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magazine

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# Surfing the Waves of Standards & Regulations



**This Month's Feature Article:**  
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## Standards & Regulations

Navigating the industry's standards and regulations can be a lot like surfing a killer wave: One misstep and you could wipe out! As EIPC Technical Director Michael Weinhold discusses with I-Connect007's Pete Starkey, are standards and regulations a threat, or an advantage? Also on hand: Dan Gamota, who addresses standards for the monetization of PE, Dennis Fritz on the newly developing efforts of CAMEST, and IPC's Dave Torp.

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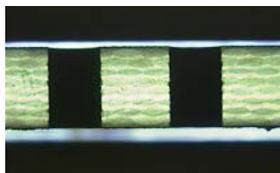


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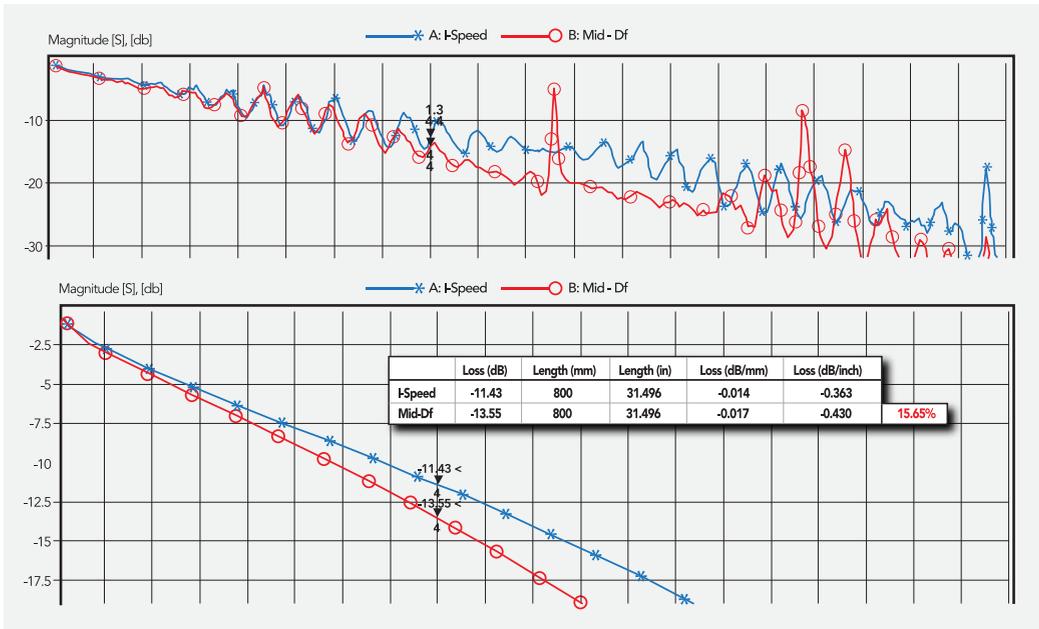


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Supplying the base for innovation

# ESTC, CAMEST and More

by Ray Rasmussen

I-CONNECT007

In May, IPC launched a new conference in Las Vegas. Electronic System Technologies Conference (ESTC) was the first of its kind for IPC, stepping out of its comfort zone of PCBs, design and assemblies. Here's how the association's website describes the event:

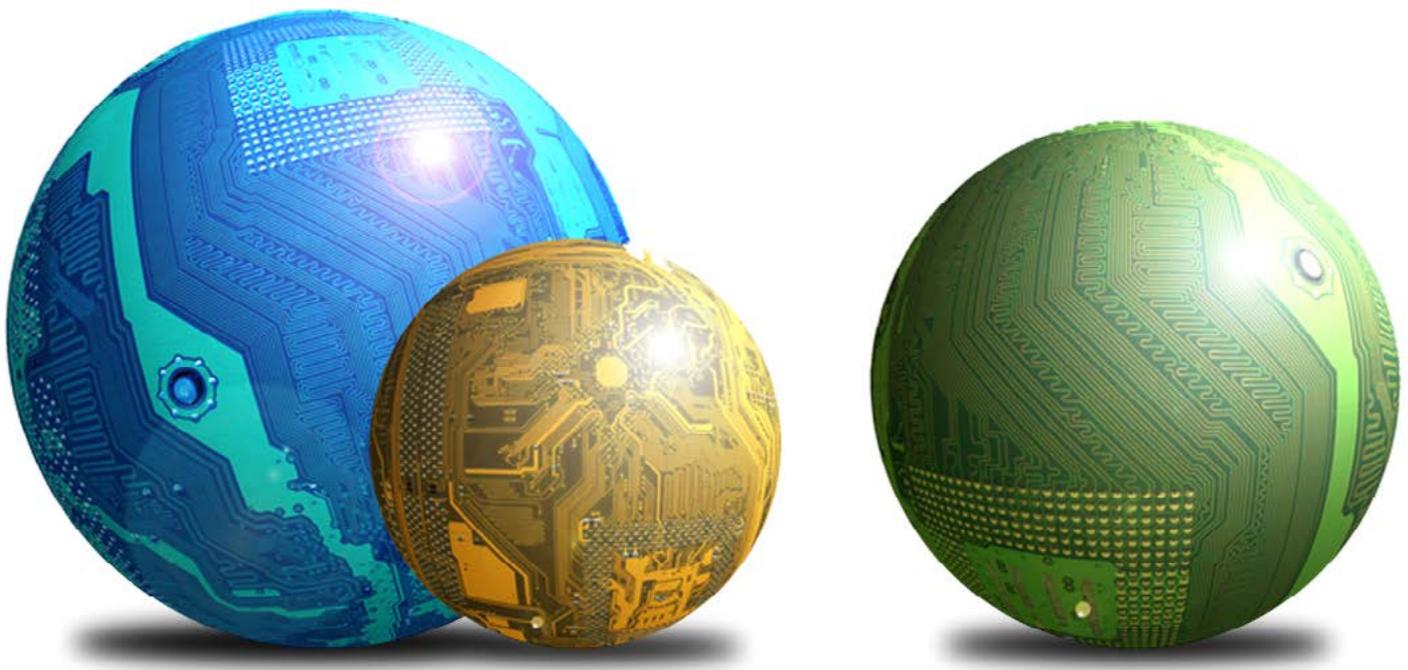
"IPC ESTC is an exciting new event for the entire electronics industry, from foundry and components to board assemblies and complete systems. It's an unprecedented opportunity to break new ground in the discussion of the technologies, products and services that will shape the future of the entire electronics industry."

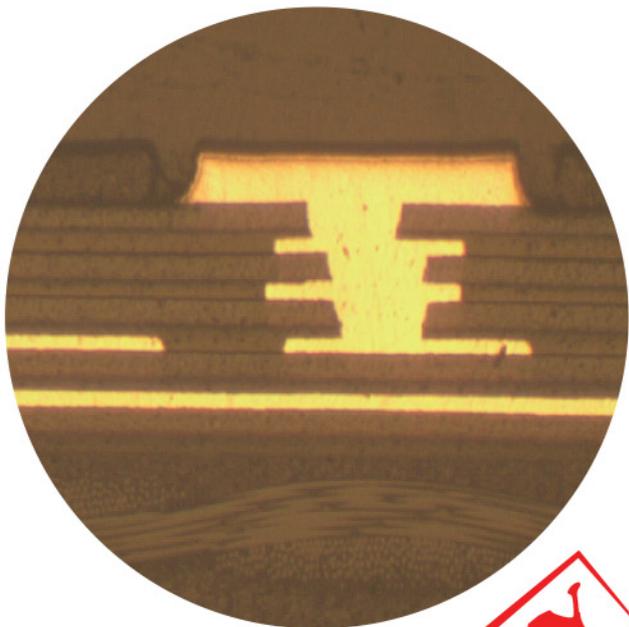
The conference seems to want to be all things to all people. It's a good "perspective" event which gives all in the supply chain a look at the issues facing technologists in other sectors.

Senol Pekin of Intel led the charge for ESTC. His energy and clout brought a lot of horsepower to the event. You need to see the [program committee page](#) to get a sense of the depth of

the conference that he and his team put together. It was quite impressive. Although it was a great first-time effort, there were a few problems with the conference/show, which seemed obvious. First, the location: A few people mentioned that a high-level conference like this would have done even better in Silicon Valley. Although the Tropicana Hotel was a good venue for the event, there's nothing like a Valley location to attract a good technical crowd. I agree.

Next, I'm not sure why an exhibition was part of the event. There were only a handful of exhibitors, many of which spent most of the day talking to each other, answering e-mails, or talking on the phone, since everyone else was in the conference sessions. I guess as the conference grows and expands, and with a few adjustments to the schedule, allowing more time for attendees to visit the floor, the exhibition will make more sense. In the future, I could see some tabletop displays where, during the breaks, people would be free to walk around





## CERTIFIED FABRICATOR SPOTLIGHT



### PWB REPORT: 5-n-5 Daisy Chain with 3mil Stacked Microvias Survives 1,000 IST Cycles

**A printed circuit board with 5 layers of Zeta® glass-free dielectrics, built up on a core by Streamline Circuits, was cross-sectioned for IST testing at PWB lab - "Coupons very robust and no material degradation in capacitance measurements. Results were excellent. ."**

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Streamline has been re-investing into their business by buying the latest state-of-the-art equipment to deliver the most cutting edge next generation HDI technology.

"Zeta is a great material that helps us get there," Doslak added.

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Figure 1: Senol Pekin, ESTC general chair, moderates during the Q&A portion of the event held in Las Vegas in May.

and learn about some of the latest technologies. But setting up and manning a 10' x 10' booth set expectations too high. I doubt that any of the 20 or so companies exhibiting were happy.

That said, it really was an outstanding conference.

Certainly, there were more PhDs than I've ever seen in one place, not that PhDs necessarily make good speakers or attendees, but the quality of the content and of those in attendance was excellent.

When I first heard of this conference and checked out the program topics, it seemed a bit too far off the PCB/assembly path. I figured that most of the offerings would be over our heads (or mine, at least). But after attending a few sessions, it started to make sense. In fact, this high-level conference should be attended by every CTO in the industry. If you want to know where things are headed, this was the place to be. This was an outstanding event.

### **CAMEST: a New Industry Council**

In conjunction with the conference, I attended a meeting led by Denny Fritz. He and a group of folks that included Dieter Bergman, Gene Weiner, Dan Feinberg, Krista Crotty, Marc Carter, Phil Marcoux and Matt Holzmann, continued work on a new organization, Coalition

for Advancement of Electronic Systems Technology (CAMEST). The effort is designed to build a technology bridge between industry groups like IPC, iNEMI, and SEMI, among others. Specifically, their charter is to identify and close the technology gaps that exist between these industries and serve as "the glue among associations and consortia." Here's what they say about their reason for doing this:

"The purpose of this council is to promote a strategic partnership among organizations interested in the total solution for interconnecting, assembling, packaging, mounting and integrating system design by increasing global awareness."

Here's their mission statement:

"CAMEST is dedicated to the identification and dissemination of the critical technology application knowledge needed for the further development of the electronics industry. This organization identifies gaps in design, manufacturing, test and reliability across all aspects of electronic component assembly and subsystem manufacturing from semiconductor to final assembly, and facilitates cooperation among industry, academia, government and existing consortia to deliver solutions."

It seems to have a noble purpose. I'm still not clear on the difference between CAMEST and iNEMI, but perhaps Denny Fritz's feature this month will help clarify that. Regardless, here's what iNEMI states as its mission:

"The International Electronics Manufacturing Initiative's mission is to forecast and accelerate improvements in the electronics manufacturing industry for a sustainable future."

In the iNEMI meetings I've attended and in the interviews I've conducted, I've always come away with the impression that what CAMEST is proposing is what iNEMI is doing. iNEMI identifies gaps in the technologies and puts task teams together made up of major OEMs, EMS providers and even some fabricators to come up with solutions. And with their very long list of [OEM and major supply chain partners](#), they have the clout to make things happen. I believe

CAMEST is more about gathering information about the gaps and then sharing it with iNEMI, HDPUG, IPC and others. Walking hand-in-hand, CAMEST and these groups will likely be a good partnership going forward. And although IPC is lending its support to the new industry council, they are being careful not to make CAMEST an IPC initiative, in order to keep the door open to other industry groups. Since IPC is leading the effort to get this off the ground, they should kick in the initial funding. There was lots of goodwill from the kick-off committee, but they need money to get the tools in place that will create the inertia needed to get this rolling.



Figure 2: OMG's Michael Carano at the ESTC event.

### A Bit About Counterfeiting

At ESTC, I was listening to a discussion about counterfeit components. During the Q&A, I asked if it wouldn't it make more sense to go after the counterfeiters instead of spending all this money on inspection, detection and prevention? We know where most of the counterfeits come from...China. And some companies (not governments) pursue the culprits, but the response by CALCE's expert on the subject, [Dr. Diganta Das](#), surprised me. He said that people need to make a living and local governments are reluctant to clamp down on the counterfeiters since they employ a lot of people. And in China, keeping people employed is critical.

I had always seen counterfeiting as sort of an organized crime-driven effort, relegated to obscure warehouses with blacked out windows. But it seems that it's often much more above board, located in traditional factory settings. I knew that Gucci bags, Rolex watches and Calaway Golf clubs were copied out in the open, but I had never placed microprocessors in that same category. Look for a comprehensive discussion of the topic in the September issue of

*SMT Magazine*. The article, "Development of a Methodology to Determine Risk of Counterfeit Use," written by a team from iNEMI and Corealis, will run in two parts.

The organizers of this year's ESTC promise a bigger and better event next year. Whether it's located in Vegas or Silicon Valley, if they're able to put together a stellar conference again, this thing will start to take on a life of its own. I encourage technical leaders to attend this event for two reasons: to get a good look at what's going on around us and to act as representatives from our sectors to make sure the other guys know what we're doing and where we're headed. **PCB**



Ray Rasmussen is the publisher and chief editor for I-Connect007 publications. He has worked in the industry since 1978 and is the former publisher and chief editor of *CircuitTree Magazine*. Contact Rasmussen [here](#).

# IPC Guiding Monetization of Printed Electronics



by **Daniel Gamota**

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## Abstract

Printed electronics is considered by many international technologists to be a platform for manufacturing innovation. The strong foundation established at IPC in 2010 and the complementary activities recently initiated at IEC and other organizations substantiate this claim. Its rich portfolio of advanced multi-functional, nano-designed materials, scalable ambient processes, and high-volume manufacturing technologies lends itself to offer an opportunity for sustained manufacturing innovation. Moreover, the intrinsic mechanical, electrical, and optical properties of the materials and design architectures that are used enable a plethora of novel and highly desirable final product features such as flexibility, stretchability, transparency, and bio-compatibility. These features are driving designers as they strive to offer customers product differentiation.

The success of introducing a new manufacturing technology platform is strongly dependent on the ability to achieve high final product yields at current or reduced cost. In the past, standards have been the critical vehicle to enable manufacturing success. In 2000, it was proclaimed that printed electronics would revolutionize many aspects of our daily lives. Some futurists even suggested that it was the platform technology for “smart everything,” “virtual everything,” and “interconnect everything.” Today the future is brighter for printed electronics as the participation by representatives from small and large companies, academia, and technical laboratories in standards activities has observed sustained growth; as an example, the number of participants in the different IPC Printed Electronics Standards Subcommittees averages 80 individuals. This involvement suggests that companies are engaging in “technology pull” in contrast to the pre-2010 period of “technology-push.”

During the past few years, the printed electronics field has seen an increase in the num-

ber of companies attempting to scale-up their manufacturing processes for new product introduction. A key operations-related activity during this exercise is the establishment of a robust supply chain. Many of the printed electronics companies have negotiated unique quality conformance documents (i.e., Certificates of Compliance) with each individual supply chain member. Also, these companies have made significant investments to develop internal standard operating procedures.

Historically, the adoption of standards has shown that it facilitates the growth of an emerging field and reduces the burden placed on individual companies to invest significant resources in the development of company specific compliance documentation. This paper provides an overview of the internationally recognized IPC Printed Electronics Standards initiative which has demonstrated its ability to provide leadership to the emerging field of PE by implementing a standards development structure that does not impede creativity for sustained printed electronics based products innovation. IPC is well positioned to become the internationally recognized repository for PE intellectual assets.

