure 2. A complete circuit was created by connecting pairs on the PCB side that were skipped on the package. All solder joints were monitored as one "net." A failure on any solder joint meant the remaining solder joints could no longer be electrically monitored.

Except where parameters were intentionally varied, the daisy-chain packages were mechanically similar to the final products: same die

Parameter	512TEPBGA
Body Size	25mm x 25mm
BGA Pitch	0.8mm
Mold Size	22.5mm x 22.5mm
Mold Thickness	1.15mm
Mold Material	Epoxy Mold Compound α1=9ppm/°C E=26GPa Tg=125°C (TMA)
Substrate Thickness	0.56mm, 4 layer
Substrate Material	Variable – See Table 2
Die Size	8.1mm x 9.6mm x 0.28mm
Package Pad Design	Variable – See Figure 1
Package SRO	0.45mm
Pad Finish	Electroplated Ni/Au
Sphere Diameter	0.50mm
Sphere Alloy	Sn 3.5Ag

Table 1: Package details. DOE variables in yellow.

Substrate Dielectric	CTE (TMA)	Modulus (DMA)	Tg (TMA)
Standard	α1=16ppm/°C	19GPa	180°C
Low CTE	α1=11ppm/°C	22GPa	260°C

Table 2: Substrate dielectric mechanical properties.

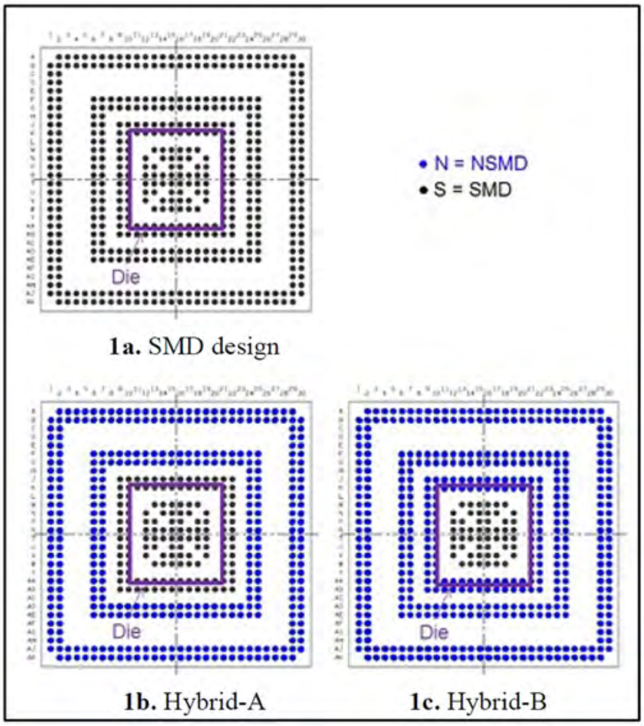

Figure 1: BGA footprint showing arrangement of SMD and NSMD pads for the three different designs.

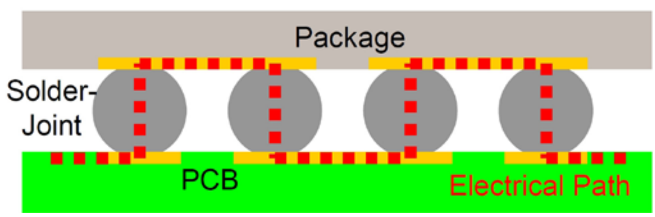

Figure 2: A daisy-chain connection representation between package substrate bottom metal and printed circuit board top metal. The red dashed line illustrates the electrical path.

size, area and thickness. Similarly, the same material sets were used: mold compound, die attach, and assembly factory.

Assembly

The PCB and assembly details are in Table 3. Assembly of daisy-chain parts to boards followed industry norms. Solder paste printed to boards used the alloy Sn3.8%Ag0.7%Cu (SAC387) and a no-clean flux system. Placement of parts to boards used a dual eyepiece placement machine for aligning parts to solder-paste print. Finally, boards were run through a 10-zone reflow furnace with a peak temperature between 235°C and 245°C.

Experimental Matrix

The six experimental cell combinations shown in Table 4 were built and tested. Sixteen from each were subjected to monitored TCoB -40°C/+125°C cycling, with additional unmonitored units included for crack propagation measurements. Non-destructive T0 characterization was performed on all cells.

Cycling, Electrical Testing and Data Analysis

Assemblies were tested in an Air-to-Air Thermal Shock (AATS) dual chamber system whereby one chamber remained hot (+125°C) and the other remained cold (-40°C). An elevator system moved test boards between these chambers within about 10 seconds.

Both chamber dwell times were set at 30 minutes totaling 1 cycle/hour. Typically, ~5 minutes was required to reach equilibrium, yielding ~25 min dwells. Figure 3 displays a typical temperature profile obtained by placing thermocouples in the assembly solder joints.

Assemblies were monitored in-situ during cycling using a 1.2mA current through each net. An event detector logged a failure when a net resistance exceeded 300 ohms. Failures were defined per IPC-9701[4]. Generally, daisy-chain resistances were few ohms at the beginning of an experiment.

Net resistance did not immediately change measurably during early stages of solder joint crack growth, but climbed quickly as the crack approached 100%. Therefore, a net failure was logged when any one of the solder joints in that net had a crack near 100%.

For each test cell, cycling continued until at least 75% of the samples failed, after which the data were fit to a 2-paramter Weibull distribution using maximum likelihood estimate (MLE). Three metrics of solder joint lifetime were extracted from each distribution: (1) characteristic life (Eta), (2) extrapolated

Parameter	512TEPBGA
PCB Thickness:	1.56mm, 4 layer
PCB Material	FR-4 Epoxy Laminate α1=16ppm/°C E=20GPa Tg=160°C (TMA)
PCB Pad	NSMD, 0.4mm, OSP finish
Stencil	Aperture 0.40mm Thickness 0.10mm
Stencil Finish	Laser cut openings with electropolish and Ni coating
Paste	SAC387 (Sn 3.8Ag 0.7Cu)

Table 3: PCB and SMT assembly details.

Cell	Design	Substrate Dielectric Material
1	SMD	Standard
2	Hybrid-A	Standard
3	Hybrid-B	Standard
4	SMD	Low CTE
5	Hybrid-A	Low CTE
6	Hybrid-B	Low CTE

Table 4: Experimental matrix.

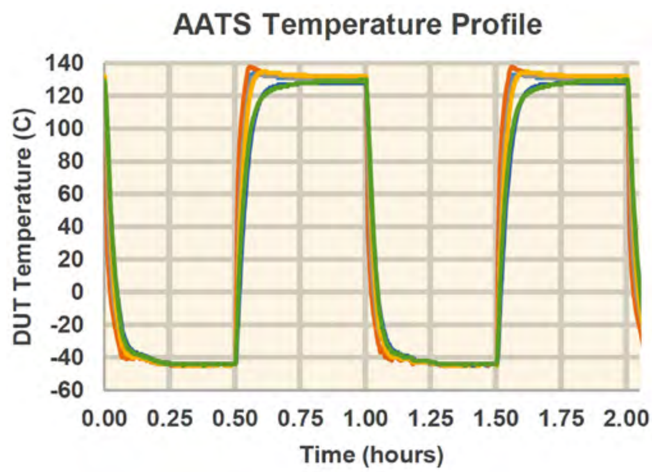

Figure 3: AATS temperature profile.

number of cycles for a 1% failure rate, and (3) first failure. Each of these metrics were linearly regressed versus the DOE factors.

Package Characterization

Solder ball height, diameter and coplanarity of the unmounted packages were measured at room temperature using an RVSI LS8000 scanner. Ball height was measured relative to the soldermask surface. The widest portion of the ball was taken as the ball diameter. Coplanarity was calculated according to the seating plane method described in JESD22-B108A[5]. Package warpage was measured using an Akrometrix TherMoire PS400 according to JEDEC standard JESD22-B112A[6], and reported here for the temperature range of interest: -40°C to 125°C. Measurements were made on the bottom (substrate) side of the package after removing the solder spheres.

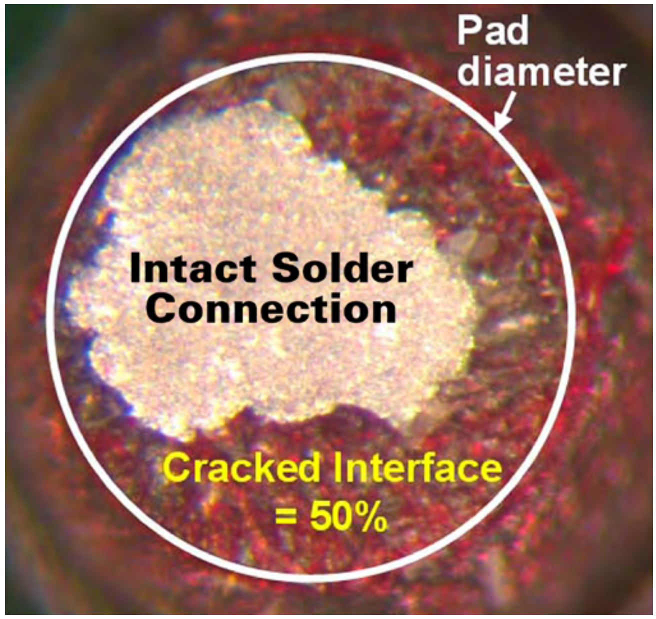

Figure 4: Example dye-and-pry image and degree of cracking calculation.

Crack Propagation Analysis

Two methods were used to examine crack propagation in the solder joints during cycling: dye-and-pry and cross-section.

Dye-and-pry was a quick and simple method to obtain an overall view of cracking quantity, degree and distribution. A dye was applied to the solder joint array to mark crack locations, followed by a forced separation of package from board. Cracks formed during cycling were stained with ink, and were distinguishable from fracture surfaces created merely because of the forced pry [7].

Dye-and-pry had some limitations. First, it only revealed one crack interface in each solder joint, whichever cleaved first during pry. Sometimes a solder joint cracked along both package and PCB sides simultaneously. Additionally, PCB pads often ripped out during peel, even when solder joint cracking had occurred. In these incidences it was assumed the degree of cracking was low (<50%) since the solder joint strength was greater than PCB pad adhesion.

For cross-section, standard potting, sectioning, grinding and polishing techniques were used to prepare and study solder joint crack growth. SEM images were captured for the measurements. In all cases, sections were made through the joint center line. Cross-sections provided a more definitive picture of crack propagation location in the solder joint than dye-and-pry. Often cross-section identified multiple cracks within a joint. One caution: crack front propagation may be at any arbitrary angle to the cross-section plane, thereby distorting crack length measurements.

Samples were studied for degree of crack growth, location within the solder joint, and distribution across the array. For solder joints examined by cross-section, degree of cracking was calculated as the percentage of visible crack length divided by apparent pad diameter (all linear). For dye-and-pry, it was the crack area (red die visible) divided by pad area for each pad where a crack surface was revealed. See Figure 4 as an example.

RESULTS:

Ball Size and Coplanarity Characterization

Solder ball diameter and height of the unmounted packages are summarized in Figures 5 and 6, respectively. Distributions for the SMD and NSMD pads are plotted separately. Twenty packages were measured for

each cell. For both dimensions, the balls on the SMD pads were essentially the same across all the cells. This was expected since these dimensions were dictated by the package substrate SRO and solder ball size, which were nominally. Likewise, the balls on NSMD pads were the same among the cells.

Since solder wets the NSMD pad sidewalls, it's expected that the height of these pads would be lower than an SMD pad of the same diameter. Surface evolver simulations predicted the NSMD pads would be 22 µm shorter if the same 0.45 mm pad were used. To compensate, the NSMD pads were designed slightly smaller. Surface evolver predicted only a 3 µm difference for the compensated NSMD pads. Figure 6 shows that an actual difference of 6 µm was observed. No difference was apparent in ball diameter.

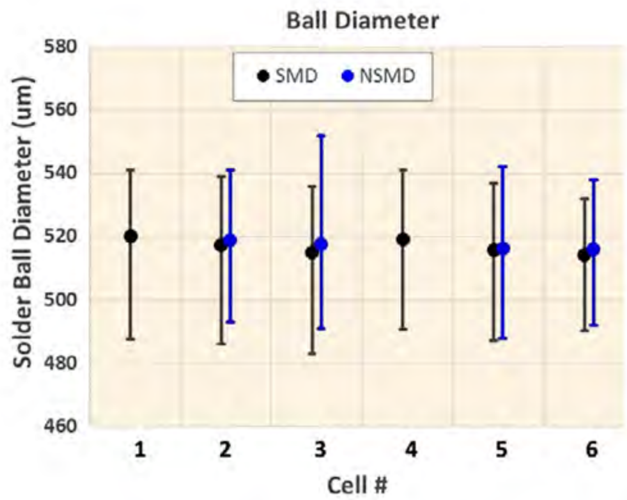

Figure 5: Ball diameter measurement by RVSI scanner. Error bars represent the data range.

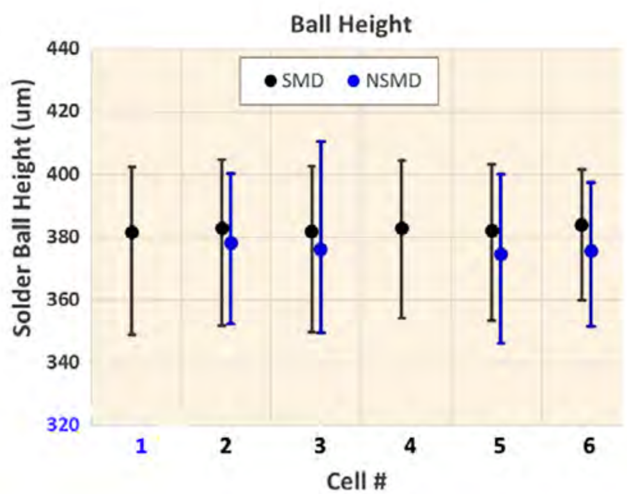

Figure 6: Ball height measurement by RVSI scanner. Error bars represent the data range.