## Introduction

The development of standards can be critical to the successful launch of an advanced technology such as printed electronics (PE)<sup>[1]</sup>. If introduced at the appropriate time during technology development, significant resources can be conserved and redeployed into other new product introduction operations to ensure commercial success. However, standards also have the potential to squelch creativity by demanding rigorous structure and great oversight. Therefore, it is critical to ensure that standards are introduced at the optimal time. The time for PE standards appears to have arrived based on two general trends: 1) The number of companies interested in integrating PE technologies in high-volume products to reduce expenses related to prod-

uct manufacturing has increased substantially over the past three years (e.g., technology pull vs. technology push) and 2) Many well-funded ventures are attempting to scale-up manufacturing of PE-based products.

Moreover, organizations that have published PE roadmaps during the past five years, International Electronics Manufacturing Initiative (iNEMI)<sup>[2]</sup> and Organic Electronics Association (OE-A)<sup>[3]</sup>, have stressed the importance of the development of standards.

As early as 2008, IPC stakeholders began to identify PE as a potential game changer and suggested that the field should be closely monitored. This IPC activity, initiated by Vice President of Standards and Technology David Torp, led to several exploratory standards working group meetings held with key stakeholders in

attendance to filter the hype from reality. Ultimately, this activity, initiated

by Torp, became the foundation for the present IPC Printed Electronics Standards Portfolio development effort led by IPC Director of Technology Transfer Marc Carter: Printed Electronics Subcommittees—D-61, D-62, D-63, D-64, D-65, and D-66.

Due to the diversity of the fundamental PE technologies (designs, materials, processes, tooling, etc.) in development and nearing commercialization, which offer seemingly unbounded

opportunities for product extension as well as new product portfolios, at each subcommittee meeting three questions are posed to facilitate group discussion when reviewing standards development long term strategy:

- What value is PE providing you today? What can PE offer you near-term? In the long term?
- Can your existing products or manufacturing processes benefit from PE?
- Can your company extend product portfolios or expand into new businesses by developing products and manufacturing processes that leverage PE?

“  
**As early as 2008,  
IPC stakeholders  
began to identify PE  
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changer and suggested  
that the field should be  
closely monitored.**”

Operations Related Impact	Final Device/Component/Product Attributes
Raw materials—cost reduction	Thinner— lower profile
Utilities—lower electricity demand, less stringent manufacturing environment	Conformal/Flexible—unique designs
Personnel—fewer engineers and operators required	Lighter—reduced weight
Equipment—less costly processing and assembly platforms	Large Area—distributed functionality
Manufacturing—high product pulse rate	n/a
Waste—Greater material usage resulting in lower waste management expenses	Energy Efficient—energy harvesting

Table 1: IPC stakeholders and printed electronics.

The dialogue at the subcommittee meetings over the past three years has been energetic and the participants find the activity rewarding. The recorded topics of discussion have been analyzed, and the potential benefits from PE can be categorized into two groups: 1) operations related impact and 2) final device/component/product attributes. Table 1 is a compilation of the insight collected during IPC PE Standards subcommittee meetings and discussions with PE subject matter experts.

Further fueling this increase in interest in PE is that the term today encompasses a variety of materials (organic, inorganic, metallic, hybrid, etc.) and processes (ambient, vacuum, hybrid, printing, pick-and-place, etc.) that when combined, enable applications providing unique functionality—flexible, conformal, stretchable, distributed, low profile, large area. Due to the continued promoting of the great financial value promise of the field, the term itself has become an “umbrella” to capture commercial products, technologies in the final stages of qualification for commercial launch, laboratory proof of concepts, and theoretical models.

Subject matter experts of PE technology discuss the field in terms of three waves with each wave representing a different period of growth (Figure 1).

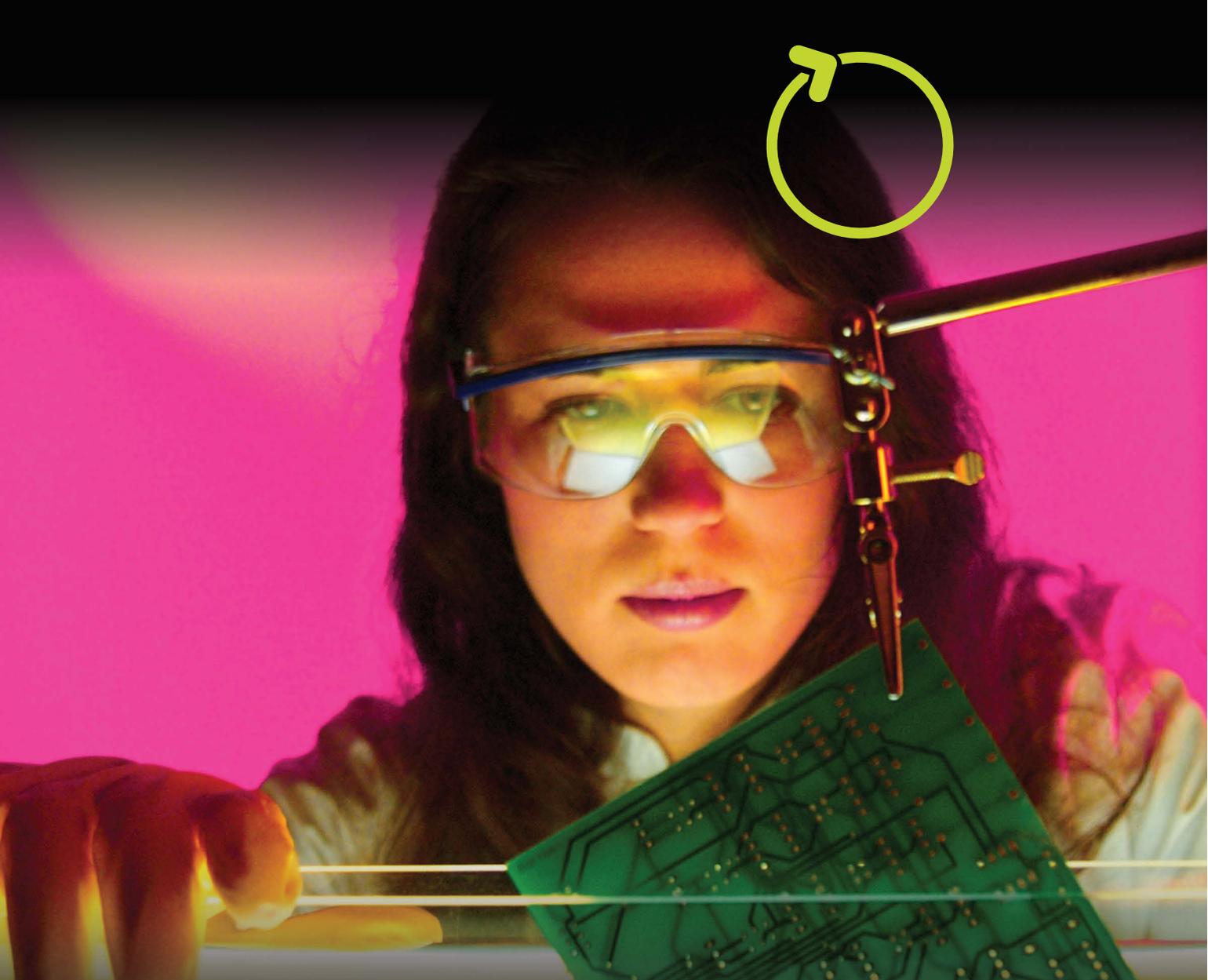
**1<sup>st</sup> PE Wave: RFID**

The first PE wave was driven by the opportunity to offer an RFID solution at a fraction

of the cost associated with silicon based RF-ICs—\$0.25 for a silicon-based RFIC versus \$0.01 for a PE-based RFIC. The low cost proposed by using non-vacuum, printing manufacturing processes to fabricate the RFIC and minimal or no final assembly cost were highlighted during this first PE wave. Unfortunately, several factors led to the “beaching” of the first PE wave. The most commonly cited is that the electrical performance of solution processed semiconductor materials were not adequate to yield circuitry that could operate at the necessary frequencies.

**2<sup>nd</sup> PE Wave: Flexible Displays**

The second PE wave was fueled by the vision of a low profile, light weight, and conformal display that could provide information real-time and anywhere, as long as one was connected to an access point. Consumer marketing studies were compelling and the price point for a PE-based display offering untethered, mobile data downloads was highly desired. Unlike RFICs that required circuit operating speeds of high MHz, the PE based displays did not demand such high performing transistors (e.g., kHz). Although, the second PE wave did not appear to have as great of technical challenges as the first PE wave, it ultimately was beached due to the accelerated cost reduction curve experienced by conventional amorphous silicon TFT active matrix driven displays (i.e., manufacturing economies of scale). During this PE wave, standards



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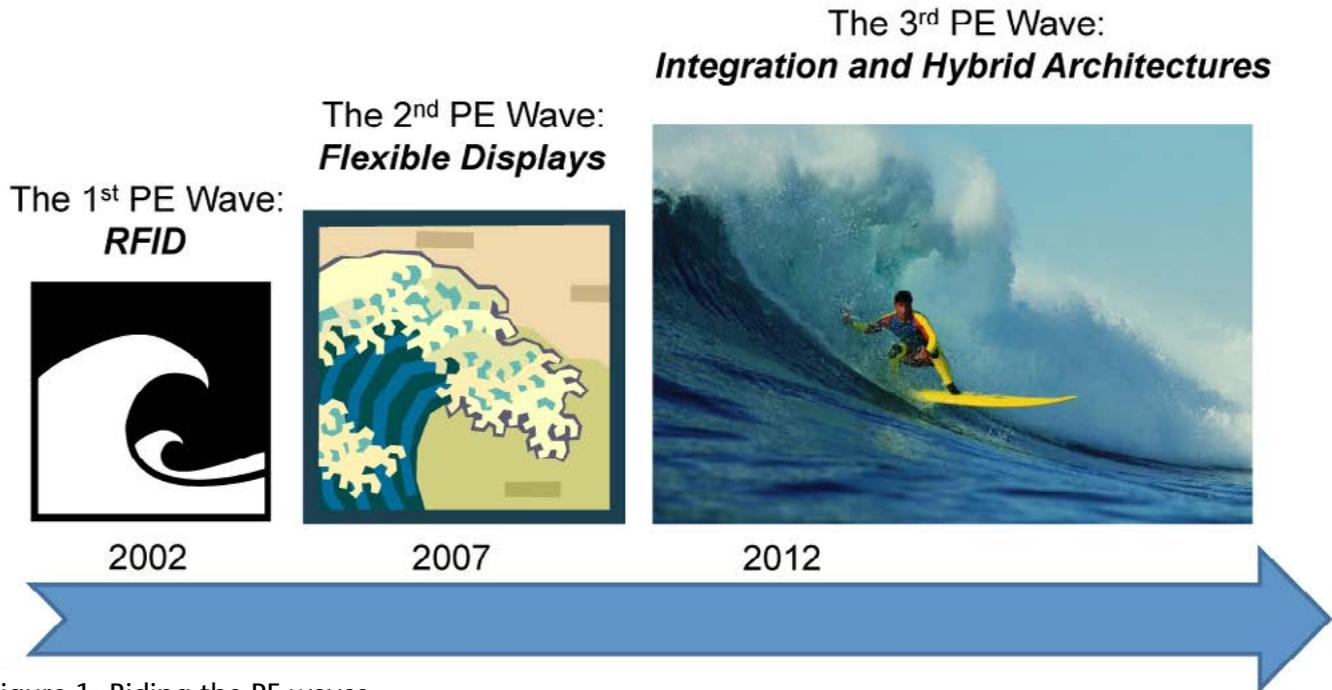


Figure 1: Riding the PE waves.

and elements of the PE infrastructure became topics of discussion by PE stakeholders.

### 3<sup>rd</sup> PE Wave: Integration and Hybrid Architectures

In 2011, the third PE wave began to form as stakeholders observed that the technology had matured to a level that substantially reduced the risk associated with its commercial launch. Although still in its infancy, it has already experienced a few early commercial successes. Several products using PE functional inks and base substrates have achieved commercial success. Also, designers contemplating the use of PE are better educated about its limitations and have a design philosophy that PE is not only a stand-alone technology to replace an incumbent, but can be integrated with mature technologies to form a hybrid architecture. This philosophy, designing products with PE components integrated with non-PE microelectronics components, has the potential to facilitate the long-term sustainability of PE as a platform technology. Therefore, PE technology diffusion will be fueled by both PE products that are based on all-printed designs and architectures and PE prod-

ucts that are based on a hybrid architecture.

Several factors today are driving international standards development. The greatest one is the stronger appreciation for PE technology: hype, reality, risks, opportunities, and investment. It appears that critical mass is being achieved during the third PE wave, which should ultimately drive technology diffusion supported by a strong portfolio of PE standards, best practices, and guidelines.

### Background

The most vocal PE industry participants have stressed the importance of standards since as early as 2004, when the first international activity was formed to develop standards for organic electronics. The activity was established within the Institute of Electrical and Electronics Engineers (IEEE) and had international participants from large companies (e.g., Motorola, Kodak), academia (e.g., University of Michigan), and well-funded venture backed start-ups (e.g., Plastic Logic). A key underlying theme for the formation of the standards working group was that PE represented a manufacturing innovation that would disrupt the traditional micro-

Expense Category	Activity
Introductory meeting (1 vice president, 1 director, 3 engineers)	Initial materials due diligence (background)
Process engineering (2 engineers, 1 operator)	Materials selection Process development Devices fabrication
Electrical engineering (1 engineer, 1 operator)	Test fixture design and set-up Test parameter selection
Follow-up meeting (1 director, 3 engineers)	Reporting of processing and electrical performance testing

Table 2: Materials assessment related activities.

electronics and semiconductor industries. The disruption was fundamentally grounded on the development of innovations that integrated novel solution-processable materials (dielectric, semi-conductive, and conductive) and scalable high-volume manufacturing processes (e.g., gravure, flexo, screen, and ink-jet printing) to offer unique electronic product designs.

The IEEE standards initiative resulted in the first (IEEE 1620) and second (IEEE 1620.1) organic electronics standards that enabled the community to progress down the path toward product commercialization. The topics for these standards were selected based on input from international subject matter experts that identified the topics as potential roadblocks for adoption of the emerging PE technology.

Since the IEEE 1620 standard was published, its value has been quantified and reported during various organic and printed electronics workshops. More than 20 subject matter experts formed the IEEE P1620 Standards Working Group to develop this standard for characterizing solution processable semiconducting materials (organic, inorganic, and hybrid). The driver for its creation and sustained value was the increase in the number of companies offering higher-performance semiconductors. A standardized test for characterizing solution processed thin film transistor devices was necessary to reduce the increase in expenses incurred by companies interested in designing products that integrated PE-based thin film transistors.

At the 2006 Printed Electronics Foundation Conference, a presentation discussed the value of the IEEE 1620 standard. A brief overview of an internal case study (Adherence to Standard Results in Realized Savings) was provided<sup>[4]</sup>. The presenter stated that prior to publishing the standard, the company incurred approximately \$29,000 in expenses to assess one solution-processable material. This expense was determined by the resources (human capital and materials) necessary to perform the activities listed in Table 2.

Since the first publishing of IEEE 1620, it has been updated based on the PE community having identified a critical characterization parameter that was not included. The parameter, when not considered, led to the publishing of inaccurate device performance data that subsequently caused circuit designers to produce unstable designs. The original standard was modified and later adopted after an in-depth review to ensure that the protocol outlined in the updated standard captured all recently published nuances for device performance.

**Printed Electronics Standards Development at IPC**

The interest in the PE industry by large original equipment manufacturers (OEMs) has grown as the fundamental PE materials and processing technologies have continued to mature. Representatives from OEMs have stated that PE can be leveraged in the near-term to reduce costs associated with existing products and can be used in the future to expand and

develop new product offerings.

Since 2010, IPC stakeholders have supported the commitment by IPC to become the repository for Printed Electronics Intellectual Assets: road-

maps, standards, guidelines, and best-practices. The commitment is built on the establishment of a portfolio of PE technology assets that provides the tools to facilitate the PE industry growth.

**Standards Development**

<b>Organization</b>	<b>Effort Description and Update</b>
ASTM International	Portfolio of standards for printed membrane switches published: materials, design, processing, and performance. (Standards groups continue to identify topics.)
International Electrotechnical Commission (IEC)	New Technical Committee for Printed Electronics established: IEC TC 119 (New Projects for standards development are being identified and ad-hoc working groups are being established and populated.)
IEEE	IEEE 1620-2008 <sup>[5]</sup> <i>Standard for Test Methods for the Characterization of Organic Transistors and Materials</i> (Published in 2004; modified in 2008)
	IEEE 1620.1-2006 <sup>[6]</sup> <i>Standard for Test Methods for the Characterization of Organic Transistor-Based Ring Oscillators</i> (Published in 2006, the IEEE mandated five-year review was completed in 2011.)
IPC	D-60 IPC Printed Electronics Standards Committee Subcommittee D-61 IPC/JPCA-2291 <sup>[7]</sup> <i>Design Guidelines for Printed Electronics</i> (Approved by ballot on May 16 2013. To be published in July 2013.)
	Subcommittee D-62 IPC/JPCA-4921 <sup>[8]</sup> <i>Requirements for Printed Electronics Based Materials</i> (Published in July 2012; updates for inclusion in Revision A are being captured.)
	Subcommittee D-63 IPC/JPCA-4591 <sup>[9]</sup> <i>Requirements for Printed Electronics Functional Materials</i> (Published in December 2012; updates for inclusion in Revision A are being captured.)
	D-64 Subcommittee IPC/JPCA-6901 <sup>[10]</sup> <i>Performance Requirements for Printed Electronics Assemblies</i> (In Draft.)
	D-65 Subcommittee <i>Test Method Development and Validation</i> (In formation.)
	D-66 Process Subcommittee (New)
JPCA <sup>[11]</sup>	Strategic alliance with IPC established to co-develop portfolio of printed electronics standards.

Table 3: Printed electronics standards efforts.

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Environmental scans are continually conducted to appreciate the PE standards landscape. Also, these scans are necessary to identify potential standards development organizations for collaboration (e.g., JPCA). Table 3 shows several standards development activities that are complemented by the IPC standards development effort. The leadership teams of the organizations listed in this table were contacted early and arrangements were made to establish pathways for collaboration and mitigate redundancy.

**Printed Electronics Stakeholders**

The PE field is a compilation of diverse technologies leveraged from several well established industries: graphic arts printing, microelectronics, semiconductors, and nanotechnology. Thus, it is critical to have representatives from each of these groups participating in the PE standards development effort to ensure that an accurate foundation on which to build is created.

IPC has actively been recruiting and reaching out to the leadership teams at organizations such as IEC<sup>[12]</sup>, SEMI<sup>[13]</sup>, IMAPS<sup>[14]</sup>, SGIA<sup>[15]</sup>, PIA<sup>[16]</sup>,

OE-A, NPES<sup>[17]</sup>, iNEMI, and IEEE<sup>[18]</sup> to provide an overview of IPC standards activity and to discuss opportunities for collaboration. IPC strategy is based on engaging subject matter experts and organizations that can provide insight into product markets, guidance for the standards' landscape, and visibility in trade associations. Invitations for participation are continually sent to potential members of the Printed Electronics Standards Development Community (Figure 2). The three major groups that form the community are: 1) standards development organizations; 2) trade associations; and 3) user groups. IPC continues to actively engage representatives from each group to establish a robust strategy that is aligned with sustained long term PE enabled product commercialization.

**Strategy**

A PE intellectual assets strategy has been in place at IPC since 2010. It is fundamentally based on due diligence performed to appreciate the industry needs and market readiness. The strategy is continually assessed and, if necessary, updated. The modifications to the



Figure 2: Printed electronics standards development community.

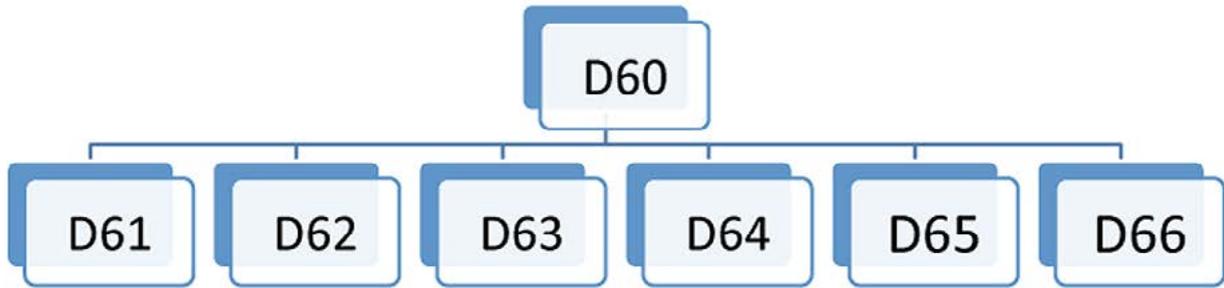


Figure 3: IPC printed electronics standards hierarchical structure.

strategy are based on the input from PE ecosystem members to ensure that the most relevant topics for standardization are addressed first, followed by topics that are necessary for technology diffusion into the market, followed by topics that will sustain adoption. This enables the most dynamic strategy; it was designed to enable the IPC Printed Electronics Standards Committee (D-60) to respond quickly based on industry trends and market dynamics. A hierarchical structure was established to enable the initial formation of four subcommittees (D-61, D-62, D-63, and D-64) to focus on PE community identified areas for standards development. This flexible structure has provided the means to seamlessly add two new subcommittees: D-65 and D-66 (Figure 3).

The subcommittees were formed to focus on specific critical topics that have been identified and refined over several months of discussion. These topics are fundamentally well aligned with the PE supply chain and have been identified as critical for PE technology adoption (Figure 4). The different elements and listed topics highlighted in the supply chain represent those that have been most often mentioned by representatives from the ecosystem. In the long term, several additional subcommittees will be formed to develop standards, supporting the various supply chain elements.

At the present time, subcommittees D-62 and D-63 are identifying content to include in their respective Revision A of the standards that they published in 2012. The document developed by Subcommittee D-61 was approved by ballot in May and is presently being prepared for public release in July 2013. The last of the original four subcommittees, D-64 is complet-

ing its draft with a goal to publish an approved document in early 2014. The newest members of the IPC PE standards family, D-65 and D-66, are in their infancy and will continue to identify topics for review by the subcommittee members in an effort to down-select the potential topic list in preparation to begin drafting.

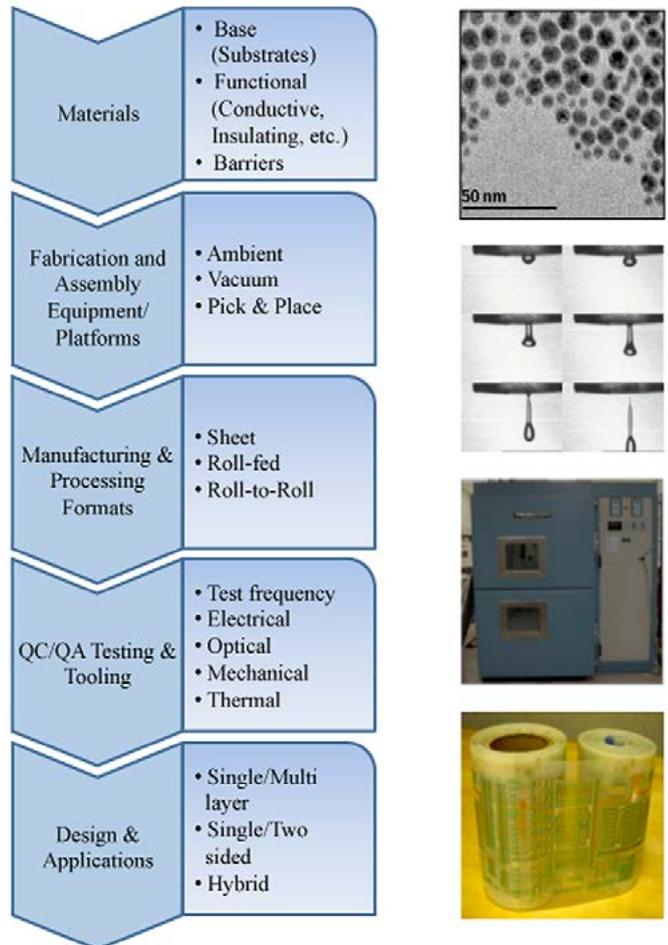


Figure 4: Printed electronics supply chain.

**Computer-Aided**

<b>Design Tools</b>	<b>Substrates</b>
• File format	• Mechanical properties
• Design rules	• Electrical properties
• Layout rules	• Optical properties
• Test & Simulation	• Thermal properties
<b>Data Transfer</b>	<b>Conductors</b>
• File format	• Electrical properties
• Conversion	• Optical properties
• Check	• Mechanical properties
	• Thermal properties

Table 4: D-61 identified topics categorized in groups.

**D-61 Subcommittee**

The *Design Guidelines for Printed Electronics (IPC/JPCA-2291)* was recently approved by a ballot that was generated by the D-61 subcommittee. This document is considered a bridging tool, for it establishes the bridge necessary between the product designers and the manufacturing engineers. During drafting of the document, example topics that were discussed were organized into four groups: 1) Computer-Aided Design Tools, 2) Data Transfer, 3) Substrates, and 4) Conductors. Table 4 is a snapshot of the different topics that were mentioned within the four groups.

The most often stated topic during D-61 meetings is PE design and layout. In the past, PE companies have developed internal procedures for design and layout of PE-enabled products using software packages from the electronics industry; as an example, some companies use Gerber format which is specialized electronic design automation (EDA) software commonly used by printed wiring board designers. Once the design in Gerber format is validated, it is prepared for transfer to the printing platform operations group within the company or sent outside the company to a receiving manufacturing services provider. This handoff is viewed as a critical gating step in new product introduction.

Since a framework was adopted by D-61 and is presented in IPC/JPCA-2291, discussion among D-61 subcommittee members will continue in an effort to identify the most appropriate bridging tool.

**D-62 Subcommittee**

The D-62 Subcommittee was the first IPC subcommittee to publish its standard and is presently discussing Revision A of *IPC/JPCA-4921: Requirements for Printed Electronics Based Materials*. This topic, base materials, was identified as a key structural material for the field of PE. Also, the growth in variety and number of commercially available and near-commercially available materials has fueled the innovation of novel PE-based products in new fields. Figure 5 provides the layout of the document as built around five substrate categories. These categories captured the most prominent families of substrate materials existing today. The published standard was structured to enable new substrate materials to be added in IPC/JPCA-4921 with minimal effort.

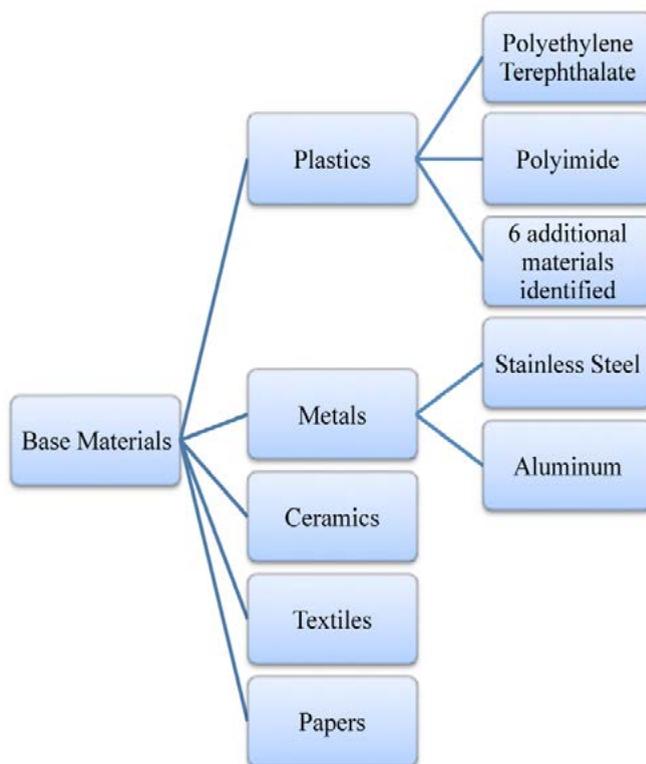
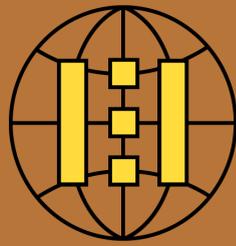


Figure 5: IPC/JPCA-4921 document structure.



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<ul style="list-style-type: none"> <li>• Semiconducting materials</li> </ul>	<ul style="list-style-type: none"> <li>• Light sensing (PV, optical sensors)</li> </ul>	<ul style="list-style-type: none"> <li>• As function of pressure</li> </ul>
<ul style="list-style-type: none"> <li>• Resistive materials</li> </ul>	<ul style="list-style-type: none"> <li>• Color change (i.e., thermochromic)</li> </ul>	<ul style="list-style-type: none"> <li>• As function of humidity</li> </ul>
<ul style="list-style-type: none"> <li>• Capacitive materials</li> </ul>	<ul style="list-style-type: none"> <li>• Piezochromic</li> </ul>	
<ul style="list-style-type: none"> <li>• Piezo-electrical materials</li> </ul>	<ul style="list-style-type: none"> <li>• Pyroelectric</li> </ul>	

Table 5: D-63 proposed functional materials topics for standardization<sup>[15]</sup>.

Since its publication, the IPC-4921 document has been referred to as fundamental for the field of PE. Moreover, it is considered by many as one of the most critical drivers of manufacturing innovation. The paradigm shift that flexible and stretchable substrates offers for transitioning from batch to roll-fed and roll-to-roll manufacturing is considered paramount for realization of vibrant new areas of manufacturing growth.

The D-62 Subcommittee has held a few meetings to identify new topics to include in Revision A. During the meetings the content and comments received since its publication have been discussed.

**D-63 Subcommittee**

The second IPC subcommittee to publish its standard was D-63. This subcommittee is presently discussing Revision A of IPC/JPCA-4591—*Requirements for Printed Electronics Functional Materials* based on comments received since its publication in December 2012. The content of IPC/JPCA-4591 is considered as important as that in IPC/JPCA-4921. Also, many view this subcommittee as long term, providing the greatest number of standards documents due to the continued expansion of material categories. These categories are based on materials systems that demonstrate novel intrinsic properties provided by the design and synthesis of advanced materials structures: conductive, semi-conductive, dielectric, photoactive, thermally active, and chemically active.

IPC/JPCA-4591 compiles the general re-

quirements to specify and quantify the mechanical, surface, and optical properties for functional materials displaying electrical conductivity. This document serves as an example for the general outline of future documents that will focus on the previously mentioned intrinsic property specified topics. Future topics that may be undertaken by the D-63 Subcommittee are shown in Table 5.

**D-64 Subcommittee**

Independent of the debate for whether PE commercial success will ultimately be determined by developer push or customer pull, industry members agree that a clearer go-to-market strategy must be articulated. This need has fueled the identification of potential topics for the D-64 Subcommittee-led project titled, *Performance Requirements for Printed Electronics Assemblies (IPC/JPCA-6901)*. During the past 10 years, the PE industry has observed several high-visibility opportunities for early PE-based products such as RFID, flexible displays, etc. A component for success to launch these products is based on the performance demanded by the end customer.

Members of the D-64 Subcommittee structured a draft of IPC/JPCA-6901 that attempts to organize PE assemblies by markets and levels. Figure 6 shows the different segments most often identified as opportunities for PE assemblies as organized in a proposed Market Classification System.