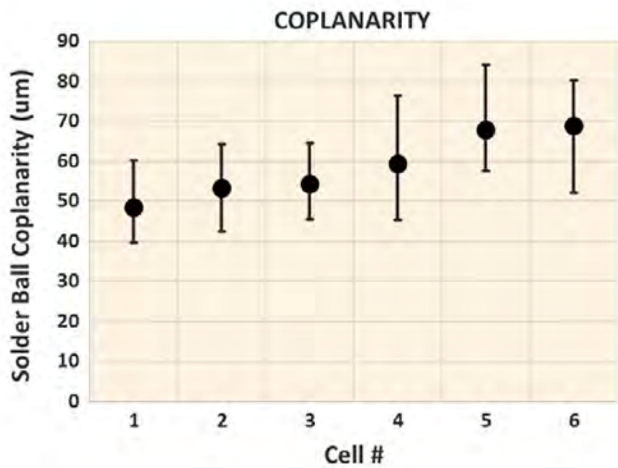

Figure 7: Solder ball coplanarity at room temperature.

Room temperature solder ball coplanarity is summarized in Figure 7. There is a tendency for the hybrid Cells 2-3 and 5-6 to be slightly higher than the SMD Cells 1 and 4 due to the slight difference in ball heights. Also, the low CTE Cells 4-6 were higher than the standard material Cells 1-3. This was unexpected and is opposite the warpage results shown in the next section. Reasons for this discrepancy are under investigation. In any event, all are well within the case outline (package outline) specification of 200 µm max.

Warpage

Figure 8 plots the freestanding component warpage across the thermal cycle tempera-

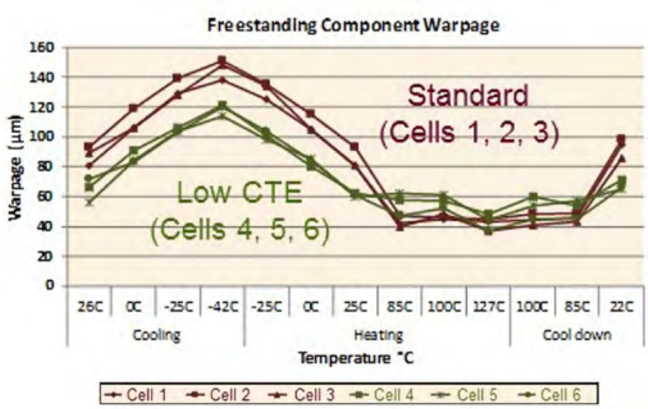

Figure 8: Package warpage by TherMoiré.

ture range. One sample per cell was measured. Pad design was not expected, nor observed, to influence package warpage. Therefore, the three samples for each substrate material type were considered to be from the same populations.

Packages using the low CTE dielectric warped considerably less on the cold side (-40°C to +25°C), 25 µm on average. This was expected based on the following analysis. Package warpage is driven primarily by the CTE mismatch between the mold compound and substrate. Below Tg, the mold compound expansion is 9ppm/°C. The low CTE dielectric expansion is 11ppm/°C, but the standard dielectric is 16ppm/°C. Therefore, the package will warp as it is cooled from the neutral temperature (roughly 150°C to 175°C.) But since the delta between mold compound and substrate is greater for the standard dielectric, the warpage will also be greater.

Solder Joint Characterization

One unit from each of two hybrid cells 2 and 6 were selected for T0 solder joint characterization after mounting to the PCB. Standoff and solder joint diameter were measured for four joints of each pad type (SMD and NSMD) for each sample. Examples are shown in Figures 9 and 10. Surface evolver predictions based on single joints anticipated the NSMD solder joints would be about 7 µm shorter. However, the actuals were much closer since attaching both types in a single package forces them to a common standoff. The standoff differences observed here between the two types possibly resulted from PCB or package warpage. Overall the joints were shorter and wider than predicted.

Temperature Cycle Electrical Test Results

Sixteen components from each of the six cells described in Table 4 (p. 42) were mounted on PCBs and cycled -40°C to +125°C as described above. The test was terminated after all cells had at least 12 units fail (75%). The results are plotted in Figure 11. The legend symbol n/s represents the number of units tested (n) and number of suspensions (s). Also shown

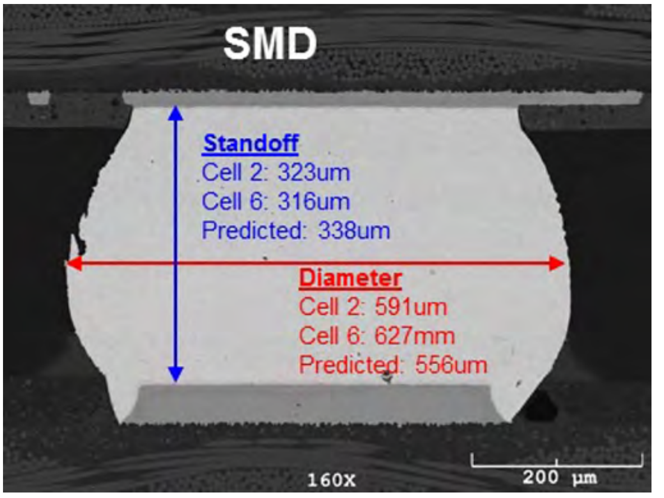

Figure 9: Cross-section of typical SMD solder joint after mounting to PCB.

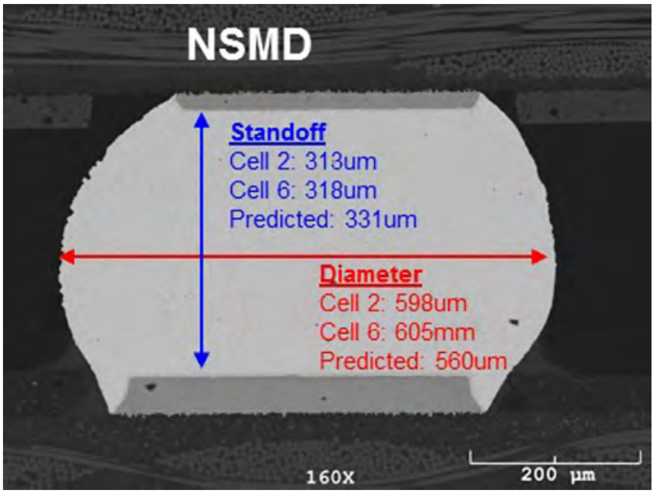

Figure 10: Cross-section of typical NSMD solder joint after mounting to PCB.

are the fitted two-parameter Weibull characteristic life (Eta) and shape factor (Beta). Good fits were obtained for all except cell 1, which had an outlier first failure. Inspection of the graphs suggests that the six populations can be divided into three groups. From least to most reliable: (A) cell 1; (B) cells 2,3&4; (C) cells 5&6. This suggests that the low CTE dielectric or either hybrid design offered an improvement over the baseline, and that combining them was best.

Three metrics (Eta, extrapolated 1% failure cycle and first failure) were extracted from each distribution and have been summarized in Table 5. Each of these metrics was linearly


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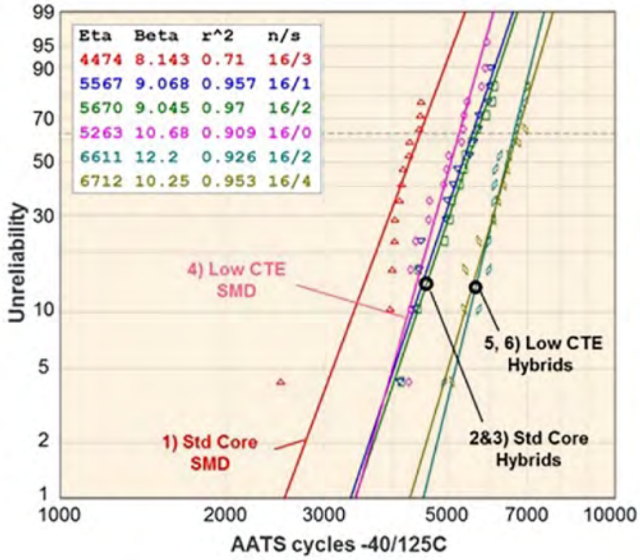


Figure 11: Weibull plot by experimental cell.

regressed against the DOE factors to assess impact on solder joint lifetimes. Results are summarized in Tables 6 and 7 for number of cycles and percentage, respectively. Factors not statistically significant at the alpha = 0.05 level are designated with an "*". Each of the three metrics tells the same story. Examining Eta, the low CTE material added nearly 1000 cycles, or 22%, to the solder joint lifetime. The hybrids added about 1200-1300 cycles, or 30%. In combination, the lifetime was improved over 2200 cycles, ~50%. This statistical analysis confirms the impression from inspection of the Weibull plots.

Cell	Pad Type	Dielectric Material	Beta	1st Fail	Eta	1% Failure Cycle
1	SMD	Standard	8.1	1st 2499 2nd 3945	4474	2543
2	A	Standard	9.1	4115	5567	3352
3	B	Standard	9.0	4134	5670	3410
4	SMD	Low CTE	10.7	4265	5263	3421
5	A	Low CTE	12.2	4954	6611	4535
6	B	Low CTE	10.3	5113	6712	4285

Table 5: Summary of Weibull results.

Cross-Section after Cycling

After 3,000 cycles, one unmonitored unit per cell was removed from the chamber for crack growth characterization by cross-section. Each was sequentially cut, polished and imaged by SEM at BGA rows B, F and K. Row B was selected for cross-section analysis since it experienced more significant cracking than row A as discovered during previous investigations [8]. Row K was along the die edge. From Figure 1, note rows B and F were all NSMD for both hybrid designs. Row K was all NSMD for Hybrid-B, but contained both types for Hybrid-A.

The degree of cracking was calculated for each solder joint as described above. Figure 12 shows a color-coded mapping of the BGA arrays. Red represents joints with over 90% crack length, yellow for those with cracks between 50% and 90%, and green for those

		1st Fail	Eta	1% fail cycles
Dielectric Material	Standard → Low CTE	1195	958	979
Design	SMD → Hybrid-A	1153	1221	962
	SMD → Hybrid-B	1242	1323	866
	Hybrid-A → Hybrid-B	89*	102*	-96*
Dielectric + Design	Std + SMD → Low CTE + Hybrid	2392	2230	1892

** Not statistically significant*

Table 6: Change in solder joint lifetime (# of cycles).

		1st Fail	Eta	1% fail cycles
Dielectric Material	Standard → Low CTE	43%	22%	39%
Design	SMD → Hybrid-A	41%	28%	39%
	SMD → Hybrid-B	45%	30%	35%
	Hybrid-A → Hybrid-B	2%*	2%*	-2%*
Dielectric + Design	Std + SMD → Low CTE + Hybrid	86%	51%	76%

** Not statistically significant*

Table 7: Change in solder joint lifetime (%).

with cracks less than 50% of the pad length. Cracks greater than 90% were observed only on the SMD cells 1 and 4. However, these occurred under the die edge along row K which in principle should behave the same as Hybrid-A for these particular joints. This result also differs from the previous study [8] which found more advanced cracking in row B in the cross-sections. Overall the hybrid cells had less cracking than the SMD cells, matching the electrical test results in this regard.

The solder joints with the most advanced cracking are presented in Figures 13 and 14. Failure locations within the solder joints are very typical: in the bulk solder near the interfacial IMC (intermetallic compound), predominantly on the package side, but a few on the PCB side as well. Keep in mind that a solder joint with 100% linear crack length measured in cross-section would not necessarily fail electrically, since the sectioning plane may completely miss portions of the solder joint that are still intact.

Dye-and-Pry after Cycling

At 4,013 cycles, dye-and-pry was performed on an unmonitored sample from each of the cells, and degree of cracking calculated. Crack distribution maps are shown in Figure 15 using the same color-coding as above. The patterns here are consistent with the electrical test results. Cell 1—SMD with standard material—showed the most solder joints with significant cracking. Only one solder joint with greater than 50% cracking was observed in the low CTE cells versus 26 for the standard material. While cracking was observed in all portions of the array, the second-to-last ring of joints experience the most. This ring experienced higher strain than the outer-most since the mold cap

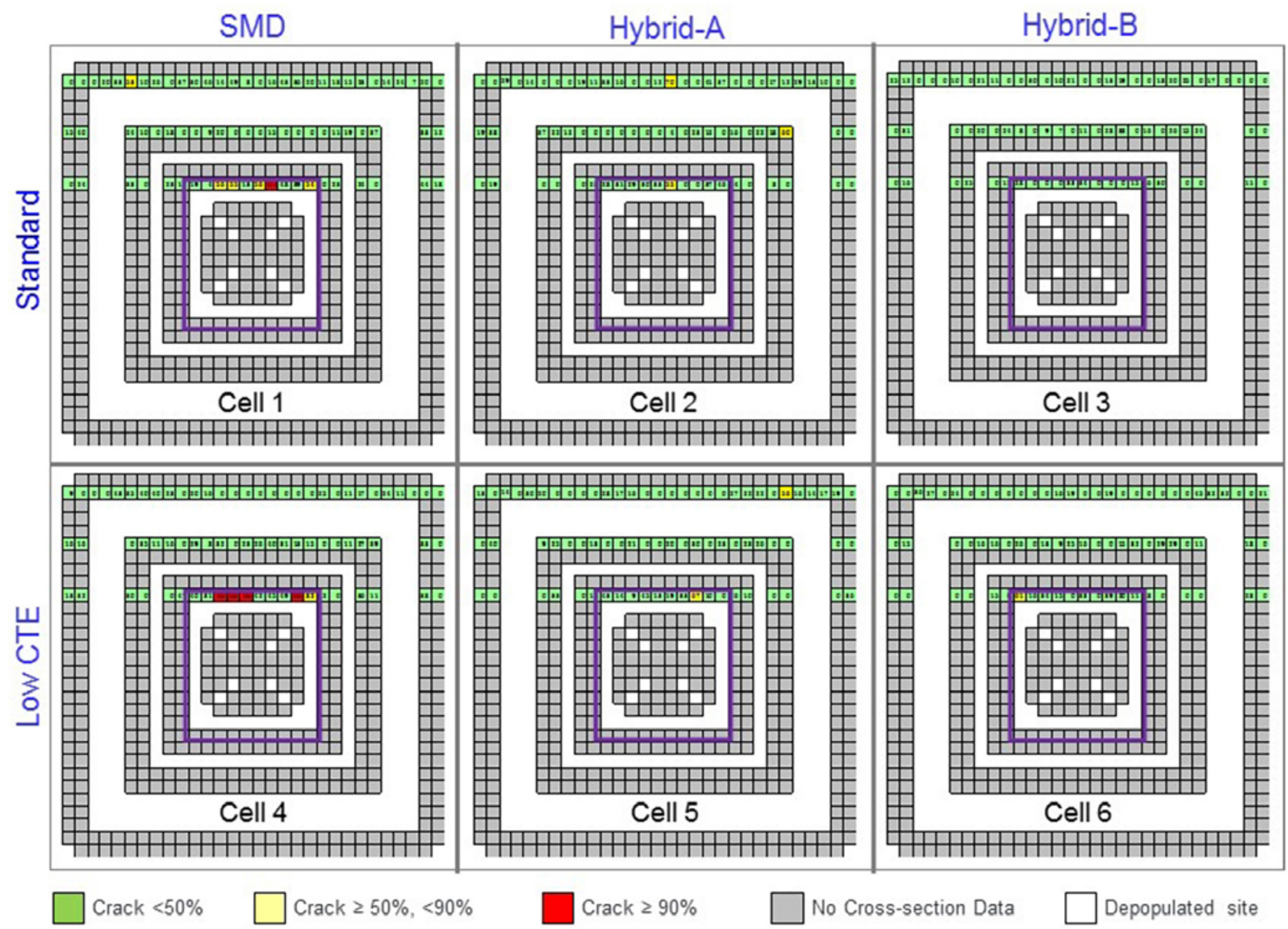


Figure 12: Distribution of degree of crack growth after 3,000 cycles, as determined by cross-section.