To further provide structure for PE assemblies, a level classification system was proposed

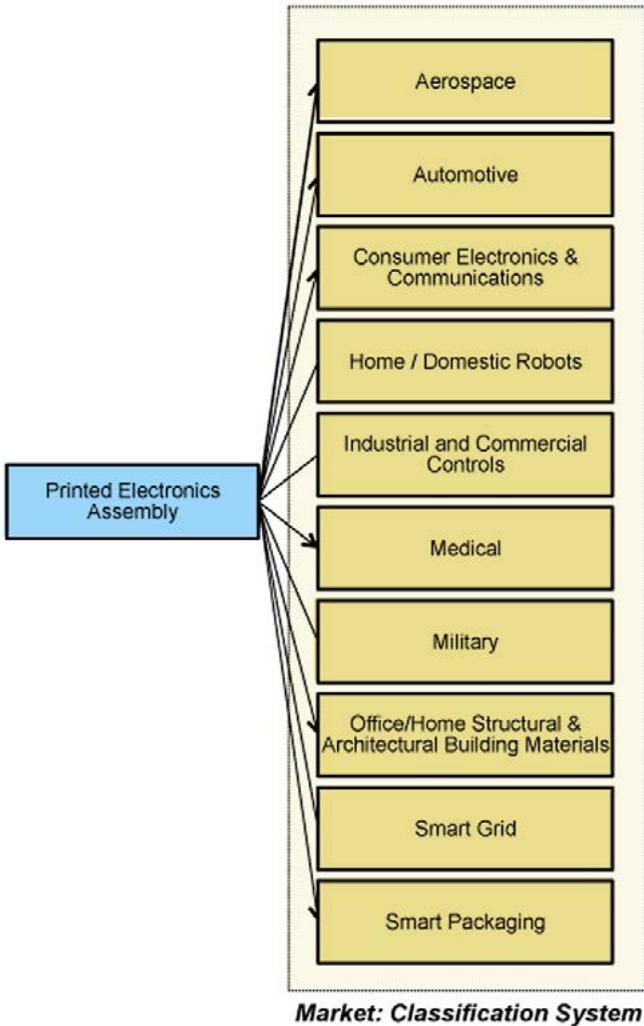


Figure 6: IPC/JPCA-6901 proposed PE Market Classification System.

that emulates classification systems adopted by other groups (Figure 7).

Members of D-64 feel that the classification systems as proposed in Figure 6 and Figure 7 will provide the necessary structure to designers seeking a PE solution.

**D-65 Subcommittee and D-66 Subcommittee**

As mentioned earlier D-65 and D-66 are the newest members of the D-60 Committee established to lead the development of the IPC PE standards portfolio. These subcommittees are presently identifying topics as well as seeking

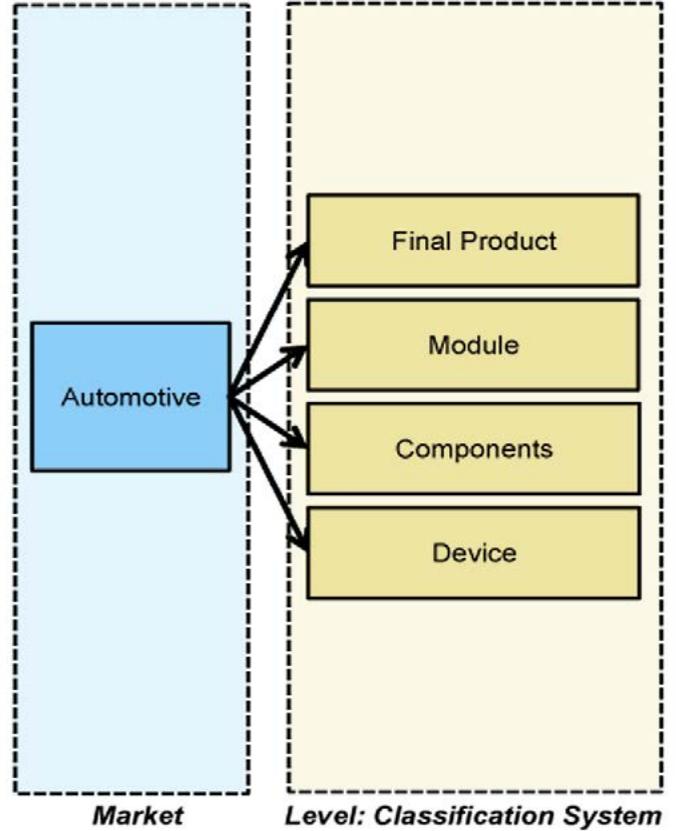


Figure 7: IPC/JPCA-6901 proposed PE Level Classification System.

subject matter experts to participate in these initiatives.

**Conclusion**

IPC has been able to establish a robust standards development initiative by implementing a strategy based on 1) partnering with leading organizations within the PE industry and 2) reaching out to subject matter experts from the different technical fields that have nurtured PE innovations. This implemented strategy has proven robust and flexible as it has led to the completion of three documents (IPC/JPCA-4921, IPC/JPCA-4591, and IPC/JPCA-2291), drafting of a fourth (IPC/JPCA-6901), and the recent formation of two new subcommittees (D-65 and D-66) to investigate PE relevant topics. A flexible hierarchical structure has been established to provide the greatest support to the emerging field of PE by maintaining a level

of discipline that does not impede creativity required for sustained innovation. IPC is well positioned to become the internationally recognized repository for PE intellectual assets. **PCB**

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9. [IPC Purchase Portal: Requirements for Printed Electronics Functional Conductive Materials](#)
10. [IPC D-64 Printed Electronics Final Assembly Subcommittee](#)
11. Japan Electronics Packaging and Circuits Association ([JPCA](#))

12. International Electrotechnical Commission ([IEC](#))
13. [SEMI](#)
14. International Microelectronics and Packaging Society ([IMAPS](#)),
15. Specialty Graphic Imaging Association ([SGIA](#))
16. Printing Industries of America ([PIA](#))
17. NPES The Association for Suppliers of Printing, Publishing and Converting Technologies ([NPES](#))
18. Institute of Electrical and Electronics Engineers ([IEEE](#))
19. Potential topics for future projects initiated by D-63 Subcommittee provided by Co-Chairman Markus Riester



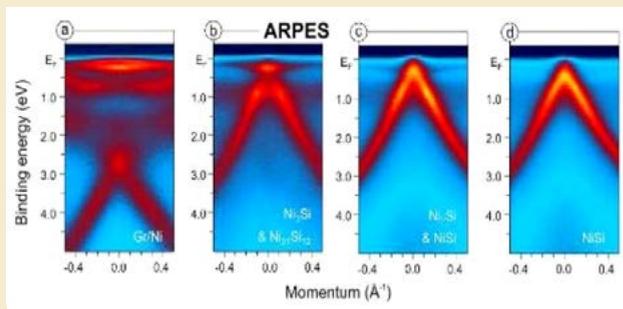
Dr. Daniel Gamota is the director of the Advanced Manufacturing Technology Organization at Jabil. He is chair of IPC Printed Electronics Standards Committee, Technical Advisor for IEC/TC 119—Printed Electronics Standards Committee International Electrotechnical Commission, IEEE Organic and Molecular Electronics Standards Group, and chair of the group that publishes the iNEMI Large Area Flexible Electronics Roadmap.

## Graphene Pushes Forward; Poised to Conquer Silicon Valley

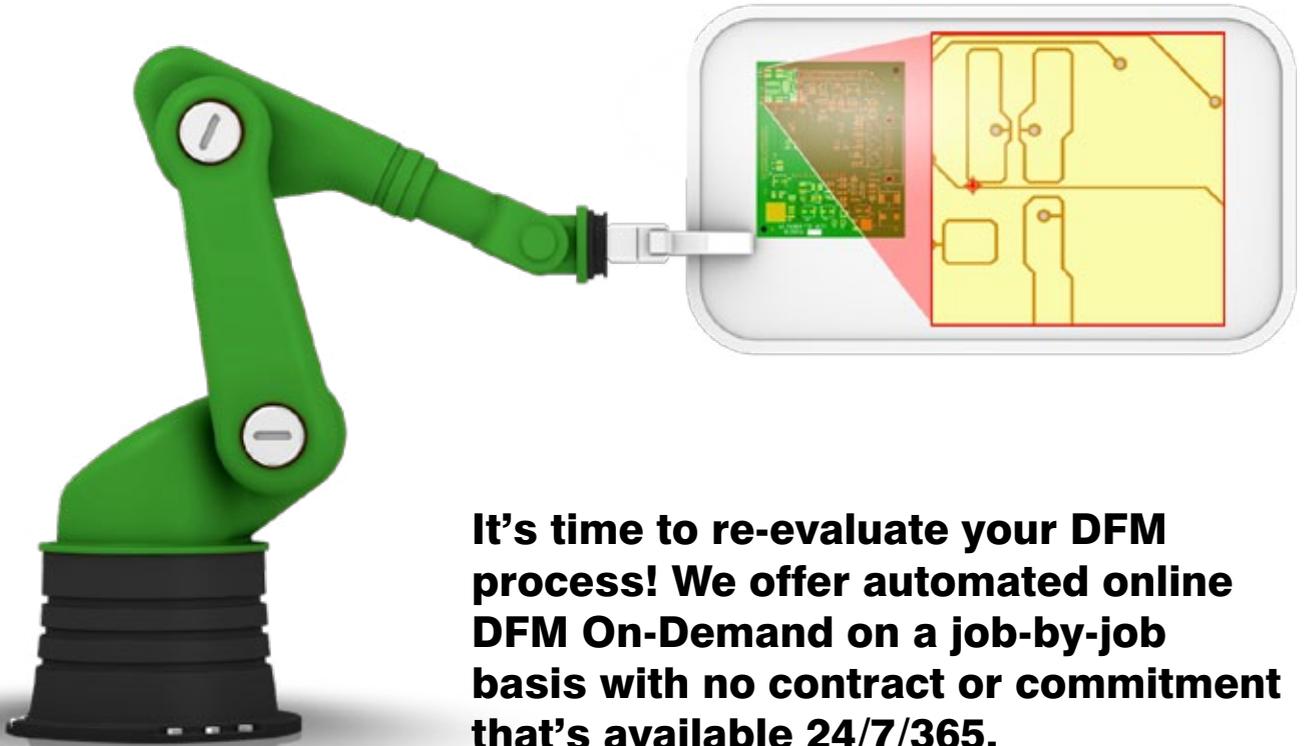
Graphene promises a wide range of applications in future electronics that could complement or replace traditional silicon technology. Researchers of the Electronic Properties of Materials Group at the University of Vienna have now paved the way for the integration of graphene into the current silicide-based technology.

One major challenge of graphene, a two-dimensional crystal of carbon atoms packed in a honeycomb structure, is to successfully integrate graphene into the established metal-silicide technology. Scientists from the University of Vienna and their co-workers from research institutes in Germany and Russia have succeeded in fabricat-

ing a novel structure of high-quality metal silicides all nicely covered and protected underneath a graphene layer. These two-dimensional sheets are as thin as single atoms. "Single-atom thick layers and hybrid materials made thereof allow us to study a wealth of novel electronic phenomena and continue to fascinate the community of material scientists," said Alexander Grueneis and Nikolay Verbitskiy, co-authors of the study.



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# PCB Industry Standards: Threat or Advantage?

by **Pete Starkey**

I-CONNECT007 TECHNICAL EDITOR

*Summary: I-Connect007 Tech Editor Pete Starkey seeks and secures the advice and opinions of EIPC Technical Director Michael Weinhold on the controversial and sometimes complicated issue of standards for the PCB manufacturing industry.*

There aren't many people as knowledgeable or as well-connected in the global printed circuit industry as Michael Weinhold, technical director of the European Institute of Printed Circuits. Almost half a century in the industry and for many years a product application

manager for DuPont in Switzerland, where he pioneered numerous developments in the fabrication of high-density interconnect: controlled expansion laminates, laser hole formation, fine-line imaging and fine pitch SMT and flip-chip assembly, and latterly an expert on embedded component technology, he travels extensively as an ambassador for the European PCB industry.

Besides his other activities, Weinhold represents Switzerland at the IEC-TC 52 and TC 91 committees, developing standards for PCB fabrication and assembly. He is the only European representative on the UL 746E standards committee and also represents the European printed circuit industry in the World Electronic Circuit Council, focused on harmonising PCB technology and standards on a worldwide basis. Moreover, he is a member of the JISSO International Council, supported by the world's major electronics industry trade and technology associations, whose mission is to harmonise standards from bare chip to finished electronic assembly.

Who better to give us the benefit of his advice and opinion on standards, increasingly a topic of controversy and heated discussion within the industry worldwide, than Weinhold?

I had the opportunity recently to sit down with Weinhold after the EIPC 2013 Summer

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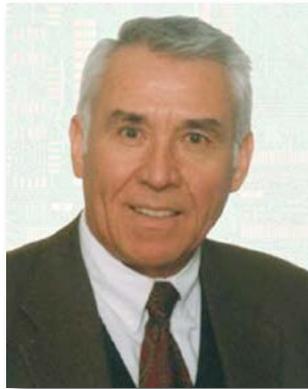
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Conference in Luxembourg, where one of the leading speakers, IPC Vice President of International Relations David Bergman, talked about standards and how they affected business, were a medium for communication, helped to deliver products faster by not having to specify basic requirements for form, fit and function, reduced overall costs by establishing a common understanding between users and suppliers, and increased the reproducibility of products and services.

**Pete Starkey: Michael, David Bergman made a pretty good case for standards and standardisation. What do you consider to be the issues? Are standards really a threat or can they be an advantage?**

**Michael Weinhold:**

There is no argument that standards are needed to communicate on an equal level of understanding. But it often happens that standards are used to shift the responsibility for product quality down in the supply chain. As a result, the PCB fabricator often gets the blame for design issues, for a lack of understanding of tolerances and for selecting materials that are not suitable for the quality and life expectation of the products that are manufactured.



But there are standards and then there are standards, and we must differentiate between them.

**PS: Please explain what you mean by that.**

**MW:** Let us first consider the standards that are effectively beyond our control. The electronics industry has to comply with safety standards for electrical, mechanical and flammability requirements. It is important that electronics fabricators understand that safety standards are not for negotiation, they must be fulfilled throughout the supply chain regardless how the PCBs are manufactured.

Safety standards are set by global operating organisations like the International Electrotechnical Commission (IEC). National standard institutes like ANSI in the U.S., BS in the UK, DIN in Germany and NF in France are all connected to the IEC. IEC standards cover a vast range of technologies from power generation, transmission and distribution to home appliances and office equipment, semiconductors, fibre optics, batteries, solar energy, nanotechnology and marine energy, as well as many others. The IEC also manages three global conformity assessment systems that certify whether equipment, system or components conform to its International Standards. And in Europe we have CENELEC as a link between the global IEC and the 33 CENELEC member countries channelled through their national electrotechnical committees. The European standards bodies define a standard as a document established by consensus and approved by a recognised body that provides rules, guidelines or characteristics aimed at optimising the degree of uniformity.

**PS: While we are on the subject of safety standards, do you wish to make any comment about UL? They have taken a lot of criticism of recent times, although they claim to drive consistency, integrity and engineering quality through establishing and applying their certification requirements. PCB manufacturers complain about the time and cost of UL certification. Do you think these complaints are justified?**

**MW:** UL is certainly a hot topic. But putting aside the issues of time and cost, the principal benefit of UL is that it provides a reference against which the supply chain can be checked-out and, if applied correctly, can give additional security to the OEM.

But Asian countries like India, China and others can be a problem: Controlling the supply chain in these areas is not easy. Whereas UL conformity in Europe and the USA defines a well-controlled supply chain, UL in some Asian counties tend to have a different meaning. Indeed, in many cases it has no meaning at all—it is just a convenient label! It should be the in-

tention of the industry to harmonise the proper testing for UL, globally.

**PS: So much for safety standards. What other standards are non-negotiable and have to be satisfied?**

**MW:** Environmental standards are the second group that have to be fulfilled. They are required for the protection of the environment and for the health of the user of these products. Environmental standards may have differences from country to country. In the EU-28 the regulations are harmonised. However, in other areas in the world, different standards and environmental requirements do exist and often allow for a lot of interpretation about how these standards are applied.

The most significant environmental standard to have been imposed upon our industry in the last decade is the RoHS Directive, which the EU has been successful in implementing since 2006. This regulation has prohibited or seriously restricted the use of certain materials in electronic equipment: lead, cadmium, mercury, hexavalent chromium and brominated flame retardants. In particular, the restriction on lead had an extremely powerful influence on manufacturing processes for electronic devices: Solder equipment for wave soldering and HASL had to be modified or replaced. Soldering temperatures increased, and this impacted the laminate and the components of the electronic devices. These higher soldering temperatures have also been regarded as indicators for reduced in-service life of electronic devices.