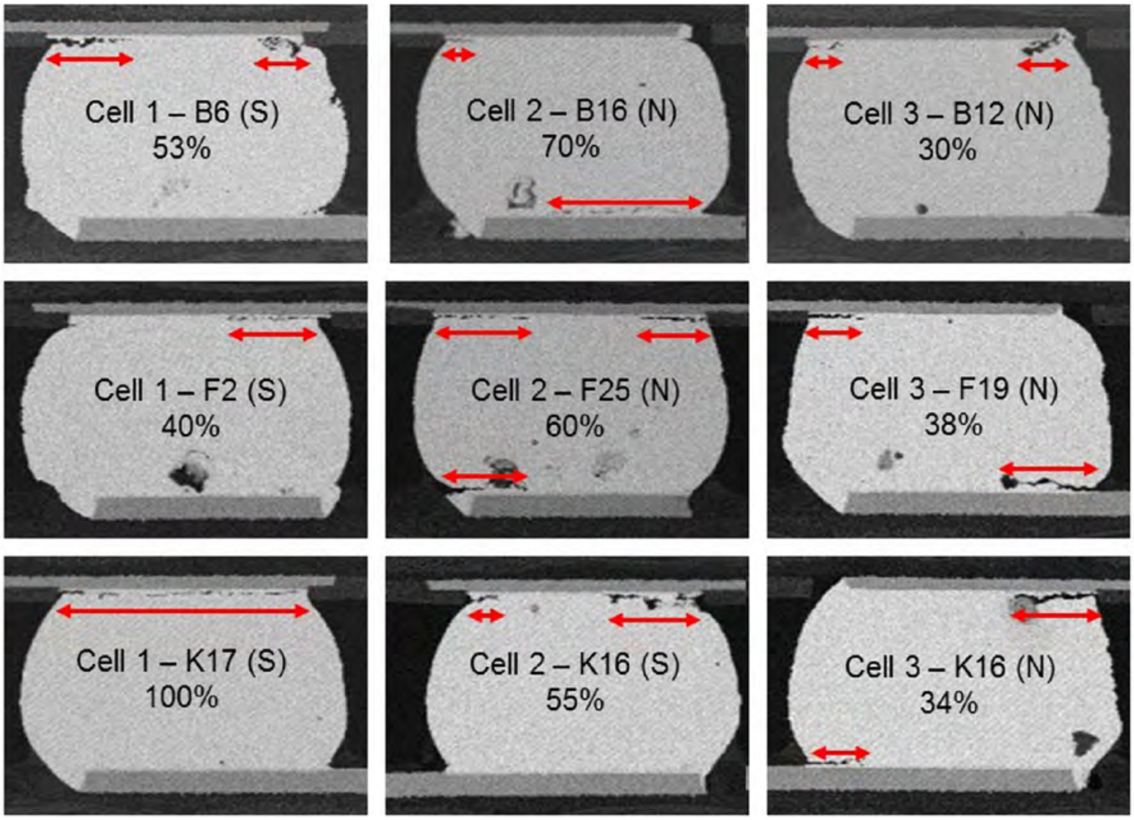


Figure 13: Solder joints with most advanced crack growth after 3,000 cycles from cells 1-3. Pad type is noted parenthetically.

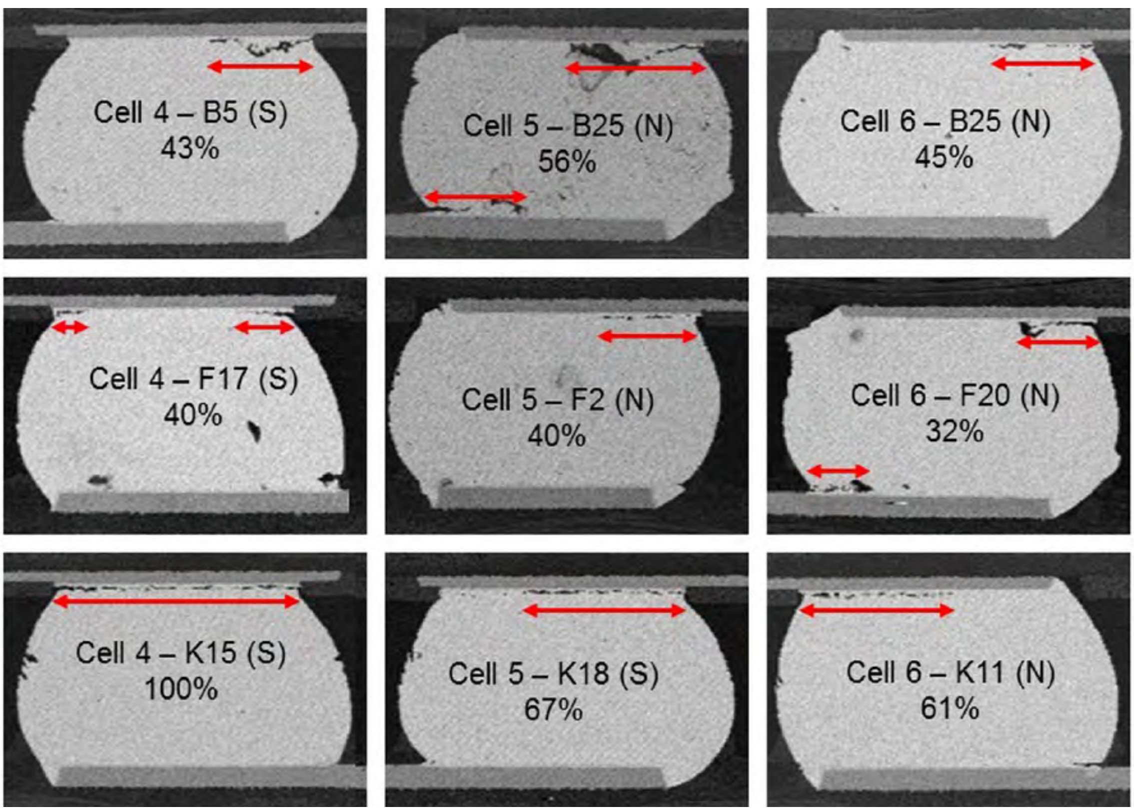


Figure 14: Solder joints with most advanced crack growth after 3,000 cycles from cells 4-6. Pad type is noted parenthetically.

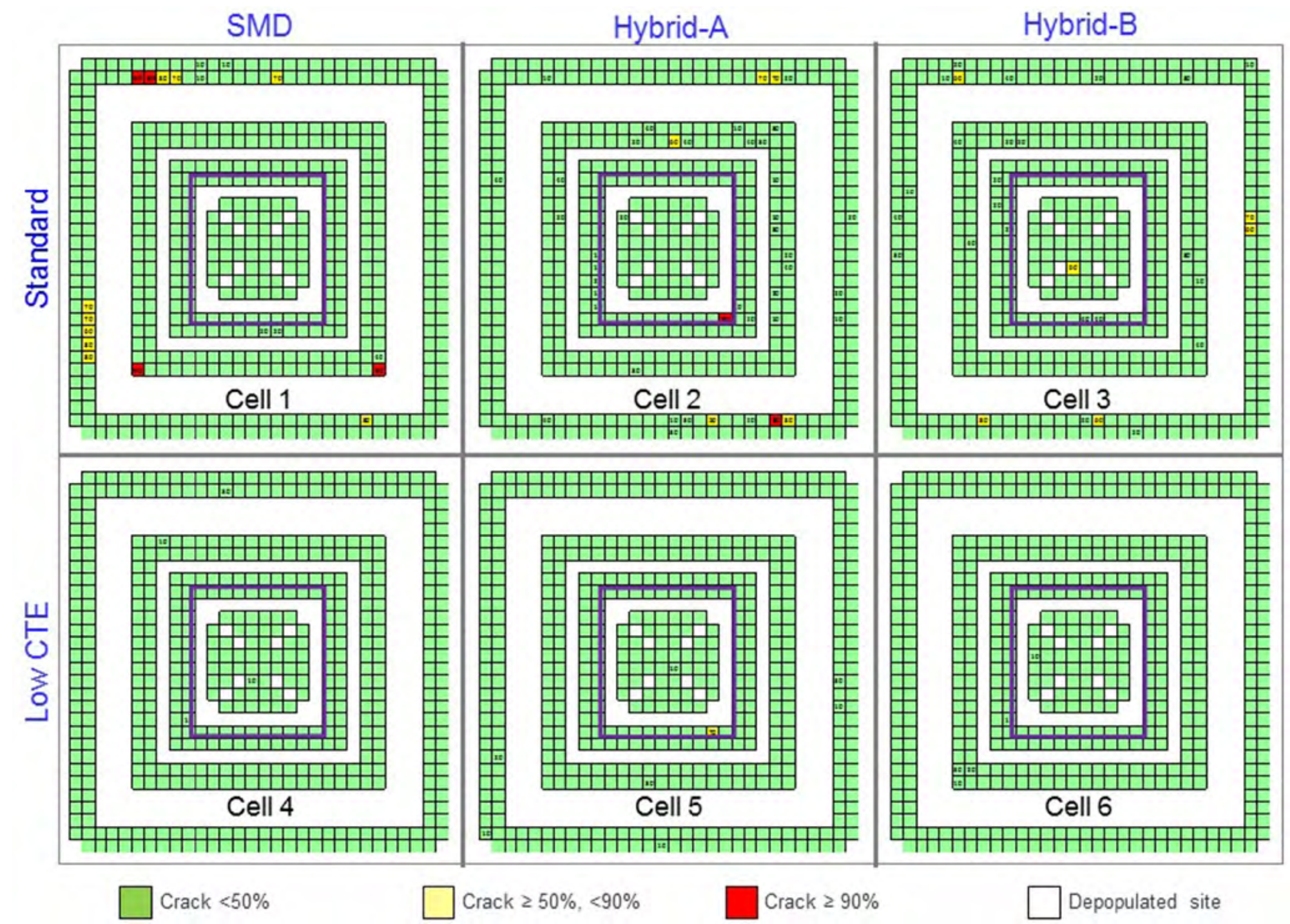


Figure 15: Distribution of degree of crack growth after 4013 cycles, as determined by dye-and-pry.

did not extend to the package edge. This result is consistent with the prior published study, which more fully explains the mechanism [8].

Example images of the dye-and-pry from cell 1 are shown in Figure 16. The fracture surfaces were between solder ball and package BGA pad, consistent with cross-section.

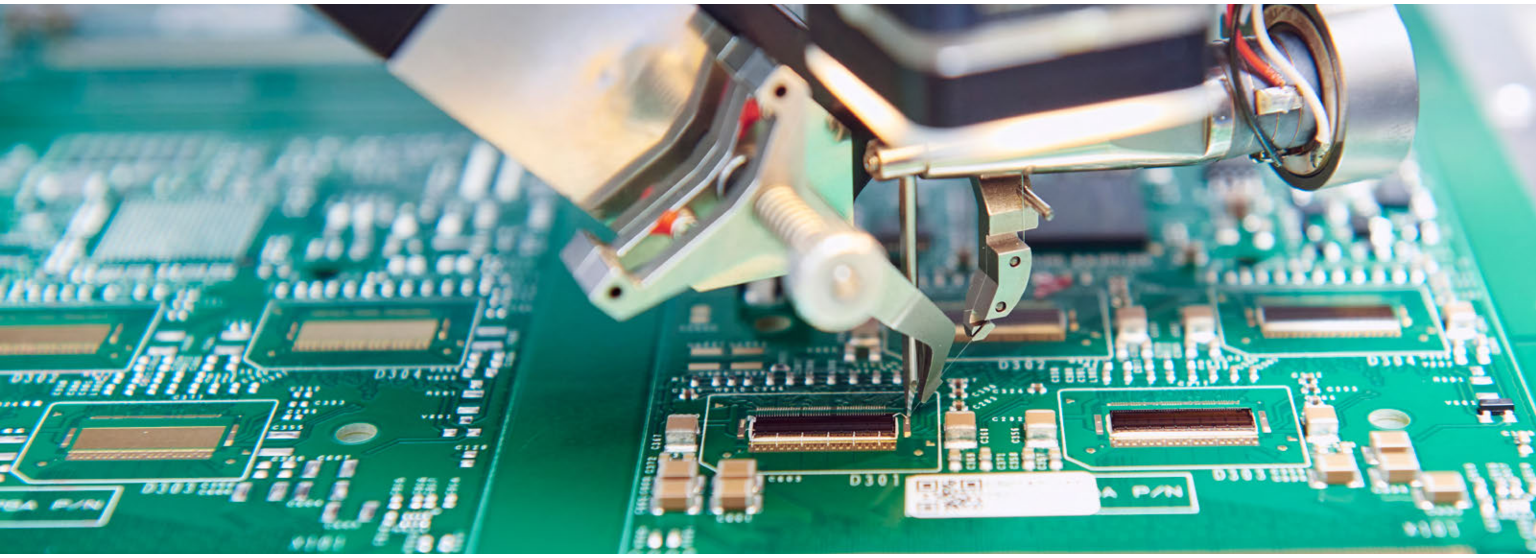
Discussion

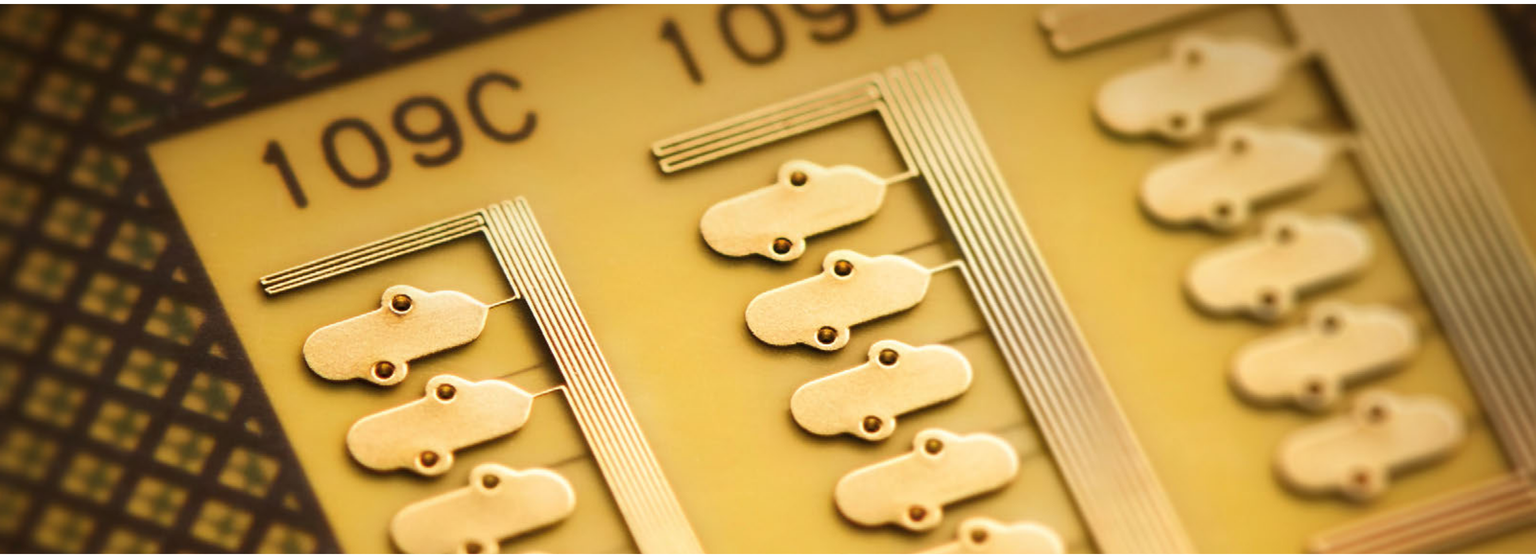
The original hypotheses were (1) a hybrid design with SMD pads under the die and NSMD pads outside the die have longer solder joint lifetime than a pure SMD design, and (2) low CTE substrate dielectric material would perform better than the standard material. Let's examine each in turn.

It's been long established that NSMD pads reduce strain in the solder joint [1, 2], offering potential to improve solder joint lifetime. Our recent investigations on 292MAPBGA and 416PBGA packages also demonstrated slower crack growth on NSMD BGA pads. However, these packages failed prematurely due to package side substrate trace cracks [3]. Once it was recognized that this alternate failure mode occurred only in the die shadow, the hybrid designs were created which placed NSMD only on the outer BGA rings.

The hybrid designs outperformed the pure SMD designs in all metrics studied in the current investigation. They had on average approximately 1,300 cycles longer characteristic life, and 1,200 more cycles to first failure. Less cracking was noted using both dye-and-pry and cross-section.

The manufacturability of mixing pad types on the same package was proven feasible. There were no abnormalities or yield issues reported

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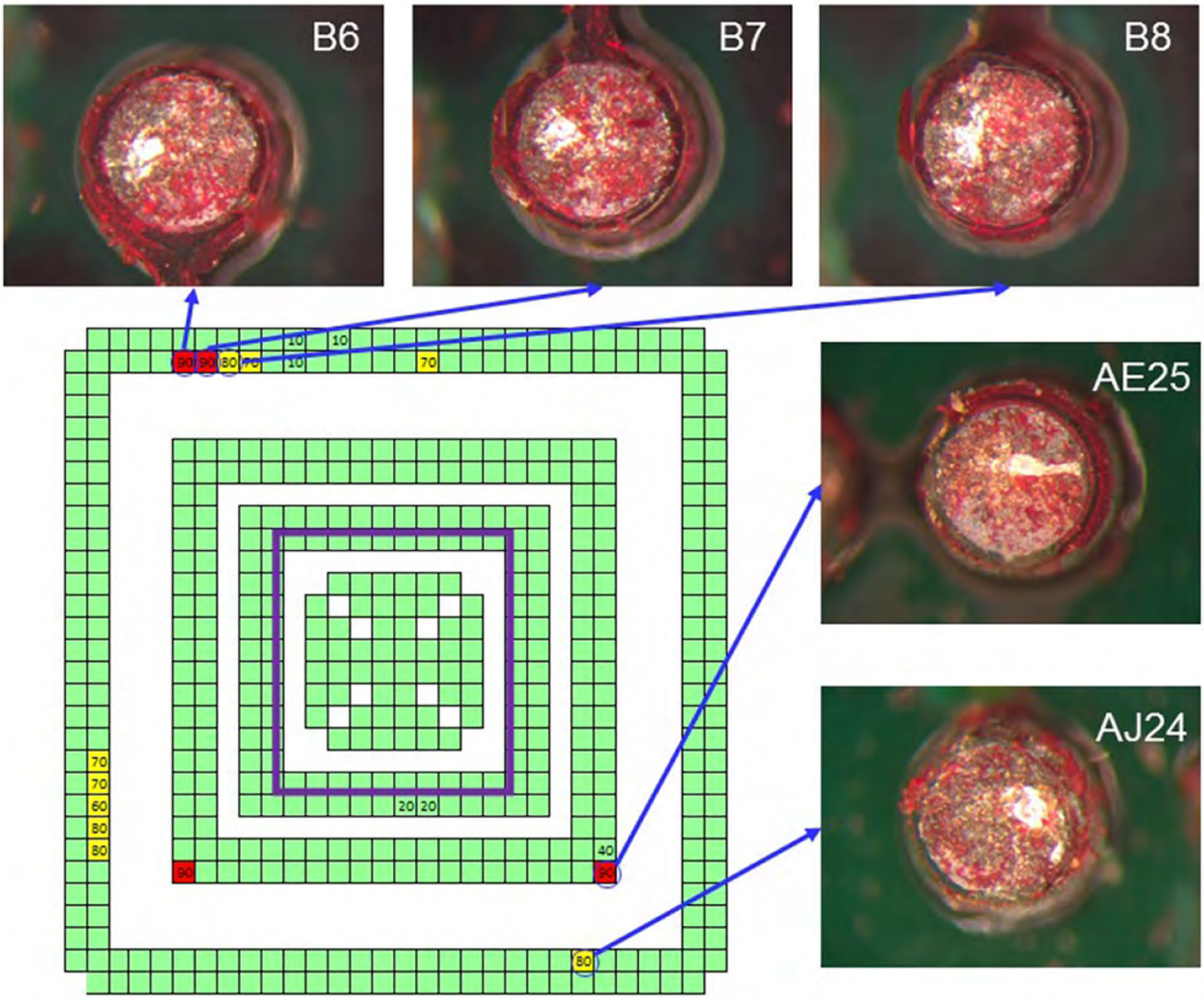

Figure 16: Example dye-and-pry results after 4,013 cycles from cell 1. Images are PCB view, on top of BGA ball attached to PCB pad after pry. Fracture surfaces were between solder ball and package BGA pad. Red area was fractured during cycling. Shiny area was still intact.

during assembly of the packages. Ball geometry and coplanarity, while slightly different, were within tolerance. These features can be further fine-tuned with the appropriate choice of relative pad sizes. With package coplanarity well within spec, the change was transparent to board assembly.

One factor not studied was comparison of the hybrid design to a pure NSMD. Perhaps there were facets of this 512TEPBGA package that made it less susceptible to the trace cracking observed on the other packages [1]. The similarity in performance between the two different hybrid designs leaves this an open question. Since Hybrid-A had SMD along the die edge, while Hybrid-B had NSMD, we expected some difference in behavior. Other aspects of the NSMD pads also need exploring, such as the ability to withstand shock from handling and shipping, and performance in drop, shock and vibration testing.

Lowering the substrate dielectric CTE from 16ppm/°C to 11ppm/°C changes the overall mechanics of the package. As noted above, package warpage is driven primarily by the CTE mismatch between the mold compound and substrate. Given the mold compound expansion of 9ppm/°C, the low CTE core is only

mismatched by 2ppm/°C, versus 7ppm/°C for the standard material. Therefore, at low temperatures the package using a low CTE substrate material should warp less. Though it was not manifest in the room temperature coplanarity data, the TherMoire results clearly show a transition to temperature range where the standard material package is significantly more warped.

Cross-section and dye-and-pry did not show clear trends. The inconclusiveness of the crack growth data likely resulted from the small sample sizes.

Results of the electrical tests were clear: the lower CTE added over 950 cycles to the characteristic life, and nearly 1,200 cycles to the first failure. Cross-section and dye-and-pry did not show clear trends. The inconclusiveness of the crack growth data likely resulted from the small sample sizes.

Based on the strength of the electrical test and warpage data, the low CTE substrate dielectric material did perform better. Verification will be needed to confirm the results, ensure it scales across different package types, and to better analyze the crack growth mechanics.

Conclusions

The conclusions are:

- A hybrid design, mixing SMD and NSMD pads on the same package is feasible for manufacturing, and was demonstrated to improve the solder joint characteristic life of a 512TEPBGA package by 30%.
- Lowering the package substrate dielectric CTE from 16ppm/°C to 11ppm/°C was demonstrated to improve the solder joint characteristic life of a 512TEPBGA package by 22%
- Greater than 3000 cycles to first failures for the 512TEPBGA package solder joint lifetime in -40°C to +125°C TCoB testing.

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CFX: The Next Step Toward the Future of Factories

Article by Stephen Las Marias
I-CONNECT007

For the past two to three years, almost every exhibitor in almost every trade show focused on the electronics manufacturing industry has an "Industry 4.0 Compatible" sign in their booth. As of today, the best question to ask is, "Compatible with what?" There has really been no standard yet developed toward this goal, and Industry 4.0 has been just a buzz word.

But for the first time in the industry, a common machine communications standard for the electronics assembly supply chain is a reality, edging the industry closer to the vision of a smarter factory.

At the recent IPC APEX EXPO in San Diego, California, the IPC Connected Factory Exchange (CFX) Showcase provided a technical demonstration operating in real time with standardized machine data delivered from participating exhibitors through the cloud and onto visitors' cellphones. This showcase was supported by more than 25 vendors who, in the words of Aegis Software's Michael Ford, "have stepped up to create the world's first conversion of a show-floor into a digital factory shop-floor."

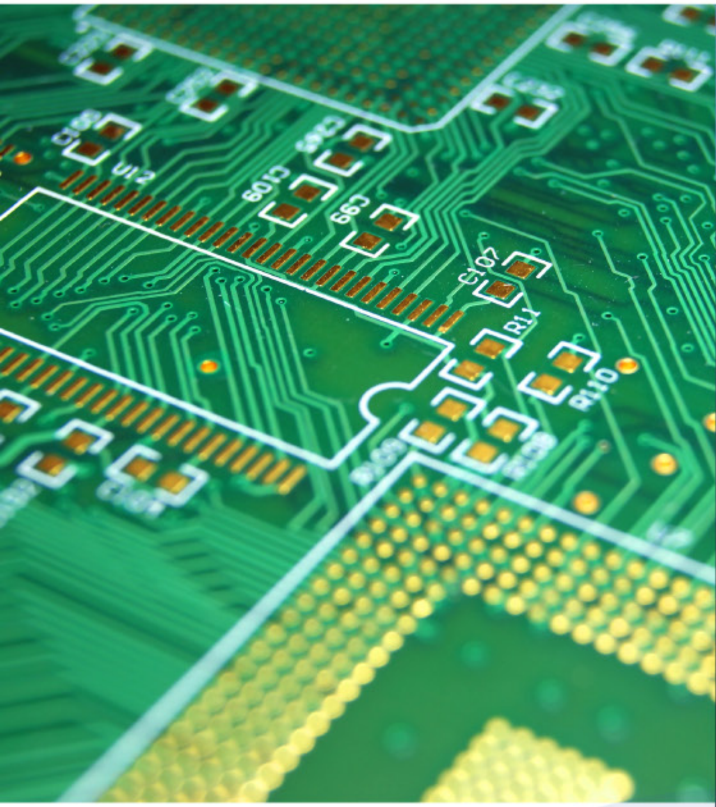
This marks the industry's introduction to a true Industrial IoT standard. Rather than being constrained by legacy data formats and content that machine engineering teams created many years ago, which were all OK in their day before the modern digital needs of customers was conceived, IoT data is now available that can support the most ambitious of Industry 4.0 projects.