EU REACH regulations affect suppliers of processes to the PCB manufacturing industry, and require manufacturers and importers of chemical substances to gather hazard information and assess risks. And this restricts the marketing and use of certain chemicals and mixtures classified as “hazardous.”

**PS: Michael, you have commented on safety and environmental standards, but what about manufacturing standards?**

**MW:** Let us begin with company standards: Large companies have a requirement to establish their own standards and specifications. This is mainly to differentiate from others and to better serve the market with high-quality products. However, when the products manufactured in accordance with such standards are mature, these standards tend to become part of the public domain and are proposed as IEC standards by the national standard association bodies. To quote some examples in Germany: Bosch (automotive), Volkswagen, Mercedes, and Siemens all have their own manufacturing standards that their suppliers are required to meet if they want their business.

Then there are association standards. Take the example of a national operating association like VDE in Germany, which is an association for electrical, electronic and information technologies and is one of the largest technical and scientific associations in Europe, with more than 34,000 members. It combines science, standardisation and product testing, and its priorities are security in electrical engineering, the development of codes of practice as national and international standards, and the testing and certification of equipment and systems.

On a technical-scientific level, VDE cooperates with other organisations. It is represented in the standardisation organizations such as CENELEC, ETSI and IEC, and also cooperates with the American Institute of Electrical and Electronics Engineers.

And of course we have the internationally operating associations like IPC, JPCA and CPCA.

**PS: What are your feelings about demonstrating compliance with standards?**

“  
**Large companies have a requirement to establish their own standards and specifications. This is mainly to differentiate from others and to better serve the market with high-quality products.**  
”

**MW:** In the first instance, intelligent vendor selection is essential. If you are an OEM or EMS and know and approve your supplier's capabilities and systems, and feel he is matched to your requirements, then every time that supplier accepts a purchase order from you he is committing to meeting the standards called up in the order and the stated purchase specification. And that is more than half the battle.

But if you want test coupons to prove conformance, don't ask for them to be supplied loose—they could have been manufactured on "Test Coupon Day," for example, when plating bath solutions are fresh and provide best results.

I have a better suggestion: Make test coupons part of the delivered PCB, incorporated into the assembly panel. Then, if there is any issue which the customer considers to justify testing to prove the compliance, let him, the OEM or EMS, carry out the testing, either in the as-received condition or after the assembly process. If the PCB conforms to the purchase specification, then the OEM or EMS company stands the cost; if not, the lot is rejected and the PCB manufacturer pays!

**PS: How should the PCB manufacturer effectively document his capability?**

**MW:** I favour the IPC-1710A approach. This OEM Standard for Printed Board Manufacturers' Qualification Profile was developed by the OEM Council of IPC. It sets the standard for assessing PCB manufacturers' capabilities and allows those manufacturers to more easily satisfy the requirements of their customers. The MQP is a very comprehensive questionnaire, about 45 pages long. It does not necessarily satisfy every single requirement of the customer, but if it is conscientiously maintained, then in conjunction with ISO 9000 registration it should satisfy all the major concerns. If the PCB manufacturer is independently audited to IPC-1710A and makes an honest self-declaration of compliance, and works within his proven capabilities, then customer audits should be simpler, required

less frequently, and involve less paperwork as customers and suppliers work closer to meeting each other's needs.

**PS: We have looked at the responsibilities of the PCB manufacturer, but what about the responsibility of the OEM or EMS customer?**

**MW:** That is a very good point. There is a tendency for customers to over-specify their requirements. The classic case is calling-up IPC-6012 Class 3 when it is not really justified, and putting the PCB fabricator in a position of having to work to tolerances that make the work more expensive to manufacture at a time when he is trying to be price-competitive.

By all means let the customer specify individual features to Class 3 requirements if they are necessary and justified to achieve a particular level of reliability or product life, but not call-up the general requirements of Class 3 for other features when IPC Class 2 and even IPC Class 1 would give acceptable results.

I will give you an example: I know of an instance where the customer had designed his test lands much larger than they needed to be, and the PCB fabricator could not avoid some solder-resist encroachment. The boards, which were perfectly serviceable and reliable, were rejected because neither IPC Class 3 nor Class 2 permits soldermask on lands!

Take the case of automotive electronics. They are designed for 15-year service life, but after five years the warranty is over and the responsibility falls upon the owner of the car. Material selection is very important and has a significant influence on the service life of the product. But with new materials being introduced all the time, how do you determine that a particular material will still be performing reliably in 15 years' time? Accelerated testing like IST and HAST can give some useful information but cannot tell the full story. Look at the recent recall of over three million cars manufactured between nine and 13 years ago, for an air-bag fault.

“  
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For the daily requirements of the total supply chain for printed circuit boards and electronic assemblies, IPC standards are excellent comprehensive standards that are available on the market. However, the correct use of these standards is an important factor and knowledge is needed throughout the supply chain from the electronic design through PCB design, material selection, PCB fabrication, component assembly and testing. Using these standards as a tool is an excellent way of making product sourcing simpler. However, it is important that all partners in the supply chain understand what the manufacturing standards mean and what skills are needed in the workforce to manufacture electronic devices that meet these standards.

**PS:** *Michael, although I am sure you could give many more examples, you have certainly given us a meaningful perspective on an inescapable fact of life in the electronics industry. As you said at the beginning, there are "standards" and then there are "standards," some beyond*

*the control of the PCB manufacturer and some which rely upon intelligent application and interpretation if electronics are to be safe and reliable on one hand, and cost-effective to manufacture on the other. And the world electronics industry must continue to strive to get everyone to both accept, and work fairly to, consistent and uniform standards.*

*I am grateful to you for giving us you time and the benefit of your opinions. Thank you. PCB*



Based in the UK, Pete Starkey joined I-Connect007 as its technical editor in 2008. Most recently, Starkey was products editor and Europe editor for CircuiTree and has more than 30 years experience in the PCB industry, with a background in process development, technical service and technical sales. To contact Starkey, [click here](#).

## VIDEO INTERVIEW

# The Industry's New Event—ESTC

by Real Time with...IPC APEX EXPO 2013



Dr. Senol Pekin and Sanjay Huprikar talk about a new event, ESTC, which was founded by Pekin and produced by IPC. ESTC is the Electronic System Technologies Conference & Exhibition.



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0" 1" 2"





# The CAMEST Story

by **Denny Fritz**  
CAMEST COORDINATOR

**SUMMARY:** *Once upon a time, when the supply chain was vertically integrated, OEMs could ensure that technology development considered all levels of interconnect within the system. Now, that challenge falls to a highly segmented industry. CAMEST aims to deliver solutions that consider all layers of interconnection, from chip to operating system, through collaboration and open communication.*

The continued drive to expand digital electronics into virtually every aspect of our lives has brought exciting opportunities and unprecedented challenges. The industry continues to create new solutions to deliver on the demand for faster, smaller, reliable and robust devices that are also environmentally friendly. Years ago, when the supply chain was vertically integrated, OEMs could ensure that technology development considered all levels of interconnect within the system. That challenge now falls to a highly segmented industry. Delivering solutions that consider all layers of interconnection

from chip to operating system can be achieved if there is collaboration and open communication in the industry.

An attempt to address the issue was made when [JISSO International](#) was formed in 2000. This organization evolved from the Surface Mount Council, from about 1980–2000, which helped develop technology, standards, and reliability data to allow surface mount to become the dominant chip configuration it is today.

After more than 10 years of involvement, JISSO North America members believe too much attention is paid to standardization and not enough to technology interchange. The term JISSO (the total packaging solution) is not well known in North America, and there has been a lack of public presentation to help our engineers derive benefit from it. From the JISSO International Council (JIC) website:

“The purpose of this council is to promote a strategic partnership among global organizations interested in the total solution for interconnecting, assembling, packaging, mounting, and integrating system design.”

In September of 2012, a group of experts began discussions that led to the formation of a

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new coalition to link various sources of knowledge about the electronics interconnection industry. They formed the Coalition for Advancement of Micro-Electronics System Technology (CAMEST), with the goal of helping members better understand the gaps in design, manufacturing, test and reliability across all aspects of electronic component assembly and subsystem manufacturing from semiconductor to final assembly.

The term “coalition” was deliberately chosen to indicate that this is a participative organization. Members are expected to actively help set goals and share interconnection information. While CAMEST is not promoting a specific technology, it hopes to become an “evergreen roadmap” with status and action plans published quarterly on the topics considered to be the most needed by its membership.

CAMEST began in earnest with a series of teleconferences starting in September of 2012, followed by face-to-face meetings at IPC APEX EXPO in February (San Diego) and at the IPC

ESTC conference in May (Las Vegas). The current specific goals are:

1. Facilitate gathering and distribution of technical information relevant to stakeholders
2. Identify gaps not publically recognized
3. Expedite transfer of needs and coordinate effort to bridge barriers which may arise between stakeholders
4. Foster cooperation between industry, academia, government stakeholders and existing consortia to accelerate the delivery of viable solutions

The first effort to prioritize the technical efforts of CAMEST was to poll the participants to help prioritize efforts on the most pressing interconnection issues facing the industry. First, 10 items from a similar JNAC proposal to JISSO International in 2010 were proposed. Interested CAMEST members suggested eight others. The myriad of gaps from multichip packages was selected as first priority to address. Additionally, some of the other seventeen candidates can be lumped together into future analyses. CAMEST members envision publishing future status and action plans for each of the focus topics under review.

Initial work on multi-chip packaging has shown two immediate obstacles. First, the concept is so broad that it is hard to organize the information. An initial plan would address the following:

1. Overview of what is covered, including definitions and characterization of subcategories
2. Design issues
3. Component requirements for inclusion into multichip packages
4. Materials, manufacturing processes, and performance requirements during manufacture
5. Further assembly requirements for the finished package
6. Quality and reliability of the final multichip package

The initial challenge for the workers addressing item 4 is to classify the various multichip packages in some way—silicon, ceramic, organ-

ic, etc. Manufacturing processes such as wire bonding and soldering are obvious, but other new manufacturing processes such as additive or printed technology are becoming viable production alternatives for select applications.

Almost immediately, defining a multichip package became a problem. Various industry standards bodies, national and international, have differing definitions for the term. One early CAMEST task is to help everyone understand what multichip package means to various stakeholders.

CAMEST has addressed a number of organization issues in formation. First, how should CAMEST position itself? The consensus is that CAMEST can function best if it is an independent organization, not a subcommittee of another association. As noted, CAMEST chose the term coalition to define itself, because it seeks participation from a wide range of individuals, other associations, and corporations. The implications of this involve forming

some kind of corporation, with bylaws and officers. CAMEST participants have spent some time researching other trade and technical organizations around the electronics industry and around the world, to identify best practices and avoid the mistakes of others. One such group that serves as an interesting model is the [Institute of Circuit Technology](#) in Great Britain. That organization has individual members and corporate sponsors. However, it does not presently have other associations as members. A draft of CAMEST bylaws has been drawn up, featuring an executive director, a steering committee, and initial membership procedure.

However the bylaws are constructed, they must conform to incorporation requirements in the state selected as the organization's official home. Selecting and constructing the legal entity is the next step for CAMEST. Hopefully that

initial paperwork will be done by the time this article goes to press. The current understanding is that federal law on tax exempt corporations favors the formation of a 501(c)6 entity—business associations. For instance, IPC is organized as a 501(c)6 corporation.

The ex-JNAC members who formed the initial core of CAMEST felt that a key stumbling block for JISSO International is the lack of permanent activity funding. The host association for the annual JISSO International Conference funds the activity for that year. The establishment of JISSO International Forums has not proved to be a consistent funding source. CAMEST is proposing a modest fee structure, so that it can pay its own way. The feeling is that supporting ongoing CAMEST operation in 2013 has to be somebody's day job. This will put the focus for operations on a paid executive and possibly a minimal staff. Finally, some members feel that even the budgeting and pay-

ment of even a minimal annual fee enforces an analysis of the benefits of CAMEST, and keeps the commitment to participation in activities visible to participating organizations.

Even these minimal initial expenses seem mundane, but without any funding, they are stumbling blocks. Incorporation costs, website maintenance fees, and even the need for a professional graphic artist to create a CAMEST logo point out the need for funding.

Besides organizing internally and getting started on the first status and action plan for multichip packages, CAMEST is working to establish a public presence. It is felt that CAMEST can still function as an affiliate of JISSO International.

Certainly, open communication links between CAMEST and JISSO will be strongly supported. Current JISSO International activity is focused on the 2014 World Electronics Circuits Conference in May 2014 in Nuremberg, Germany.

“  
**Besides organizing internally and getting started on the first status and action plan for multichip packages, CAMEST is working to establish a public presence. It is felt that CAMEST can still function as an affiliate of JISSO International.**  
 ”

JISSO International will be holding its annual conference somewhere around that same meeting time and it is likely to be co-located. JISSO International meetings have been closely allied with the meetings of International Electrotechnical Commission (IEC) Technical Committee 91 (TC91) for printed circuit boards. While North American electronics companies manufacture to IPC or JEDEC standards, Europe and some other areas of the world traditionally use IEC standards. While there tends to be great similarity between IPC or JEDEC and IEC, there are important differences—particularly in the timing of adopting new requirements and the role of national governments in overt or tacit support of these requirements. While CAMEST supports orderly development of standards, it does not see standardization as a primary organizing function.

CAMEST will be holding another organizing meeting prior to SMTA International during the regular IPC standards meetings in Fort Worth, Texas, on Sunday, October 13, 2013. Next, there

will be a public forum explaining CAMEST during the SMTAI sessions on Tuesday, October 15 at 11:30 AM.

Finally, CAMEST is looking for a venue for its first annual meeting in early 2014. This is envisioned to be partially an organizational meeting working on status and action plans, but also a technical forum soliciting presentations from CAMEST members on their activities in the focus areas. **PCB**



Since 1998, Dennis Fritz has been an independent technology consultant to MacDermid, Inc., in Waterbury, Connecticut. Fritz is the leader of the JISSO North America Council (JNAC) and the strategy leader for the Coalition for Advancement of MicroElectronic Systems Technology (CAMEST). He may be reached at [ddfritz@aol.com](mailto:ddfritz@aol.com).

## VIDEO INTERVIEW

# NA Fabricator Formula for Success

by *Real Time with...IPC APEX EXPO 2013*



One Source Group President Niles Naik talks about his company's focus on QTA and how that focus is their formula for success in this difficult market.



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# The Standards Advantage



**by Dave Torp**  
IPC

**SUMMARY:** *Component application engineers, quality engineers, procurement engineers, and process engineers understand the competitive advantage that comes with a fundamental knowledge of industry standards. The trick is to know exactly when, how and why to apply industry standards.*

As an accredited standards developer under the American National Standards Institute (ANSI), IPC parlays the technical needs of member companies into useful information that is published as an IPC standard. IPC standards are globally recognized, industry-consensus documents developed with the technical expertise of representatives of companies in all segments of the electronic interconnect industry, from design firms and PCB manufacturers to EMS providers, OEMs and their suppliers.

## Standards Development Committees

IPC standards committees are made up of many subject-matter experts with a wide variety of experiences. Achieving a representative balance between users and suppliers on standards committees is a goal to ensure a sense of fair play during the development process. Standards developed solely by users can be brutal on suppliers. It is often difficult, if not impossible, to manufacture products in accordance with user-driven standards. And standards generated solely by suppliers can lead to products and materials that don't meet application needs. In order to develop relevant industry standards, users and suppliers need to be represented on the standards development committees.

At IPC, standards are developed by volunteers in an open process. Anyone, regardless of membership, can participate on IPC committees. Typically, someone who volunteers on a standards development committee has a

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vested interest in the content of the standard. Currently, IPC has more than 400 active standards and engages more than 10,000 volunteers to participate in the development process on a global basis. Many IPC standards are developed in association with other organizations such as JEDEC and JPCA.

**Standards Development Process**

The standards development process begins by defining the scope and purpose of the standard. Sometimes defining what the standard is not going to specify is the most difficult part. This is where a strong committee leadership helps: keeping standards development activities focused, by establishing a realistic scope at the onset of a project, and on track. IPC’s committee chairmen and vice chairmen are some of the electronics industries most dedicated resources.