I went around the show floor and talked to some of the CFX demo participants to know more about the CFX from their perspectives, the importance of the demo, the next challenges to overcome, and the impact of the demo to the industry.

Importance of the Demo

Major manufacturers traditionally ask for specific interfaces between their vendor's equipment and their manufacturing systems. This has become more and more time consuming and difficult to implement.

Nearly two years ago, selective soldering specialist Pillarhouse International was asked to be involved with CFX. The company worked with the committee to put together a standard that would work across the industry. At last



year's IPC APEX EXPO, Pillarhouse demonstrated the base system, which they did in six weeks. Working with the CFX team this year, the company was able to put together a demonstration in four days. "We implemented all the modifications on one selective system, over a four-day period. And we have been running live for the last two weeks and showing this information. It's very simple and very easy to integrate and work with," says Simon Smith, marketing manager at Pillarhouse.


Simon Smith

"We were introduced into CFX only about four weeks before the show, by Michael Ford of Aegis Software," said David Fenton, group customer support manager of pick-and-place provider Europlacer. "He presented to the wider management team at Europlacer, and we all felt that we needed to be involved in Industry 4.0. We've been investigating it for over a year. Until now, we realized that there was no standard. People were talking about Industry 4.0, but, nobody really knew what it was. People were advertising 4.0-ready, and we thought that can't be right because there is no standard to be ready for. So, when Michael spoke to us about CFX, we could really see that somebody had put a lot of work into trying to create a true standard—and Aegis made it very easy for developers like ourselves to be part of this demonstration. They created a software developer kit to be part of this demo, with very easy instructions and methods. We decided that we needed to do this, so we set our R&D team to work. Within 48 hours, we had a test running with the Aegis server and messages from our software were being allowed, interpreted, and relayed back. After another week, we modified our machine software, and we were then running through live demo. So, within a week—we went from zero to software that is running correctly; Aegis helped us with that, and Michael especially. Here at the show, we have both machines, the Atom 4 and the iineo, both uploading livestream data to the CFX cloud server at the show."


David Fenton

"Four weeks ago, we know nothing about CFX. And here we are today with a fully working model. We think CFX is the way to go. I know there are some other standards out there, but the easier it is made for the R&D team to write and code software, I think the more people will get on board with it. We took CFX seriously as a company and wanted to not miss this opportunity at APEX to show that Europlacer is willing to put our R&D efforts into new things; we're not standing back and watching it happen around us. Because when it does happen, it will be another tick box on the tender sheet. If we can't tick it, we may not get the order. So, that's why we jumped into it when we knew about it.

It is important to get as many vendors' end users and software companies involved so that the industry can all talk the same language and make it easier, according to Smith. "There is no such thing as a production line that is supplied by a single hardware vendor; that does not exist. Multiple people are doing multiple things. CFX brings them all together and makes it a very simple to understand that everybody can use not only as a hardware vendor, but as an end user. You can be a head of production for a multinational company, and you can see line status, in any factory anywhere in the world. But the same system could also send an SMS message to a technician in a factory and tell them your machines are about to run out of a commodity. Those are a really good way of putting everyone together."

"This demo is to prove to the industry that no matter how big or small an equipment provider is, they can easily adopt this particular standard," said Khoo Yak Hua, R&D manager at vision inspection company ViTrox Corporation Bhd. According to him, CFX is a very flexible and easy to use format and protocol, and the company only took a few days to create the whole demo.

"The importance of this demo is to show people that there is a standard developing, but people don't really know the benefits yet of having the standard," said Fenton. "The reaction to the demo has been mixed; nobody is getting too excited about it yet. But that is because I think people haven't given it enough thought at the moment. Industry 4.0 is just a buzzword for everybody. But for me, there is a big opportunity for machine integrators. Right now, if you want to talk to a storage system, you must develop your own interface protocols; whereas in the future with CFX, it will be very easy to integrate another manufacturer's equipment into a line because we won't have to develop a communications protocol. A common protocol would make a big difference."

Tom Foley

Today, all the information that is necessary for operating a production line, and then controlling and monitoring it, is available in all machines and equipment in the electronics assembly supply chain. But unfortunately, all these machines are talking in different languages. With CFX, the industry is getting to one common language.

"The big benefit of CFX would be that all the vendors, all the machines, will speak the same language, and we can easily build applications," said Thomas Marktscheffel, Director Product Management SW-Integration Platform, SMT Solutions, at ASM Assembly Systems. "So, software companies can easily build applications that will work with all the machines. They don't need to focus on just translating data. They can focus on features. That's the opportunity we have for CFX."

"The information is already there. As far as our equipment and machines are involved, that information is harnessed, and then we could give more guidance to our customers," noted Tom Foley, quality manager, SMT Solutions, at ASM Assembly Systems. "One analogy can be the tracking services of couriers. If a customer wants to know about their order, for instance 50 circuit boards for a job add, they can just go to a web portal and they can see where their order is in the factory, and if there are any issues, problems, or delays. And they can find that out through their phones. But that's just a small example of it. It is a brand-new standard that is developing, so, more to come!"

Impact of the CFX Demo

The demo has generated a huge amount of interest, and according to Smith, there have been a lot of vendors that have come up and talked to them about their interest to get involved.

"The CFX demonstration in APEX is not just unique for APEX; it is unique as a demonstration in any exhibition floor anywhere in the world, in any industry. It has not been done before; but we have done it in a very short period. It shows that the industry can pull together for a common aim," said Smith.

"We are showing people what can be done—and they are quite impressed," says Fenton. "But at the moment, it is us telling them what the future is, rather than the customers asking us what we can do. I think we will be pushing CFX as opposed to the end-user pulling it. As it develops, maybe by the end of the year, our potential customers will be asking us what we can do."

Challenges Remain

Of course, there are still many issues to iron out with the CFX standard. According to Smith, the specification is quite a big document. "The most important thing to move the CFX forward now is if all of the other vendors will step up and provide the information, and the help to create the package of information and the specification. We want to be sitting here 12 months from now and saying not only is CFX is working, but CFX is a ratified standard that the industry accepts and applauds. To do that in what would be under two and a half years from concept to standard finish is unheard of in IPC terms."

Technically, the transport is not that difficult as it is just making use of the AMQP. But Khoo said the format, the content itself, requires further discussion. “What is the content that we should standardize and what is the data that we should send from each of the process? These are the challenges that we are facing right now. We do hope that the committee can create more open concept so that more and more companies will join in, and to create that environment where the industry can easily benefit. It is also how we can convince more parties to adopt the standard.”


Khoo Yak Hua

“The challenge is always to define the content of the data and make sure everybody understands the same content,” said Marktscheffel. “For instance, if we are talking about temperatures, I say, it is 20°C, others may likely see it as Fahrenheit. 20°F is quite cold, while 20°C is a nice temperature. If the data content is not properly defined, there’s a big risk that we think we have a common language, but we understand different things.”

Fenton said the integration had been easier than they thought. “I think IPC and Aegis have done a great job with creating the standard. It is already almost complete. The latest standard that I was sent has something like 120 message headers; it is going to be easy, for people to integrate. I think the challenge will be for other manufacturers to just put the effort into it.”

What’s Next

Building a smart factory requires the cooperation of many companies. And everyone must speak the same language to have the same understanding. Setting aside personal requirements for the betterment of the whole industry will result to more manufacturers adopting the standard.


Thomas Marktscheffel

“I think there is more work to be done by IPC and Aegis and other members of the CFX team to promote the benefits rather than the technology. The end-user really doesn’t care how it works, they care what it is going to do for his business. I think, as manufacturers like us start advertising the fact that we can do it, it is then down to us to push the benefits of why we did it,” said Fenton. “Being able to know that you can talk to other people’s equipment will be great for innovators of, maybe, different robots, different storage systems, and dashboards for productivity, for instance, will be much easier to write. Now, if you want to write a dashboard to show efficiencies, you must contact the vendor directly, ask for their data formats, and then write a front-end system. Whereas with CFX, once that becomes standard, the people that write that type of software will know exactly what the inputs will look like. And therefore, developing these productivity dashboards and MES will be much easier. I really hope it takes off, because it is going to be important in the future. But the important thing is we must explain the benefit to the customer. So that, I think, is for us the next step.”

“I am impressed with just how IPC was able to pull this together so quickly and made this exhibition and the CFX aspect to really work. It shows that the industry can pull together when it wants to pull together,” said Smith.

Khoo said, “We do hope that the committees will be able to create a great standard that everybody would adopt. I think this year is the starting pace where we will create more awareness for those parties to join in and to provide ideas and concepts.”

It is indeed important for every stakeholder in the industry to work together toward this goal of a connected factory. In this Industry 4.0 vision, we are entering an era where new technologies transform the look of systems and processes of the modern factory. This CFX demonstration was just that. Imagine the near future, where these vendors are integrated together towards one common manufacturing goal—a true industry evolution. **SMT007**

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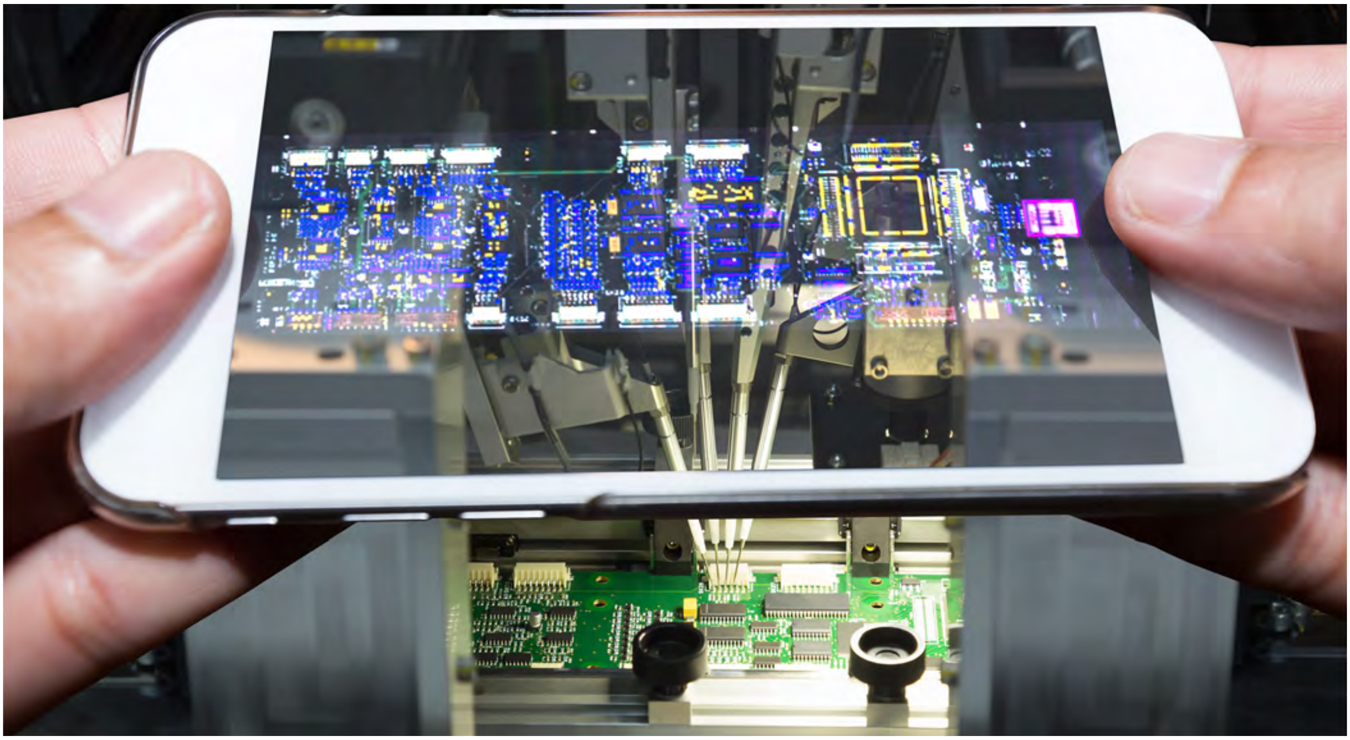

How the Factory Ecosystem Positively Drives Exponential Value

Article by Freddie Chan
KIC

We have all learned that synergy means 2 + 2 = 5. This is an old cliché but in today's factories the output must far exceed the accumulative performance of each machine to stay competitive. No machine or process is an island—they must form ecosystems. The trend towards extreme automation and the smart factory leads to ever more connectivity and interdependence.

Let's look at a few examples of the thermal process, which is close to my heart. This is arguably the least understood and the lowest priority in most factories. Most factories will use a manual profiler to spot-check their thermal processes once monthly, weekly or daily. The thinking is that the thermal process appears to be fine and does not need much attention. As electronics become ever smaller and more complex, the thermal process window keeps shrinking with a narrow margin of error. The reflow profiler's prediction software can identify the optimal oven set points for each assembly and reduce NPI time. More advanced optimization will enable near-instant oven changeover time as well as reduced electricity use. This combination of spot check and optimization impacts the entire line as well as the utility bill.

Most engineers estimate that reflow contributes less than five percent of all SMT defects. Yet, when a production line is shut down due to a defect issue, much (expensive) downtime is wasted trying to determine whether the reflow process was the culprit. This is because reflow is a black box process, and therefore, an unknown, as only spot checks have been applied to determine its status. When a yield problem occurs, the manual profiler is sitting on a shelf somewhere. Adding a continuous monitoring system provides insight into the thermal process always, instantly verifying whether the reflow process was the defect culprit. If the profile was out of spec, the system

also will provide insight into what changed, enabling maintenance personnel to fix the problem faster. Not only will adding automatic profiling improve the reflow process, but the entire production line uptime will increase due to faster troubleshooting and elimination of manual tasks.

The average manufacturing engineer spends 40% of his/her time looking for equipment, personnel, information, etc. Again, profiling is a contributor. There are multiple profile tasks for multiple jobs over multiple ovens. The new industry trend of producing products in larger varieties builds further complexities. Centralizing all reflow (wave, select) data in a single database allows the engineer to manage and retrieve the exact data required with a few mouse clicks on any authorized PC or mobile device. Relevant data for each PCB produced becomes available in seconds.

Smart factories make good use of machine and process data to run their operations more effectively. Adding analytics to thermal process data enables a higher level of automation and productivity. For example, an intelligent database that learns the relationship between each assembly, process window and oven properties can eliminate or reduce the need for manual profiling. Entering a new PCB assembly length, width and weight into the software will produce a recommended optimal setup. Data analytics promises predictive process control and preventive maintenance to further enhance productivity and advancement towards the zero-defect goal. The data will not only be used to sub-optimize the thermal processes, but it can be shared with other machines and MES systems via the factory network to optimize multiple lines as well as the whole factory.

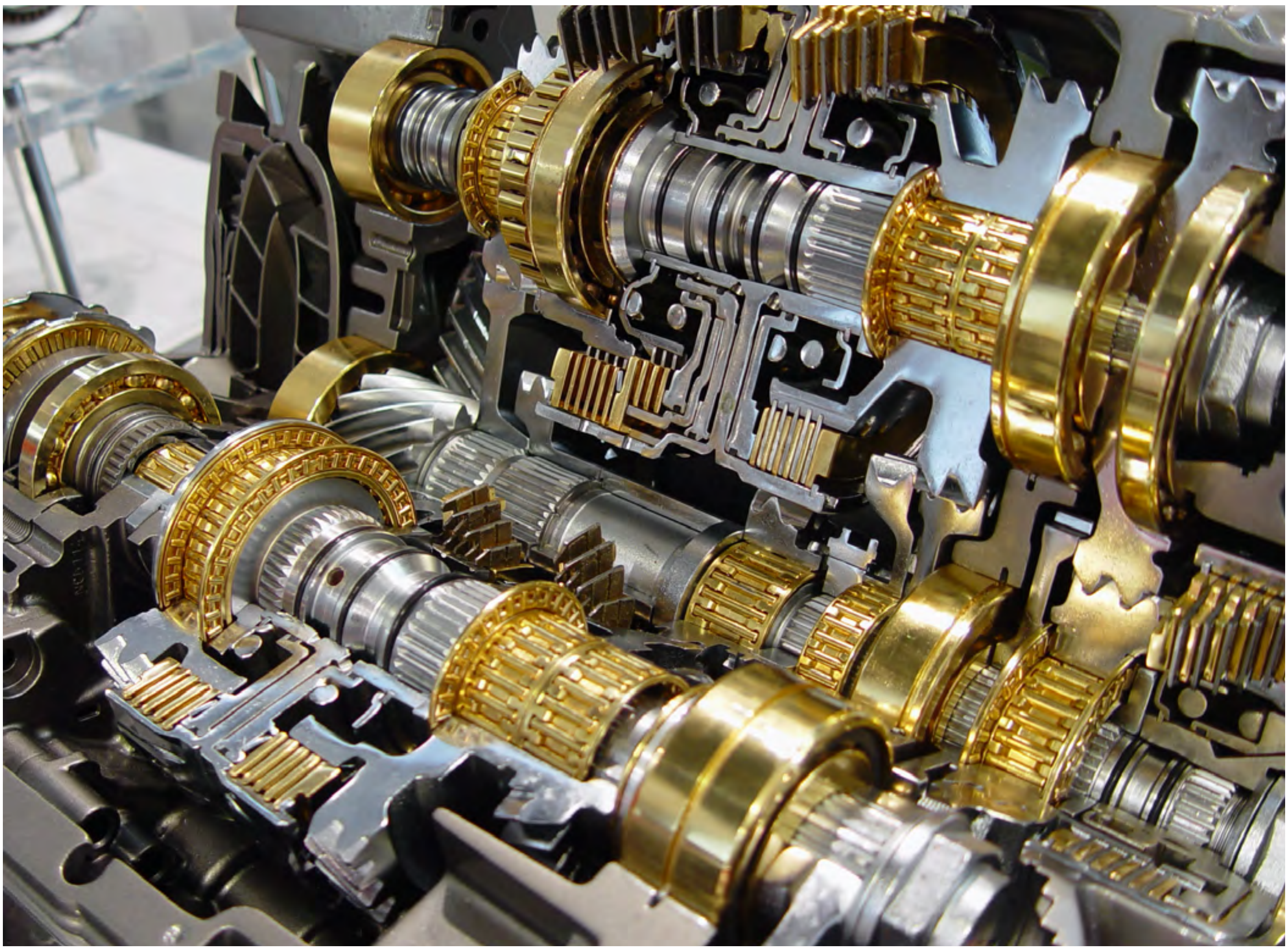

Figure 1: Several moving parts form an ecosystem.


SCIENCE
knows why it works.
CARE
knows why it's
important that it does.
KEVIN
KYZEN
At KYZEN we go way beyond just getting the cleaning science right. Because if we don't thoroughly know and understand you first, how can we create the most effective cleaning technologies for your specific needs and situation? When science and care converge, it makes all the difference.
WORLDWIDE ENVIRONMENTALLY RESPONSIBLE CLEANING TECHNOLOGIES

Each manual profiler, optimization software program, automatic profiler, central database model and data analytics offer significant individual value. But when they are combined, the value grows exponentially. A truly competitive operation can be built only when data is shared with other machines or the MES system. Productivity increases, cost decreases and consistent quality results. But interdependence and added value do not stop there. While engineers and technical managers are responsible for running a world-class factory, the salesforce and corporate executives are focused on promoting a competitive factory attractive to new (and current) clients. They are thinking about their factory's "uniqueness" and competitive advantages that can give them an edge in winning that next multimillion euro order. On top of a cost-effective operation, promoting capabilities that clients value such as process control, process transparency and process traceability down to individual PCBs, can mean the difference between winning or losing an order.

Electronic manufacturing is a capital-intensive business. A key part of engineering, management and purchasing's responsibilities is to acquire the right machines and software for their factories. There is significant money at stake, and there is pressure on factory performance in an intensely competitive low-margin industry. Reviewing each individual machine or software in isolation may lead to sub-optimization in an interdependent and interconnected environment. An ecosystem is more than the sum of each product's capabilities and benefits. Together they create exponential value that far surpasses the individual machine or process, it affects the entire factory and even deep into the non-technical aspects of a running a successful business. **SMT007**

Freddie Chan is the vice president of KIC.

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June 7 — Frankfurt, Germany
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IPC E-Textiles 2018

October 13–19 — Rosemont, IL, USA
IPC Fall Standards Development Committee Meetings
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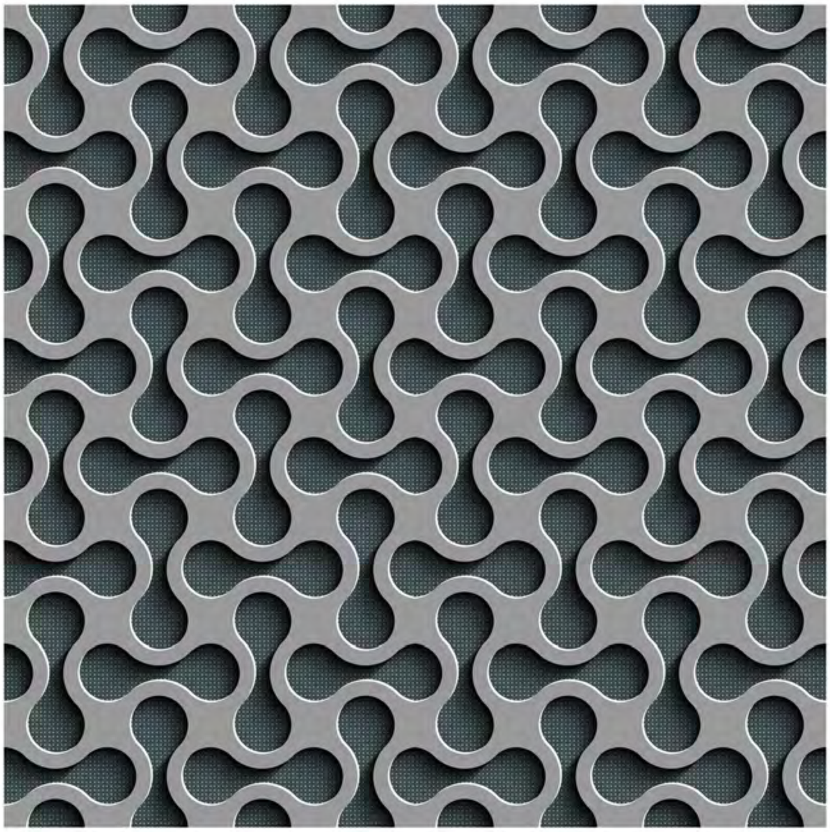

3D Printing and Additive Manufacturing in PCBA

Article by Zohair Mehkri, David Geiger, Anwar Mohammed, and Murad Kurwa
FLEX

Contrary to popular belief, 3D printing and additive manufacturing are not the same thing; however, they can be used interchangeably for the sake of ease. According to ASTM F2792-12a "Standard Terminologies for Additive Manufacturing Technologies," 3D printing is "the fabrication of objects through the deposition of a material using a print head, nozzle, or other printer technology."

The process starts with a 3D model drawing that is done on any standard CAD software. This 3D model file is then converted into a stereolithography file format by either the native program or a third-party file converter. Some printers have this file conversion capability as part of their software suite for their printers. The file is then converted into GCode or a language that the printer can understand, essentially creating the file into cross sectional slices of the part. This step is commonly known as "slicing."

Once the slicing of the drawing has been done the printer is ready to start the print. For nearly all 3D printers, the above process is the same, with the printing process itself being the main differentiator. In a fused filament fabrication printer, once the 3D drawing is sliced, the printer can begin printing. The main components of the printer are, the print bed, the extruder, the hot-end, and the material. Material for this technology usually comes in a wire form on a spool. This wire filament is fed into the extruder, the extruder uses torque and pinch to control the speed of the filament being fed into the hot-end. Once the filament is in the hot-end, it is melted using heat.

The melted material is forced out of the hot-end by the extruder that is pushing in more material from the top. The hot-end, usually made of aluminum, deposits the melted material onto the build plate in a designated pattern as dictated by the software. As the material is being deposited by the hot-end, the build plate is moving in a X-, Y- or Z-axis depending on the part requirements of what is being printed. In some printers the build plate will stay station-

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Fundamentals of RF/Microwave PCBs

ary and the hot-end will move in a Cartesian plane to create the print. This process describes fused filament fabrication (FFF), which is one of the technologies that the company currently employs.

Fused filament fabrication currently is used mainly for plastic materials. If metal printing is required, direct metal laser sintering is utilized to print metal parts. The process of creating a 3D model to be understood by Direct Metal Laser Sintering printers is as described above; however, the process of printing is vastly different. Metal printers are usually larger in footprint due to the high-quality components and the auxiliary processes required to ensure effective operation of the machine as well as quality of the print. The main components of a metal are the build plate, re-coater, laser and powder.

Before a metal part is printed, the build chamber will fill up with an inert gas, usually argon. This is to ensure that no oxidation occurs during the process. The build plate where the powder is residing, and the re-coater blade will be leveled. This can be done manually, but most printers can be automatically calibrated to level before a print starts. After the components are leveled, the print can start. A laser will sinter the powder in the cross-sectional geometry of the part. Once the sintering for that level has finished, a re-coater blade that was located off to the side of the build area will move over the sintered layer and coat a new layer of powder on top.

The layer of powder that is re-coated onto the sintered layer is very important to the integrity and quality of the print. If too much powder is re-coated, the layer below and the layer above may not be sintered together well by the laser. If there is too little powder, the laser might sinter already sintered powder, causing varying layer heights in the print. The even distribution of powder and the correct amount of powder is a key area that currently affects how the powder is re-coated on top of itself. Layer by layer powder will be re-coated and sintered by the laser until the part is complete.

Material jetting processes are very similar to the above. Resin is loaded into a printer, where it travels into a printhead, the printhead has several nozzles or resin dispensers (much like a two-dimensional inkjet printer). The resin is then extruded from the miniaturized nozzles onto a build platform in the two-dimensional cross section of the part. After, the layer is passed over with a UV light source or other light activation that cures the resin that was deposited. The printhead then deposits another layer on the previously cured layer, this is done repeatedly until the part is completed.

Materials Evaluated

There are several materials that are available for 3D printing for various engineering uses. Various vendors offer over hundreds of different materials that are either specific to an application or to a specific desired characteristic. For this study, eight materials that are regularly used for engineering applications were evaluated and characterized to determine which can be used in PCB processes. Material identifying characteristic as well as the designation is shown in Table 1.

TESTS PERFORMED

To properly characterize the materials that could be used for engineering applications, various tests were chosen and performed so that a decision tree could be created. The ultimate goal of the project is to be able to have a

ID	Identifying Characteristic
A	Black
B	Clear
C	Transparent
D	High Strength
E	Blue
F	Super High Strength
G	High Temp
H	Plastic Like Material

Table 1: List of materials evaluated for this study.

Test 1 TMA						
Dimension Change						
ID	Tg (°C)	CTE(X-Axis)ppm/°C	CTE(y-Axis)ppm/°C	% TE on Z	CTE Z-axis below Tg (ppm/°C)	CTE Z-axis above Tg (ppm/°C)
A	75.14	147	157.8	3.43%	59.1	174.65
B	71.67	158.2	158.6	3.27%	55.93	162.6
C	77.32	142.2	151.2	3.42%	25.76	173.05
D	76.08	138.1	153.75	3.53%	141.6	180.1
E	71.48	143.2	140.9	3.64%	99.2	189.55
F	79.65	157.55	158.75	3.42%	151.65	176.7
G	78.34	161.7	173.45	3.54%	98	182.55
H	79.2	208.3	233.35	8.31%	97.94	437.1

Figure 1: Thermal mechanical analysis results.

decision tree that can determine which material can be used for a specific application. The description as well as motivation to perform each test is below.