The next stage of the standards development process is the working draft phase. Invitations are sent to subject-matter experts, chief technology officers, and consultants that have vested interests in the content of the standard to form the core of the committee. Through the standards collaboration process, a rough draft of the standard is developed and is available to industry for review and input.

Once the polishing on the working draft has been completed, the committee generates a final draft for industry review and comment. This is where some fireworks can begin. Committees can generate high levels of interest and participation when final drafts are sent out. All comments are reviewed by the committee and significant changes are made to the standard, giving shape to a final standard. Once consensus among the committee has been reached, a proposed standard for ballot is sent out to a balloting group of industry peers. In order for a standard to become an official IPC standard at least eighty percent of the balloting group needs to achieve consensus.

The standards development process that IPC follows is derived from the ANSI Essential Requirements for standards development organizations and is one of the most rigorous in the electronics industry. IPC standards that make it through the entire process have been vetted by the industry several times before they are released, and represent the very best practices in electronics manufacturing.

**IPC Portfolio of Standards**

The three primary areas of concentration of IPC standards for printed boards are de-

<b>IPC Designation</b>	<b>Description</b>
2152	Standard for determining current carrying capacity in printed board design
2220	IPC family of design standards
2221B	Generic standard on printed board design
2222A	Sectional design requirements for rigid organic printed boards
2223C	Sectional design standard for flexible printed boards
2581A	Generic requirements for printed board assembly products manufacturing description data and transfer methodology
2615	Printed board dimensions and tolerances
4761	Design guide for protection of printed board via structures
7351B	Generic requirements for surface mount design and land pattern standard

Table 1: Commonly referenced IPC standards for printed board design.

design, fabrication, and assembly. Within design, several standards have become staples within the industry, with IPC-2222A the most relevant. The complementary standard for flexible printed boards is IPC-2223C. Table 1 shows some of the most popular design standards.

In printed board fabrication, the electronics industry uses two highly relevant standards as the medium for communication to inspect and manufacture printed boards. IPC-6012C covers

the qualification and performance of printed rigid boards and IPC-A-600H contains the parameters for the acceptability for printed boards. Table 2 shows the family of standards commonly referenced for printed board fabrication.

IPC assembly standards primarily focus on bringing electronic components and printed boards together through the assembly process. Within the assembly standards, two are the most relevant: IPC-A-610E and IPC-J-STD-001E. These standards represent the requirements and

<b>IPC Designation</b>	<b>Description</b>
A-600H	Acceptability of printed boards
SM-840E	Qualification and performance specification for permanent solder mask
1601	Printed board handling and storage guidelines
4101C	Specification for base materials for rigid and multilayer printed boards
4103A	Specification for base materials for high speed/high frequency applications
4203A	Cover and bonding material for flexible printed circuitry
4204A	Flexible metal-clad dielectrics for use in fabrication of flexible printed circuitry
4552-WAM1-2	Specification for electroless nickel/immersion gold (ENIG) plating for printed boards
4553A	Specification for immersion silver plating for printed boards
4554	Specification for immersion tin plating for printed circuit boards
4556	Specification for electroless nickel/electroless palladium/immersion gold plating for printed circuit boards
4562A	Metal foil for printed board applications
6011	Generic performance specification for printed boards
6012C	Qualification and performance specification for rigid printed boards
6013B	Qualification and performance specification for flexible printed boards
6016	Qualification and performance specification for high density interconnect (HDI) layers or boards
6018B	Qualification and performance specification for high frequency (microwave) printed boards
9252A	Requirements for electrical testing of unpopulated printed boards

Table 2: Commonly referenced IPC standards for printed board fabrication.

<b>IPC Designation</b>	<b>Description</b>
J-STD-001E	Requirements for soldered electrical and electronic assemblies
J-STD-002D	Solderability tests for component leads, terminations, lugs, terminals and wires
J-STD-003B	Solderability tests for printed boards
J-STD-004B	Requirements for soldering fluxes
J-STD-005A	Requirements for soldering pastes
J-STD-006B	Requirements for electronic grade solder alloys and fluxed and nonfluxed solid solders
CH-65B	Guidelines for cleaning printed boards and assemblies
A-610E	Acceptability of electronic assemblies
A-620B	Requirements and acceptance for cable and wire harness assemblies
PE-740A	Troubleshooting guide for printed board manufacture and assembly
AJ-820A	Assembly and joining handbook
CC-830B	Qualification and performance of electrical insulating compound for printed wiring assemblies
HDBK-830	Guidelines for design, selection and application of conformal coatings
HDBK-850	Guidelines for design, selection and application of potting materials and encapsulation processes used for printed circuit board assembly
7525B	Stencil design guidelines
7527	Requirements for solder paste printing
7711/21B	Rework, modification and repair of electronic assemblies
9702	Monotonic bend characterization of board-level interconnects
9704A	Printed circuit assembly strain gage test guideline
9707	Spherical bend test method for characterization of board level interconnects
9708	Test methods for characterization of printed board assembly pad cratering

Table 3: Commonly referenced IPC standards for printed board assembly.

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<b>Designation</b>	<b>Description</b>
4921	Requirements for printed electronics base materials
4591	Requirements for printed electronics functional conductive materials
2291	Design guidelines for printed electronics

Table 4: Printed electronics standards.

acceptability for soldered electronic assemblies. They serve as the industry's defacto standards for electronic assemblies. The most referenced IPC standards within the assembly family are shown in Table 3.

**New Areas of Interest for IPC Standards**

Printed electronics has been a rapidly growing arena. While a complete definition of printed electronics is still development, several standards activities are underway within IPC. These standards for printed electronics are provided in Table 4.

**The Advantage**

Knowing exactly when to apply the requirements of a specific standard at the precise time and in the right way takes experience. IPC standards development committee leaders and technical staff liaisons are available to help industry along the way. IPC's staff of subject-matter experts can tap into the world's foremost experts within the electronics industry to provide you

with the guidance and answers you need. As part of IPC membership, this technical resource is at your fingertips, as is a free copy of every IPC standard within 90 days of its issue date. For information on all the benefits of IPC membership, visit [www.ipc.org/membership](http://www.ipc.org/membership) or contact Susan Storck, IPC membership manager at [SusanStorck@ipc.org](mailto:SusanStorck@ipc.org).

To view a list of IPC standards in development, visit [www.ipc.org](http://www.ipc.org). **PCB**



David Torp is the vice president of standards and technology for IPC. Prior to joining IPC, he was a senior staff engineer at Plexus. Torp also served as vice president of marketing and business development at Kester and held various engineering positions at Rockwell Collins and Underwriters Laboratories.

**VIDEO INTERVIEW**

**The Ins and Outs of Technology Roadmaps**

*by Real Time with...IPC APEX EXPO 2013*



Technology roadmaps serve multiple purposes in the industry, and they come in many shapes and sizes, from technical to environmental. Jack Fisher (Interconnect Technology Analysis), Michael Weinhold (EIPC), Chuck Richardson (iNEMI) and Dale Kersten (Sanmina) discuss the many sides of technology roadmaps.



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# Note to the U.S. Government: Don't You Work for Us?

by Don Walsh

UYEMURA INTERNATIONAL CORP.

Thomas Jefferson said that when people are scared of their government, that is tyranny. When government is scared of the people, that is democracy. We need to get back to that concept in a hurry.

The June 8 weekend edition of the Wall Street Journal mentioned that in 2008–2009, the U.S. was ranked as the most competitive country by the World Economic Forum. In the most current ranking, for 2012–2013, we have fallen to seventh place.

One reason for this dramatic plummet is the increasing deluge of interference by our government on U.S. business. As a supplier of precious metals, we must verify that our customers are not using these transactions for money laundering ([an anti-money laundering program](#) is part of the Patriot Act). We are also pouring substantial time into the totally onerous conflict metals (a slide into the Dodd-Frank bill), even though none of that gold ore was ever reported to have come to the U.S.

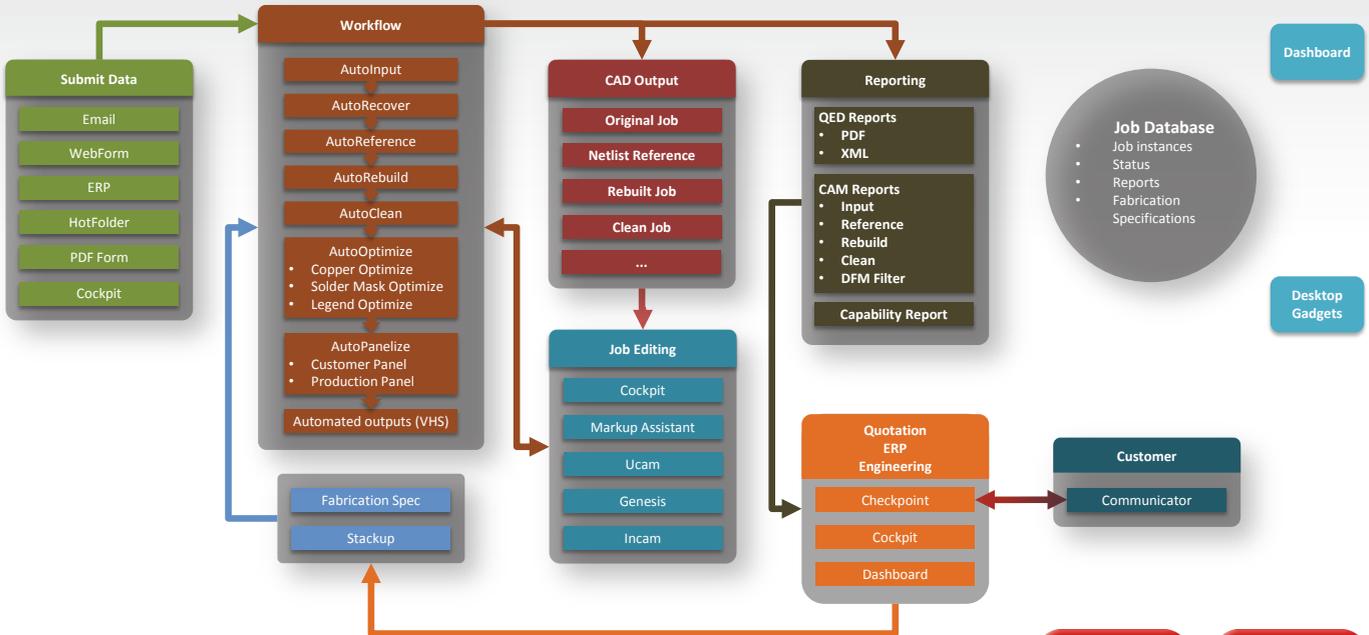
Recently, a company that buys more than 95% of their boards in Asia (where most of the

conflict gold has been shipped to) asked us for our conflict metal statement on gold. After sending it, we received a curt response that we would be in trouble if that is all we had. We then sent our EEIC/GESI forms and received a quick thank you.

Customers (or in this case, a customer's customer) don't often know what they want so we end up spending extra time and money for no recompense. Also recently, a former small customer who has not bought anything from us in four years asked that we fill out a REACH report. When we responded that we would be glad to once they are customers again, we received another very curt response: "Our other vendors have submitted these." The keyword there is "vendors." They are vendors and are at least earning some money for doing clerical work—we are not. Yet, there were several e-mails to close this one non-business issue. No income, but work nevertheless.

As a supplier of electroless nickel, we have been thrown into the bureaucracy of the DEA. Their idea of business is to wait for months/





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years until they understand what they have done. They admit they never knew about our industry and that their law was aimed at pharmaceutical companies. Only a government agency would have us register as manufacturer/importer/exporter—with fees for each—and now think that maybe we should also register as a distributor. Huh? Did they think that for two years we were going to import and manufacture only to hold onto it all? This, in light of the fact that we even paid the fees to register all of our distribution centers!

Our objections not only concern our wasted time, but also the delays they build into their system before normal business may be conducted. And by “normal business” I mean they also expect us to keep three (potentially four) separate accounts to track each of the transactions we make as an importer, exporter, manufacturer and (potentially) as a distributor. We will end up hiring as many clerks as the government has, and for what?

Another recent intrusion from our government is the “Customs Full Importer Security Filing Enforcement and Liquidation Damages,” which took effect July 9. This comes from the U.S. Customs and Border Protection (CBP). On this date they were scheduled to begin “full enforcement, with threatened fines, while the

agency continues to work on finishing a Final Rule.” This program requires advanced notice of cargo information within 24 hours before cargo is loaded on an oceangoing vehicle destined for the U.S. Brokers are now telling us they will need three days prior notice and, in the case of multiple items, five days. The irony is that this has been in existence for several years without actual enforcement, and yet they still claim to be “working on the actual rule.” This applies to all products entering the U.S. via ship.

With recent events highlighting the intrusions on freedom of the press and freedom of speech, how soon before we regain control of our government? What happened to the government needing subpoenas before infringing on freedoms? How soon before we teach our politicians and bureaucrats to respect and fear us, and to realize that they work for us? **PCB**



Don Walsh is director of operations for Uyemura International Corp. (Uyemura USA), North America's leading supplier of ENIG, electroless gold, via fill coppers and many other processes. To contact

Walsh, [click here](#).

## New Device Harvests RF Energy at Lower Input Power Levels

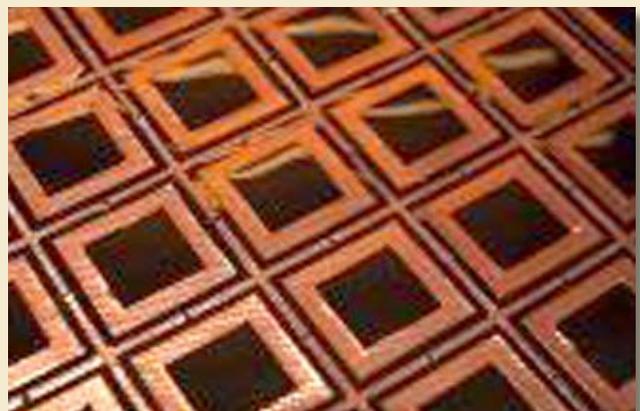
Holst Centre, in collaboration with [imec](#), the Delft University of Technology and the Eindhoven University of Technology, have designed and fabricated a self-calibrating RF energy harvester. The device is capable of harvesting RF energy at lower input power levels than state-of-the-art solutions.

Used in combination with a dedicated or even ambient RF source, the new energy harvester has the potential to power small sensor systems and shows excellent wireless range performance, leading to an increased area that can be covered by the RF source.

Building blocks include a 5-stage cross-connected bridge rectifier, a high-Q antenna and a 7-bit capacitor bank. The rectifier is brought at resonance with

the antenna by means of the capacitor bank. A control loop is added to compensate for any variation in the antenna-rectifier interface.

With this design, several limitations of existing RF energy harvesters have been overcome.