Thermal Mechanical Analysis

This test is performed to check the dimensional stability of a test specimen as well as calculate its Tg. The results of this test are important because they will indicate how the 3D printed specimen maintains its dimensional stability. For materials to be used in PCBA processes, all auxiliary components must retain their mass as well as dimensional accuracy.

Thermal Gravimetric Analysis

Thermal gravimetric analysis is performed to determine the temperature when the material, in this case, the test specimen, has lost 5% of its weight. For this study, the temperature used was 300°C. The results taken from this test help indicate the lifespan of a material, the faster it loses its weight, its lifespan decreases.

ID	Average of Temperature at 5% weight loss (°C)	Average of Weight loss at high temperature (%)
A	276.44	8.36
B	285.73	7.57
C	289.16	6.99
D	282.51	7.03
E	276.25	7.81
F	304.63	4.42
G	299.96	5.07
H	296.57	5.19

Figure 2: Thermal gravimetric analysis results.

Thermal Life Cycle Test

For this test, the 3D printed test specimens were subjected to 200 cycles of a predetermined temperature profile. Each cycle was the same in duration of time. The results of this test show what happens to a 3D printed test specimen when subjected to high temperatures. Any indication of warpage, delamination, degradation or other visible and/or cosmetic damage is important to capture. The results from this test indicate which materials are suited for high temperature applications in the PCBA process.

Test 3 Thermal		
Specimen ID	Warpage	Weight change %
A	0.372	18.03%
B	0.354	8.63%
C	0.146	26.47%
D	0.74	9.46%
E	0.471	26.39%
F	0.095	4.19%
G	0.452	4.73%
H	0.269	14.05%

Figure 3: Thermal life-cycle test results.

Density Test

This test is a calculation based on the various parameters of a test specimen. The density was checked after thermal and chemical resistance testing. The results of this test are used to determine how well the test specimen can hold its mass after being subjected to either chemical or thermal stresses. The density check of test specimens helps determine which application it is suited for.

Specimen ID	Chemical Test Density		
	Density Before	Density After	% Change
A	0.00114	0.00113	1.26%
B	0.00116	0.00114	1.69%
C	0.00114	0.0011	2.97%
D	0.00114	0.0011	3.90%
E	0.00114	0.0011	3.82%
F	0.00115	0.00114	0.54%
G	0.00114	0.00113	0.70%
H	0.00115	0.00107	7.59%

Figure 4: Density test results.

Specimen ID	Thermal Test Density		
	Density Before	Density After	% Change
A	0.00116	0.00113	1.91%
B	0.00116	0.00112	3.63%
C	0.00114	0.00109	4.29%
D	0.00114	0.00112	1.55%
E	0.00115	0.0011	4.34%
F	0.00115	0.0011	3.84%
G	0.00114	0.0011	3.38%
H	0.00115	0.00086	25.46%

Figure 5: Chemical resistance test results.

Chemical Resistance Test

The chemical resistance test is performed by subjecting the material to various chemicals. The test specimens are submerged in a chemical solution for a given period and then are subjected to a drying cycle for a given period. This test is important in the material characterization process due to it being an indicator of how the materials will react in various chemical exposure applications.

ESD Check

Electrostatic discharge check is a very crucial test in the characterization process since this determines whether the 3D printed material can be used with or around live PCBs or any other components that carry a charge. The values obtained with the ESD check for each of the materials assist in the ranking of the materials for application use.

Flexural Test

Flexural testing is performed by taking a test specimen and checking the materials ability to resist deformation under a specified load. This is a significant destructive test since the results of this test indicate how well a material can perform under mechanical stress but how well it can retain its dimensional accuracy. If the material does not break but bends or deforms under a load, the value or threshold at which this occurs helps guide which application the 3D printed material is well suited for.

Thin Wall Flexural Testing

Thin wall flexural testing is performed by taking a thinner specimen and subjecting it to load to check the material's ability to resist deformation. This test is different from the standard flexural test in the sense that it helps identify how the 3D printed materials react

Test 6 ESD											
Initial(S/N,1-10)				After Thermal(S/N,1-5)				After Chemical(S/N,6-10)			
Top	Bottom	Side1	Side2	Top	Bottom	Side1	Side2	Top	Bottom	Side1	Side2
9.13E+10	2.00E+11	2.39E+11	2.34E+11	1.37E+11	2.45E+11	1.02E+11	1.20E+11	7.33E+10	4.96E+10	4.50E+10	3.43E+10
8.10E+10	1.07E+11	1.66E+11	1.04E+11	7.86E+10	9.78E+10	1.32E+11	1.40E+11	1.22E+11	1.08E+09	1.46E+11	8.70E+10
9.56E+09	1.06E+11	7.90E+10	8.12E+10	1.39E+11	1.34E+11	9.30E+10	1.06E+11	5.88E+10	1.34E+11	1.96E+11	1.51E+11
2.55E+10	5.54E+10	7.70E+10	8.54E+10	1.57E+11	1.37E+11	2.24E+11	2.13E+11	1.27E+11	4.78E+10	5.78E+10	3.85E+10
6.81E+09	3.34E+10	3.57E+10	3.08E+10	8.74E+10	4.32E+11	2.59E+11	2.41E+11	8.63E+10	1.16E+11	3.73E+10	1.57E+11
9.42E+10	1.18E+11	1.25E+11	1.20E+11	8.10E+10	9.36E+10	8.78E+10	8.30E+10	3.37E+10	8.03E+09	1.47E+10	2.19E+10
9.46E+10	1.10E+11	2.92E+11	2.92E+11	1.40E+11	1.68E+11	2.00E+11	1.62E+11	2.82E+10	1.95E+10	2.09E+10	5.63E+09
2.49E+10	1.24E+11	1.26E+11	1.82E+11	1.01E+11	9.63E+10	1.09E+11	1.66E+11	6.92E+09	5.40E+09	7.88E+10	1.70E+10

Figure 6: ESD check results.

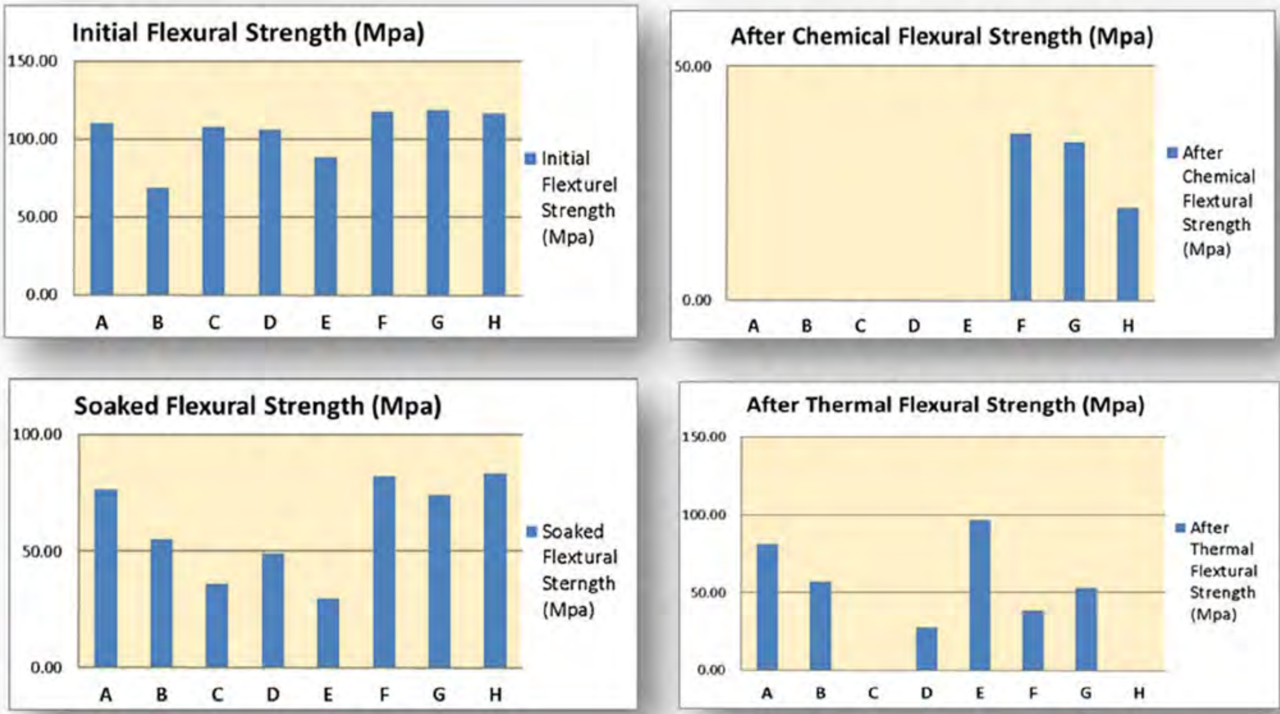

Figure 7: Flexural test results.

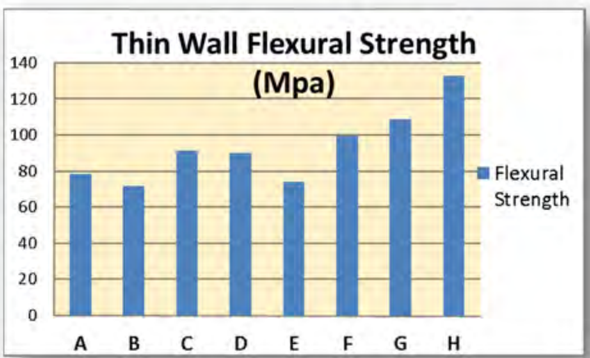

Figure 8: Thin wall flexural testing results.

with thinner walls and less material support. The mechanical stress that the test specimens are subjected to help determine how well the specimens retain their dimensional accuracy. The results from this test also help guide which applications each of the materials are suited for. As with flexural testing, any bending, breaking, deformation, delamination or other functional and/or cosmetic effect is recorded.

X-ray Analysis

The test specimens were placed in an X-ray machine before and after tests to determine if and how they are affected by various tests. The significance of this analysis is that the results can accurately reflect how the test specimen has reacted in various conditions. The results of this test are qualitative in nature and represented by pictures taken of the test specimens.

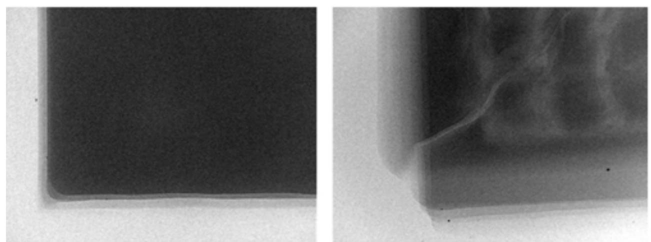

Figure 9: X-ray analysis results.

Qualitative Analysis – Optical Checking and SEM

Throughout the process of the material characterization, various optical recordings were performed such as pictures taken of the test specimens, X-ray analyses done, as well as scanning electron microscope pictures and measurements. The results of these tests and analyses are to provide a deeper understanding of what happens to the 3D printed materials under various conditions and helps guide the application decision process.

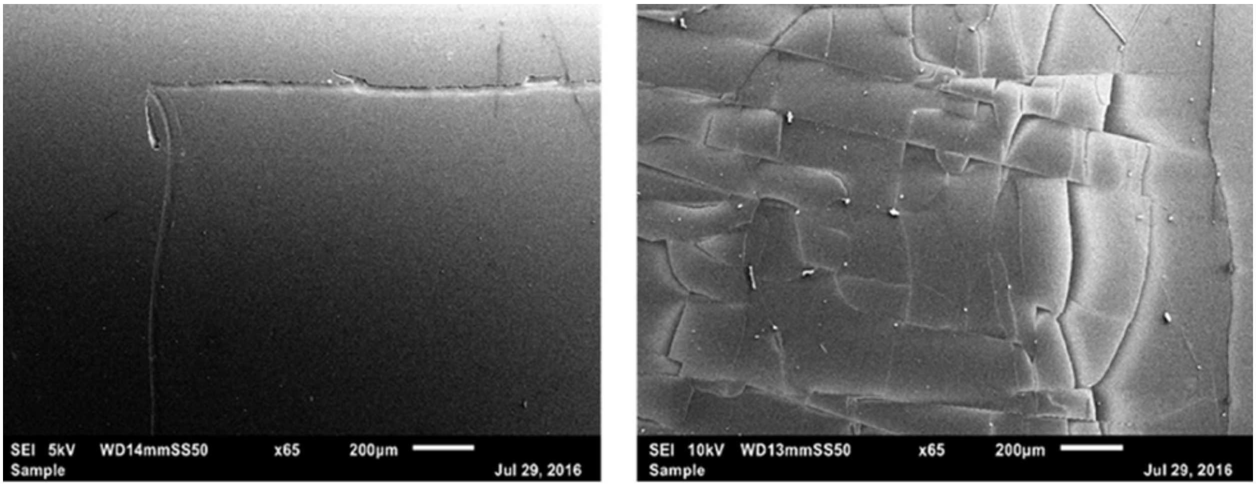

Figure 10: Qualitative analysis–optical checking and SEM results.

Specimen ID	Test 1 TMA	Test 2 TGA	Test 3 Thermal	Test 4 Density	Test 5 Chemical	Test 6 ESD	Test 7 Flexural	Test 8 Thin Wall	Qualitative Analysis
A	4	8	6	1	3	8	4	6	1
B	2	6	2	4	4	6	6	8	1
C	1	4	5	6	8	3	8	4	8
D	3	5	7	5	2	7	7	5	1
E	6	7	8	7	5	4	5	7	1
F	5	1	1	3	6	1	1	3	1
G	7	2	3	2	7	5	2	2	1
H	8	3	4	8	1	2	3	1	1

Figure 11: Summary of all test results.

Conclusions

From our testing we were able to see that the material that has the highest number of favorable rankings is material F. This material was able to perform well under thermal and flexural tests, therefore opening up applications that require these types of characteristics. The material that had the second highest number of favorable rankings was material G with material H following with third highest. **SMT007**

Acknowledgements

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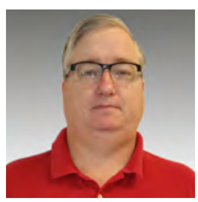

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2 A Not So Surprising Focus for Flex in the XR Realm ▶

Dan Feinberg recently met with Eric Braddom, VP of Extended Reality (XR) Product Management for Flex, to discuss the future of augmented, mixed and/or virtual reality, or as Flex calls it, "extended reality."

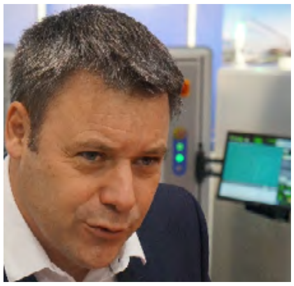
3 IPC Releases IPC/PERM-2901, Pb-free Design and Assembly Implementation Guide ▶

IPC/PERM-2901, Pb-free Design and Implementation Guide, provides an in-depth review of printed board defects, manufacturing and soldering processes, supply chain control, selection, use and assembly with commercial off-the-shelf products and obsolescence management.

4 9 Essentials of an Electronics Contract Manufacturer ▶

Here are nine essentials to look for when hiring an electronics manufacturing service.

5 Mycronic Announces the Acquisition of Vi TECHNOLOGY ▶

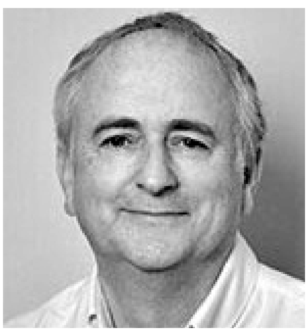


Mycronic recently announced the acquisition of Vi TECHNOLOGY, with the intent of combining VIT's inspection technology with Mycronic's jetting capabilities.

6 IPC Issues Paper on Priorities for Ambitious EU Industrial Policy Strategy ▶

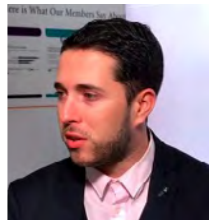
IPC – Association Connecting Electronics Industries has issued a position paper, "IPC Priorities for an Ambitious EU Industrial Policy Strategy" in support of EU Industry Day.

7 The Vital Role of Solder Paste Printing in New Product Introduction ▶



In this first in a series of articles exploring SMT assembly, we highlight the specific attributes, and the vital importance, of the solder paste printing process for your NPI.

8 RTW IPC APEX EXPO: Asteelflash Expansion Plans and Industry Challenges ▶



Mathieu Kury, business development manager at EMS firm Asteelflash, discusses the company's expansion plans and activities amid the growing demand in the automotive electronics space.

9 RTW IPC APEX EXPO: IPC Highlights Latest Developments in EDGE ▶

David Hernandez, senior director of learning and professional development at IPC, speaks about talent recruitment and retention, skills gap challenges facing the industry, and how IPC is addressing these issue through its IPC EDGE platform.

10 Setting Clear Boundaries with Your EMS Provider ▶

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- Reports directly to Americas Manager

QUALIFICATIONS:

- A minimum of seven years related experience or training in the manufacturing sector or the equivalent combination of formal education and experience
- Excellent oral and written communication skills
- Working knowledge of Microsoft Office Suite
- Mechanically inclined a plus
- Valid driver's license
- Travel within the region up to 75% of the time with occasional travel outside the region

apply now

Career Opportunities

Mentor®
A Siemens Business

PCB Manufacturing, Marketing Engineer

Use your knowledge of PCB assembly and process engineering to promote Mentor's Valor digital manufacturing solutions via industry articles, industry events, blogs, and relevant social networking sites. The Valor division is seeking a seasoned professional who has operated within the PCB manufacturing industry to be a leading voice in advocating our solutions through a variety of marketing platforms including digital, media, tradeshow, conferences, and forums.

The successful candidate is expected to have solid experience within the PCB assembly industry and the ability to represent the Valor solutions with authority and credibility. A solid background in PCB Process Engineering or Quality management to leverage in day-to-day activities is preferred. The candidate should be a good "storyteller" who can develop relatable content in an interesting and compelling manner, and who is comfortable in presenting in public as well as engaging in on-line forums; should have solid experience with professional social platforms such as LinkedIn.

Success will be measured quantitatively in terms of number of interactions, increase in digital engagements, measurement of sentiment, article placements, presentations delivered. Qualitatively, success will be measured by feedback from colleagues and relevant industry players.

This is an excellent opportunity for an industry professional who has a passion for marketing and public presentation.

Location flexible: Israel, UK or US

apply now

American Standard Circuits
Creative Innovations In Flex, Digital & Microwave Circuits

Front-End CAM Operators

Chicago-based PCB fabricator, American Standard Circuits, is currently seeking front-end CAM operators to join their team. Desired applicant will have three years of CAM experience.

The candidate should also possess:

- Expertise in Valor/Genesis CAD/CAM software and PCB process
- Ability to process DRC/DFMs
- Excellent customer/people skills
- Ability to be a self-starter
- Ability to read prints and specifications

American Standard Circuits is one of the most diverse independent printed circuit board fabricators in the country today, building PCBs of all technologies, including epoxy MLBs, flex and rigid-flex, RF and metal backed.

To learn more about this position, please send your information to American Standard Circuits.

apply now

Career Opportunities

MacDermid Enthone
ELECTRONICS SOLUTIONS

Technical Service Rep, North East

Do you have what it takes? MacDermid Enthone Electronics Solutions is a leading supplier of specialty chemicals, providing application-specific solutions and unsurpassed technical support.

The position of the Technical Service Rep will be responsible for day-to-day support for fabricators using MacDermid Enthone's chemical products. The position requires a proactive self-starter who can work closely and independently with customers, sales group members and management to ensure that customer expectations and company interests are served.

- Thoroughly understand the overall PCB business, and specifics in wet processing areas
- Prepare action plans for identification of root cause of customer process issues
- Provide feedback to management regarding performance
- Create and conduct customer technical presentations
- Develop technical strategy for customers
- Possess the ability to calm difficult situations with customers, initiate a step by step plan, and involve other technical help quickly to find resolution

Hiring Profile
- Bachelor's Degree or 5-7 years' job-related experience
- Strong understanding of chemistry and chemical interaction within PCB manufacturing
- Excellent written and oral communication skills
- Strong track record of navigating technically through complex organizations
- Extensive experience in all aspects of customer relationship management
- Willingness to travel

apply now

saki
The Future in Focus

Field Application Engineer

Saki America Inc., headquartered in Fremont, CA, a leader in automated inspection equipment, seeks two full-time Field Application Engineers (FAE), one in the Fremont headquarters and the other for the Eastern and Southern United States.

The FAE will support the VP of Sales and Service for North America in equipment installation, training, maintenance, and other services at field locations. The FAE will provide technical/customer support and maintain positive relationships with existing and future customers.

Strong analytic abilities and problem-solving skills are a must in order to understand customer applications and troubleshoot issues. The FAE will perform demos and presentations for customers and agents as well as assisting in trade show activities. Candidate must have a minimum of a two-year technical degree, experience in AOI, SPI, and X-ray inspection, and strong verbal and written communication skills. The position requires the ability to travel about three weeks per month. Must be a US citizen and be able to lift up to 40 lbs.

apply now

Career Opportunities

ventec
INTERNATIONAL GROUP
騰輝電子

Ventec Seeking U.S. Product Manager for tec-speed

Want to work for a globally successful and growing company and help drive that success? As a U.S.-based member of the product and sales team, your focus will be on Ventec's signal integrity materials, tec-speed, one of the most comprehensive range of products in high-speed/low-loss PCB material technology for high reliability and high-speed computing and storage applications. Combining your strong technical PCB manufacturing and design knowledge with commercial acumen, you will offer North American customers (OEMs, buyers, designers, reliability engineers and the people that liaise directly with the PCB manufacturers) advice and solutions for optimum performance, quality and cost.

Skills and abilities required:

- Technical background in PCB manufacturing/ design
- Solid understanding of signal integrity solutions
- Direct sales knowledge and skills
- Excellent oral and written communication skills in English
- Experience in making compelling presentations to small and large audiences
- Proven relationship building skills with partners and virtual teams

This is a fantastic opportunity to become part of a leading brand and team, with excellent benefits.

Please forward your resume to
jpattie@ventec-usa.com and mention
"U.S. Sales Manager—tec-speed"
in the subject line.

apply now

CHEMCUT
BOUNDLESS INNOVATION | UNBEATABLE PRECISION

Field Service Technician

Chemcut, a leading manufacturer of wet-processing equipment for the manufacture of printed circuit boards for more than 60 years, is seeking a high-quality field service technician. This position will require extensive travel, including overseas.

Job responsibilities include:

- Installing and testing Chemcut equipment at the customer's location
- Training customers for proper operation and maintenance
- Providing technical support for problems by diagnosing and repairing mechanical and electrical malfunctions
- Filling out and submitting service call paperwork completely, accurately and in a timely fashion
- Preparing quotes to modify, rebuild, and/or repair Chemcut equipment

Requirements:

- Associates degree or trade school degree, or four years equivalent HVAC/industrial equipment technical experience
- Strong mechanical aptitude and electrical knowledge, along with the ability to troubleshoot PLC control
- Experience with single and three-phase power, low-voltage control circuits and knowledge of AC and DC drives are desirable extra skills

To apply for this position, please apply to Mike Burke, or call 814-272-2800.

apply now

Career Opportunities

BLACKFOX
Premier Training & Certification

IPC Master Instructor

This position is responsible for IPC and skill-based instruction and certification at the training center as well as training events as assigned by company's sales/operations VP. This position may be part-time, full-time, and/or an independent contractor, depending upon the demand and the individual's situation. Must have the ability to work with little or no supervision and make appropriate and professional decisions. Candidate must have the ability to collaborate with the client managers to continually enhance the training program. Position is responsible for validating the program value and its overall success. Candidate will be trained/certified and recognized by IPC as a Master Instructor. Position requires the input and management of the training records. Will require some travel to client's facilities and other training centers.

For more information, click below.

apply now

ventec
INTERNATIONAL GROUP
騰輝電子

Technical Sales Engineer

Positions available in the Chicago area and California

Do you want to advance your career by joining a globally successful and growing world class CCL manufacturer and help drive that success? As a California-based member of the technical sales team, your focus will be on Ventec's core market segments: mil/aero, automotive and medical, offering a full range of high-reliability materials including polyimide, IMS and thermal management products.

Skills and abilities required:

- Drive & Tenacity!
- 7 to 10 years of experience in the PCB industry in engineering and/or manufacturing
- Detail-oriented approach to tasks
- Ability to manage tasks and set goals independently and as part of a team
- Knowledge of MS office products

Full product training will be provided. This is a fantastic opportunity to become part of a successful brand and a leading team with excellent benefits.

Please forward your resume to:

jpattie@ventec-usa.com and mention "Technical Sales Engineer - California Based or Chicago area" in the subject line.

apply now

Career Opportunities

ARLON

Arlon EMD, located in Rancho Cucamonga, California is currently interviewing candidates for **manufacturing** and **management positions.** All interested candidates should contact Arlon's HR department at 909-987-9533 or fax resumes to 866-812-5847.

Arlon is a major manufacturer of specialty high performance laminate and prepreg materials for use in a wide variety of PCB (printed circuit board) applications. Arlon specializes in thermoset resin technology including polyimide, high Tg multifunctional epoxy, and low loss thermoset laminate and prepreg systems. These resin systems are available on a variety of substrates, including woven glass and non-woven aramid. Typical applications for these materials include advanced commercial and military electronics such as avionics, semiconductor testing, heat sink bonding, high density interconnect (HDI) and microvia PCBs (i.e., in mobile communication products).

Our facility employs state of the art production equipment engineered to provide cost-effective and flexible manufacturing capacity allowing us to respond quickly to customer requirements while meeting the most stringent quality and tolerance demands. Our manufacturing site is ISO 9001: 2008 registered, and through rigorous quality control practices and commitment to continual improvement, we are dedicated to meeting and exceeding our customer's requirements.

more details

IPS INTEGRATED PROCESS SYSTEMS INCORPORATED

PCB Equipment Sales

World-class manufacturer of wet process equipment for the PCB and plating industries, Integrated Process Systems Inc. (IPS) is seeking qualified candidates to fill a position in equipment sales. Potential candidates should have:

- Process engineering knowledge in PCB manufacturing
- Outside sales background
- Residency on the West Coast to manage West Coast sales
- Knowledge of wet process equipment
- Sales experience with capital equipment (preferred)

Compensation will include a base salary plus commission, dependent upon experience.

more details

Events Calendar

MicroTech 2018 ▶
April 9–10, 2018
Egham, UK

Smart Systems Integration ▶
April 11–12, 2018
Dresden, Germany

NEPCON China 2018 ▶
April 24–26, 2018
Shanghai, China

Electronics in Harsh Environments Conference ▶
April 24–26, 2018
Amsterdam, The Netherlands

2018 SE Asia Technical Conference on Electronics Assembly ▶
May 8–10, 2018
Kuala Lumpur, Malaysia

PCB EXPO Thailand ▶
May 10–12, 2018
Bangkok, Thailand

Medical Electronics Symposium 2018 ▶
May 16–18, 2018
Dallas, Texas, USA

SMT Hybrid Packaging & Micro Electronics 2018 ▶
June 5–7, 2018
Nuremburg, Germany

EIPC 50th Anniversary Summer Conference ▶
June 21–22, 2018
Dusseldorf, Germany

NEPCON South China 2018 ▶
August 28–30, 2018
Shenzhen, China

electronica India 2018 / productronica India 2018 ▶
September 26–28, 2018
Bangalore, India

electronica 2018 ▶
November 13–16, 2018
Munich, Germany

Additional Event Calendars

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Coming Soon to SMT007 Magazine:

MAY: **ALL ABOUT 5G**
A look into PCB design, fabrication and assembly challenges in the 5G world.

JUNE: **FLEX CIRCUIT ASSEMBLY**
Tackling the challenges in flex circuit assembly.