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### RIGID PCB BOARD MANUFACTURING FACILITY



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- (2) Inner Layer Multibond Lines with Mac Dermid & Kuttler Equipment
- OEM 7-Station Laminate Press System (5 Hot and 2 Cold) with Lauffer Automatic Board Punch with Siemens PLC systems (2001)
- Lauffer 7-Station Laminate Press system (5 Hot and 2 Cold) with Siemens Simatic OP7 control (1993-2000)
- Reduce Copper and Tin Stripping Lines with Schmid and Kuttler equipment
- Through Hole Line with Höllmüller, Circuit Automation, L+H & Kuttler Equipment
- Outer layer Imaging Line with Schmid, Kuttler, Hakuto, Steif, Teknek, Eigenbau, Techmech & Advanced Engineering Equipment
- Pola e Massa and Schmid Brushing / Grinding Lines
- (4) Galvanic Plating Lines; Ludy, (2) ATOTECH and Huber Industries (up to 2001)
- Schmid De-Smear and Aqueous wash lines
- Höllmüller Organic Coating Line
- Solder Mask, Solder Mask Vertical Coating & Heat Treatment Lines with Höllmüller, Schmid, Circuit Automation, Optical Radiation Equipment, ITC Intercircuit, Optical Radiation, Bacher & Kuttler (up to 2011)
- TePla 4061 Plasma Desearing System

#### Artwork Generation

- (2) Hope EG 751 PCB Processors (2011)
- (2) Barco Silverwriter MF/860 Plotters (2000)
- Orbotech PT14 Micro Film AOI
- Microvision ACM 2000 3D CMM
- Mycrona Magnus I 600 3D CMM

#### Drills

- (6) Posalux Ultra Speed 6000 5-Spindle 125K Spindle Speed (2000)
- (10) Schmolli-Maschinen System XL5-24 5-Spindle Linear 125K Spindle Speed
- (21) Schmolli-Maschinen System 5/5 5-Spindle 125K Spindle Speed
- (3) Schmolli-Maschinen System 1 twin 2-Spindle Drilling Machines
- Schmolli-Maschinen System 5/Euro 5-Spindle 125K Spindle Speed
- Schmolli-Maschinen System 5 5-Spindle 125K Spindle Speed
- Comet FXS-160.40 SG Feinfocus X-Ray Drill (2006)
- Pluritec Inspectra X-Ray Drill
- (2) ESI 5320 UV Laser MicroVIA Drill (2002)
- ESI 5220 UV Laser MicroVIA Drill

#### Routing/ Scribing

- Schmolli-Maschinen System XL6-21R 6-Spindle Linear 125K Spindle Speed Router (2001)
- (2) Schmolli-Maschinen System 6/5R (System 5) 125K 5-Spindle Speed Router
- Schmolli-Maschinen System 1/1
- (2) Klingelberg MIC 8-50 5 Head Routers
- Schmolli-Maschinen 992550 Scribing Machine
- Alfa 1500L/ FBW 50110R Scribing Machine

#### AOI – Automated Optical Inspection

- (2) Orbotech Spiron 8800 Avip (2004)
- Orbotech Spiron 8800 Vip (2004)
- Orbotech Spiron 8800 (2004)
- (2) Orbotech Inspire 9060-I (2000)
- (2) Orbotech IS-9060-AR (99/2000)
- (3) Orbotech VRS-4 LI (99/2000)
- (2) Orbotech VRS 4 Stereoscope (1999)
- (2) Orbotech VRS-4I (1999)
- Orbotech VRS-4 M (1998)
- Orbotech Visa Pro VRS-4I (1998)

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- Adaptronic KT630 & KT638 Hi-Pot Testers
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# Standards are DAM Important!

by **Gray McQuarrie**  
Grayrock & Associates

“Letting your customers set your standards is a dangerous game, because the race to the bottom is pretty easy to win. Setting your own standards—and living up to them—is a better way to profit. Not to mention a better way to make your day worth all the effort you put into it.”

—*Seth Godin*

I remember long ago my first job in the PCB industry, which was at a small, humble captive board shop owned by a larger, but still small, upstart company in Salt Lake City. One day, the VP of quality came to visit. He was fresh from a multi-day affair with a large consulting company. He asked, “What is quality?” We stumbled around trying to extract a definition. We talked about products we loved and cherished; travel experiences that changed our lives; a book that caused us to think differently about ourselves; an experience we shared with a close friend, which

shaped an unexpected future and gave our lives new meaning. Everything we were saying was personal, important, and intimate. Collectively, we are very proud and floating on a cloud. Then it happened: the sudden rush of air coming out of our balloon. The VP said, “You are all wrong. Quality is just meeting customer requirements. That is all it is and ever will be for this company.” The silence was deafening. In less than a year this company filed for bankruptcy. Their major customer no longer wished to do business with us.

Throughout the decades I have spent in this industry, I have often asked, what is quality? Too often, I hear, “Quality is meeting the customer’s standard requirements. Nothing more.” I have no idea where this definition originated, but somehow it stuck in our industry. It is the reason why we have such a difficult time competing and staying profitable. It is the reason why we have such a difficult time retaining customers where, despite all of our technology, and complex processes, we get



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no respect. We are seen as “nothing more than a pair of socks at Walmart” ([August 2011](#)). Yet, WigWam socks, which will only make their socks in America ([December 2012](#)), has a globally competitive, growing, profitable business. Why? Because they have an organization that lives, breathes, and performs to very high exacting standards with absolutely no excuses, no compromises, and no exceptions. Standards are DAM important!

Consider these words by retired U.S. Army General Norman Schwarzkopf:

“You show me a high performing organization and I will show you an organization where the leadership has established high standards and demands them. You show me a low performing organization and I will show you an organization where the leadership accepts low standards.”

And it is also about people. Schwarzkopf also says:

“How do you get more out of your people? You set high standards.”

Let me give you an example on why high standards are so important. Some plant managers I have spoken to don't understand the importance of keeping their plant spotless and reject the need for a [5S program](#) (sort, set, shine, standardize, sustain).

After all, what does a clean plant have anything to do with getting product made and out the door? Yet when I see a messy shop I know instantly they have a sales and profitability problem that threatens their very existence. And I know their quality is low, because of their own low standards that surround me. No need for fancy charts and presentations. Just show me the exit and point me toward the airport.

If you don't believe the environment of your factory is fundamental to your business, consider this. Back in the 1980s, New York City had an extremely high crime rate. Within ten

years it became (and still is) one of the safest big cities to walk around at night in the world. What happened? In 1985 New York City adopted the [broken window theory](#).

In essence, it is a 5S program for an entire city. The first way in which it was enforced was a policy of not having any graffiti on subway cars. If it got sprayed with paint, it was immediately taken off the line and cleaned. Just after doing this, [crime took a nosedive](#). As illogical on how this would have any impact on crimes such as robbery and murder, it worked.

Before we move on, let me ask you: What is your definition of quality? When I was a young man I read [Zen and the Art of Motorcycle Maintenance](#), by Robert M. Pirsig. Just remembering this book has compelled me to pull my worn copy off the bookshelf and hold it in my hands. Quality is a strong, attractive force! Pirsig defined quality in this way: “Quality is a characteristic of thought and statement that is recognized by a non-thinking process.” What does

that mean? He goes on to explain that, “Because definitions are a product of rigid, formal thinking, quality cannot be defined. But even though quality cannot be defined, you know what quality is!”

This is how I define and understand quality: Quality is about how people emotionally feel about you and your products. For example, do you create such a positive experience with your product that customers will pay more for it than your competitor's product? Put another way, if your product was a book, would your customers feel compelled, in a non-thinking way, to go get it, hold it, and start reading it?

Take this example: Steve Jobs was fanatical that the inside of the product, even though the customer would never see it, even though it had nothing to do with how the product functioned, had to be as good as the outside. Why did this seemingly unrealistically high standard work? Because it infected the

“  
**After all, what does a clean plant have anything to do with getting product made and out the door? Yet when I see a messy shop I know instantly they have a sales and profitability problem that threatens their very existence. And I know their quality is low, because of their own low standards that surround me.**”

way everything was conducted in the company including the precision and clarity of how the computer code was commented! The result was a quality product that attracted us like bees to honey.

Many executives and managers don't like this definition of quality because it seems too soft and psychological and it can't be measured. But it can! For example, when we are happy, our brains release endorphins. Companies that make products that aren't good for us understand this. This is why nicotine is in cigarettes. Endorphin release can be measured using sophisticated scanning techniques, such as a PET scan, which needs many circuit boards to operate, by the way.

A less invasive approach is to use something called the [net promoter score](#) (NPS).

With NPS, you simply ask a customer whether they would promote your product. If many of your customers are promoters, your business should be growing. They see your product or service as having exceptional quality. If you ask, they will likely tell you how they were extraordinarily pleased. If you doubt this, think about freely promoting a product that you enjoyed so much that you mentioned it to a stranger. Why do we do that? It's a psychological need to promote and a pathological indicator that our brain has been affected (or possibly infected).

Quality is psychological. Compliance is technical. This is a vital distinction.

For example, our quality departments are really customer compliance departments. Compliance is all about meeting customer standards and requirements. It's unemotional. It's detached. It's uninspiring. In fact, too many of us in our industry have encouraged our suppliers (without knowing the consequences) to make a mediocre commodity product. We don't want to be pleased by our supplier, because we could be locked into a high price. We don't want to

work with our supplier on a new technology, because it might hurt our existing business. We don't want our supplier to be better, because we want to be able to play one supplier off of the other in a never-ending game of price reductions, so we can report cost reductions to our bosses. The net result of this low standards commodity mindset has been nothing short of a revolt.

Let me explain. Many laminate suppliers moved away from a compliance commodity mindset imposed on them by their PCB fabricator customers, to a quality mindset aimed at the OEMs. This strategy goes by the name of OEM marketing. Your laminate suppliers have learned what to say to the OEM to get them excited and involved emotionally. They back it up with a variety of performance testing demonstrating high-signal speed with strong signal integrity. Before long, the OEM has so bought in

that they want this material, and no other, in their new product. We, as the PCB fabricator, have become completely cut out of the laminate vendor decision! This has changed the game. The laminate vendors have leapfrogged the supply chain to take away our control. As angry as this might make you, realize this was born out of a PCB industry-wide, commodity mindset that quality is nothing more than meeting customer standard requirements. It was born out of our own low standards.

We created this. Now, how do we get out of it?

Consider this. Our behaviors and how we conduct ourselves have either a strong attractive force or a strong repulsive force. Since quality is about attraction, then the behaviors of people and the culture of the enterprise matter. In my books, "Change Your DAM Thinking," and, "You Have a DAM Problem," I refer to the ego DAM. Are we attracted to people who have to demonstrate they are stronger, smarter, and better than we are or are we attracted to

“  
**Compliance is all about meeting customer standards and requirements. It's unemotional. It's detached. It's uninspiring. In fact, too many of us in our industry have encouraged our suppliers (without knowing the consequences) to make a mediocre commodity product.**”

people who want to show us our true potential and help us to be better? The pathology of the ego DAM is a complete inability to ask for help when we need it. This might be because we want full credit or we want to demonstrate that we can do something ourselves. Whatever the reason, the ego DAM blocks productivity.

Here is one way to break the ego DAM. Make your objective clear, including when the objective must be met. If your people need more time, but don't want to ask for help, insist they do so, in order for the job to be done on time. Remember, you are setting the schedule. It will become painfully obvious that you aren't kidding about what you expect and demand.

Once you are focused on standards for behaviors you can focus on standards for performance. For example, sorting bad product from good product never works 100% of the time. You will have escapes, which will threaten to ruin your quality reputation with your customers. The other problem created with processes incapable of producing to the customer requirement is the temptation to ship bad product because it just crosses the compliance line. I have seen this happen far too often and when this is allowed as standard practice then the survival of the company is at risk. The internal requirements for product compliance have to be higher than the customer requirements. In a way this

was the true intent of a Cpk being equal to two, which is what is described within a Six Sigma context. The challenge is this is a very difficult standard to achieve and it has to be done in such a way that it attracts customers. When Six Sigma is about being arrogant, it doesn't work.

These two areas, the behavior of your people and your company's performance, are good starting points. Standards are DAM important. If you think that your PCB shop is just a commodity where there is nothing you can do that is special, different, or unique that will command a higher price and create customer loyalty, then consider another quote from Seth Godin:

"We all have so many degrees of freedom than what we give ourselves credit for. Even a waiter at Denny's can figure out how to become the waiter who will be missed when gone." **PCB**



Gray McQuarrie is president of Grayrock & Associates, a team of experts dedicated to building collaborative team environments that make companies maximally effective and author of [Change Your DAM Thinking](#) and [You Have a DAM Problem](#). To read past columns, or to contact McQuarrie, [click here](#).

## Powerful Superconducting Quadrupole Magnet Successfully Tested

The U.S. LHC Accelerator Program (LARP) has successfully tested a powerful superconducting quadrupole magnet that will play a key role in developing a new beam focusing system for CERN's Large Hadron Collider (LHC). This advanced system, together with other major upgrades to be implemented over the next decade, will allow the LHC to produce 10 times more high-energy collisions than it was originally designed for.



Dubbed HQ02a, the latest in LARP's series of high-field quadrupole magnets is wound with cables of the brittle, but high-performance superconductor niobium tin ( $Nb_3Sn$ ). Compared to the final-focus quadrupoles presently in place at the LHC, made with niobium titanium, HQ02a

has a larger aperture and superconducting coils designed to operate at a higher magnetic field. In a recent test at the Fermi National Accelerator Laboratory, HQ02a achieved all of its challenging objectives.



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# Mil/Aero007 News Highlights



## [FTG, TPC Form JV to Supply PCBs to Aerospace Market](#)

The joint venture will build on the strong customer base FTG has in the aerospace market as well as FTG's knowledge and expertise of aerospace technical and quality requirements; this will be combined with TPC's established manufacturing facilities in Tianjin, China.

## [Westak Awarded MIL-PRF-31032 Certification](#)

Westak has successfully achieved certification and qualification to MIL-PRF-31032 for its Forest Grove, Oregon manufacturing facility. The certification was awarded in recognition of the company's advanced quality management system and production processes that meet the stringent requirements of the standard.

## [FTG Circuits Segment Sales Down \\$1.4M or 13% in Q2](#)

"The second quarter of 2013 saw a return to profitability for FTG while we continued to invest in technology and facilities across the corporation. Obviously, the joint venture we announced with TPC is an important strategic investment and will provide an exciting new solution for our customers," stated Brad Bourne, president and CEO.

## [Commercial Aero Revenue Up 16.2%; Defense Down 1.3%](#)

The study found that in 2012, commercial aerospace revenues significantly increased and more than made up for declines in the defense segment. Commercial aircraft segment revenues increased 16.2% or US \$38.4 billion in 2012, while defense segment revenues decreased 1.3%, for a combined increase of 5.9%, up from a 1.6% increase in 2011.

## [Global UAV Market to Reach \\$89B in Next 10 Years](#)

"The UAV market is evolving, it is becoming an increasingly international market as it grows," said Philip Finnegan, Teal Group's director of corporate analysis and an author of the study. "UAVs have proved their value in Iraq and Afghanistan

and are being sought by a growing number of militaries worldwide."

## [Asia's Defence Budgets to Outpace North America's by 2021](#)

Asia Pacific budgets are set to outstrip the U.S. and Canada by 2021, fuelled by an explosion in global arms trade that threatens the competitive edge and dominance of the U.S., the UK, and European defence trade according to the biggest budget and export study since the economic downturn.

## [Report: U.S. Electronic Security Industry Outlook to 2017](#)

The U.S. has been the largest market for the electronic security products worldwide for several past years. The demand for the electronic security systems continues to be driven by a high perceived risk of crime, despite a long-term trend of falling crime rates.

## [Business & Commercial Aircraft Market Forecast Released](#)

As the business and commercial aircraft markets continue to recover from the industry downturn, signs of forward momentum are beginning to emerge. Demand for new aircraft orders will continue to come from established and developed markets, and the growth potential in emerging markets such as China, India, Russia, and Latin America is predicted to play an increasingly important role in the global aviation marketplace.



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# Lessons from Lombardi: Not Just for Football Anymore

by Steve Williams

## Old School = New School

It occurred to me after reading an article in a local paper recently that solid management fundamentals are timeless and cross all industries. It is critical that an organization have a foundation based on a practical management game plan to be in the chase for excellence.

The article, [Would Vince Lombardi be successful in today's NFL?](#), written by sportswriter Gary D'Amato, appeared in the Milwaukee Journal Sentinel, a politically skewed newspaper for which I have no particular fondness. However, the sports reporting has always been very good. In my home state of Wisconsin, the mere mention of Saint Vinny generally elicits a reverent hush, recollections of legendary Packer moments, and the occasional genuflection from the old timers. For those of you with your football heads in the sand, [Vincent Thomas Lombardi](#) built one of the greatest dynasties in sports history in the 1960s, about 90 miles north of my home. Vince would have been 100 years old on June 11, 2013.

The article noted the facts that NFL players today are bigger, stronger and faster, and that the offensive and defensive schemes were a magnitude more complicated than in Vince's day. Also discussed was just how modern players, especially "me generation" football divas like Terrell Owens, Randy Moss, Jay Cutler, and Chad Ochocinco Johnson, would react to Lombardi's demanding, no excuses, and winning-is-everything coaching style. The answer is that Vince Lombardi would most certainly be not only successful today, but I would bet a boatload of beer that he could lead a modern-day team to a world championship. How is this possible? Because Lombardi's success was built on the foundation of fundamentals: hard work, discipline, flawless execution and the pursuit of building blocks of excellence that never go out of style.

Looking at the lessons of Lombardi's success, it is clear that his philosophy is not football, or even sports-centric, but applies to any business, organization, service and industry that is will-



[The New York Times](#)/Associated Press.

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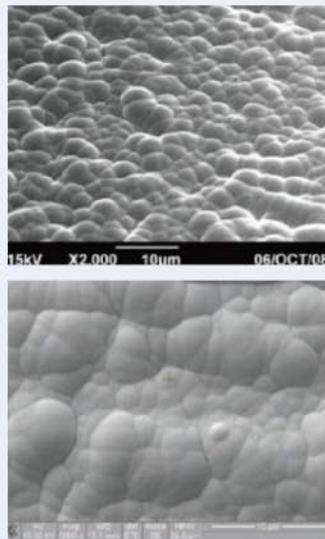
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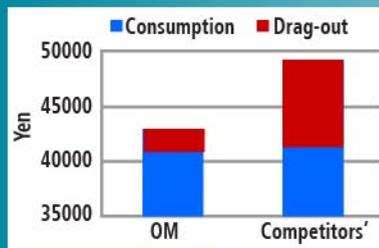
OM doesn't attach Ni surface under low Au content

Au bath	Conventional IG	Conventional IG	OM	OM
Au content	2g/L	1g/L	1g/L	0.5g/L
NBath	Conventional Ni	Conventional Ni	930	930
SEM				

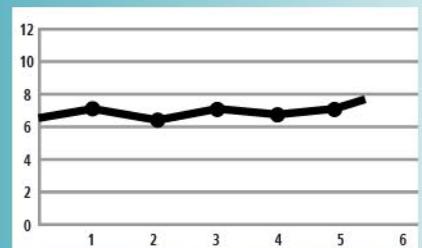
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ing to embrace it. I challenge you to step out of your “Lombardi is football” mentality and take a fresh look at what can be learned from the legend and applied to your business.

## **Lessons from Lombardi**

### ***It's About Winning***

Lombardi saw the importance of winning in any game—in life and so on. He couldn't accept defeat as final and he had a single-minded focus when it came to winning football games. As a leader, it is important to understand that people want to be part of a winning team, which requires a winning attitude. Lead by example; be positive while at the same time persistent. In whatever thing you want to do, there will be resistance and you need that winning attitude to break through and reach your team's goal.

### ***What it Takes to be Number One***

Lombardi famously stated “Winning is not a sometime thing; it's an all-the-time thing. You don't win once in a while; you don't do things right once in a while; you do them right all the time.” This speaks to the culture of an organization, whether the organization is a football team or a printed circuit manufacturer. A winning culture is an attitude that needs to be lived and breathed by every single employee, every single day.

### ***Outwork Everyone***

Lombardi knew that the price of success was hard work, hard work, and more hard work. He lived and breathed it with his teams, and this discipline helped them win their championships. You cannot bypass hard work; hard work is the shortest path to success. Show your team the value of hard work by personal example; and as you lead by hard work, your team will follow.

### ***Teamwork is Essential***

Lombardi recognized the importance of teamwork and he made sure each and every player understood that “there is no I in team.” There are many ways to say it:  $2 + 2 = 5$ ; two heads are better than one; synergy. Lombardi

understood that teamwork was the only way to win, whether it was in the game, or in life.

### ***KISS***

Lombardi's Packers had only a handful of plays and none of them were overly complicated. He had no laminated cards, nor did his players have to flip over wrist bands listing dozens of plays with multiple options. However, the few plays that he did use were constantly and passionately enforced and practiced until it became second nature to every single player. Simplicity all but eliminated any misunderstandings and confusion so that everyone was on the same page.

### ***Chase Perfection***

Several former Packer players have described Lombardi's practice regime of running one rather simple offensive play dozens of times in a single practice until every individual player executed his assignment flawlessly. Over and over and over again, not a single mistake was overlooked or tolerated. Games were conducted in the same manner: Mistakes that weren't tolerated in a loss weren't tolerated in a win either. Lombardi's premise was that no team or individual has ever come even close to perfection by accident; the only chance of ever reaching perfection is to actively and constantly chase it.

### ***Look in the Mirror***

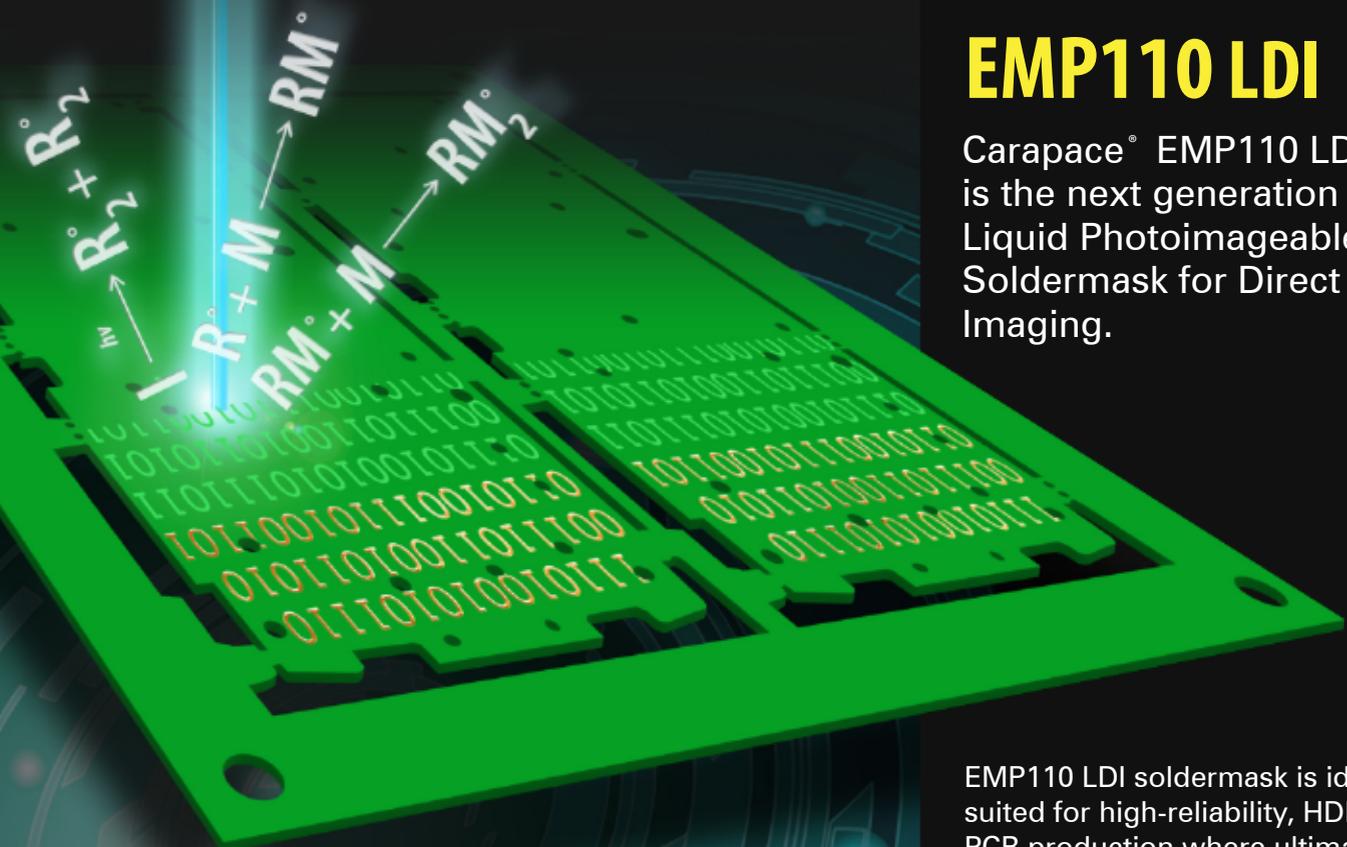
I would again challenge you to take a look at these lessons from Lombardi and find any one of these that doesn't, or shouldn't, apply to your organization. By the way, ESPN just voted Lombardi the [greatest coach in NFL history](#).

As the great Vince Lombardi once said, “Perfection is not attainable, but if we chase perfection we can catch excellence.” **PCB**



Steven Williams is the commodity manager for a large global EMS provider, and author of the book [Survival Is Not Mandatory: 10 Things Every CEO Should Know About Lean](#). To read past columns, or to contact the Williams, [click here](#).

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# Miniaturization and Reliability

by Karl Dietz

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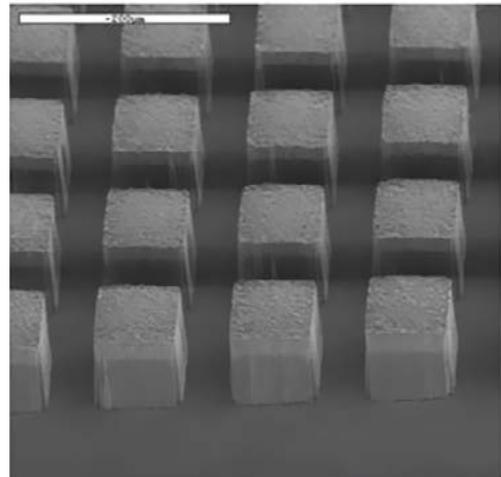
Miniaturization of electronic devices has been a trend over decades and is continuing into the foreseeable future. How this trend affects the reliability of these devices is an important question. Some processes, when applied to ever-smaller dimensions, reach a point where they yield less reliable structures, and changes in materials and processing are necessary to maintain reliability. On the other hand, other novel technologies that enable smaller structures are inherently more reliable. The following technologies are examples of miniaturization-reliability relationships.

## Wafer Bumping with Plated Copper Pillars

Wafer bumping, the formation of solderable, raised, conductive features that allow the connection of flip chips to a package, typically involves the use of solder, either applied by a stencil, or plated, or by the mechanical positioning of a preformed solder ball. Height and width of these bumps are about the same after reflow (i.e., the bumps become spherical after reflow). This means that minimum spacing requirements between solder bumps and the “stand-off height” are linked, and one cannot reduce one without reducing the other.

The use of plated copper pillars as bumps “decouples” the stand-off height from the minimum spacing between bumps because there is no reflow and the aspect ratio of the pillars remains as plated (Figures 1 and 2). The cop-

Wafer with plated copper pillars, capped with tin, after resist stripping



Source: Fraunhofer Institut

Figure 1: Plated copper pillars, capped with tin, after resist stripping.

## Copper Pillar Area Array Interconnects

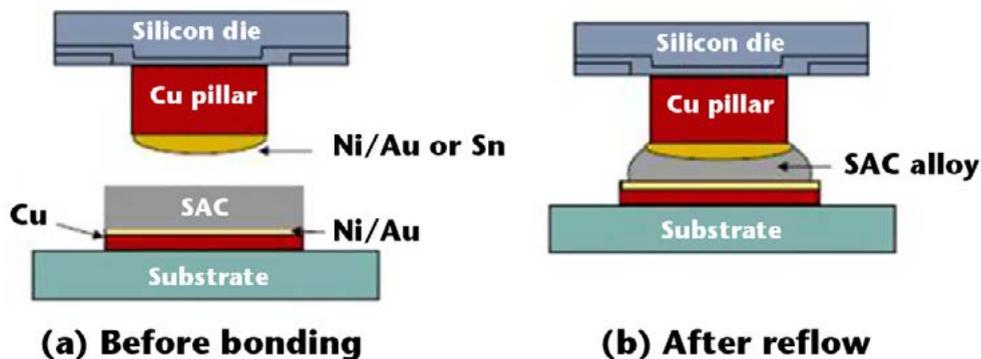


Figure 2: Schematic of copper pillar area array interconnects. (Source: Micron)

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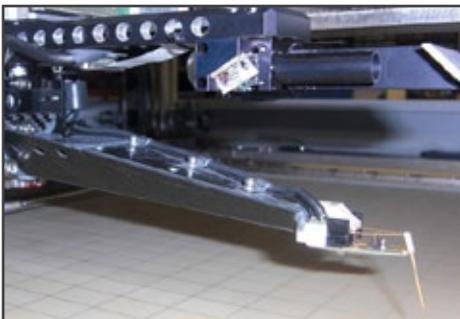
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per pillars are typically capped with a solderable surface such as plated tin. The higher stand-off height at smaller bump pitches can facilitate more reliable underfill coverage, and the better thermal (and electrical) conductivity of copper compared to solder may contribute to better thermal management; both factors contribute to interconnect reliability. However, the lower ductility of copper compared to solder is a potential detriment.

### Filled Microvias and Through-holes

The filling of microvias with plated copper (plating vias shut) yields a more reliable Z-axis interconnection compared to non-filled microvias because of the improved thermal and electrical conductivity, and the seal that the filling provides against contaminants getting trapped in the microvia. Reducing the diameter of microvias, and thus increasing the aspect ratio has its limitations because of reliability concerns. These concerns focus mainly on the potential problem of not being able to clean the copper at the bottom of the microvia sufficiently so as to avoid copper-to-copper peeling between the base copper and the electroless copper. Miniaturization is enabled due to the fact that pads can be located on top of the filled microvia, avoiding the space-consuming “dogbone” design for via-to-pad connections. Plating through-holes shut is a more recent technology that offers the same advantages mentioned above for microvias (Figure 3). The specially formulated or-

ganic additives for the acid copper plating bath cause the copper to first bridge the center of the through-hole barrel. The complete filling that then follows can be viewed as the filling of two microvias (or blind vias).

The functions of plating additives are fairly well understood: Polyglycols such as polyethyleneglycol (PEG) act as inhibitors, small amounts of chloride enhance the inhibiting effect of PEG, bis(3-sulfopropyl)-disodium-sulfonate (SPS), other disulfides, thiourea, thiocarbamates act as accelerators, and quaternary nitrogen compounds act as levelers. Landau studied in particular the role of PEG and SPS in the bottom-up via fill process. He points out that at the beginning of the plating process there are hardly any additives in the via hole to be adsorbed on the hole wall and hole bottom surfaces because of the low liquid volume-to-surface area ratio in the via. PEG adsorbs faster than SPS but there is very little PEG to cover the hole walls and bottom. However, on the surface, the PEG supply is plentiful and the fast-adsorbing PEG inhibits plating on the surface. In contrast, practically all additives that end up on the hole surfaces have to diffuse into the hole. Since SPS diffuses faster than PEG, it reaches the bottom of the hole first, and once adsorbed, forms a barrier against PEG adsorption. The slower diffusing PEG slowly builds up on the upper part of the hole wall near the surface, acting as a plating inhibitor while the dominant SPS at the bottom of the hole accelerates plating.

Landau found that the relative concentrations of PEG and SPS have an influence on how well the bottom-up plating performs. His findings also explain the effect of via diameter and aspect ratio on the bottom-up plating performance. Wider via diameters mean a less favorable volume-to-area ratio in the hole which means there is more PEG initially available to adsorb on the via bottom. A high aspect ratio via results in a greater concentration gradient in the hole cylinder between a slowly diffusing additive such as PEG and a faster diffusing additive such as SPS, thus favoring bottom-up plating.

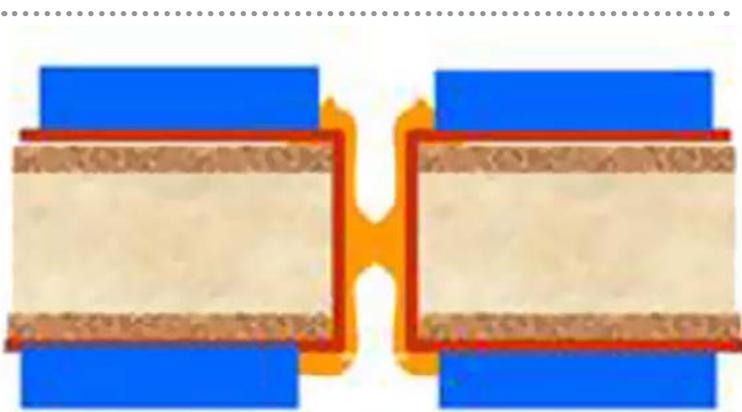


Figure 3: Early stage of plating a through-hole shut by via-fill process. (Source: Stephen Kenny, The Board Authority<sup>[1]</sup>)

### Fine Line Circuitization, Problems with Miniaturization, and Potential Alternatives

The SAP (semi-additive process) has been in use to create the finest circuit lines and spaces in electronic packages, but progressing to even finer features raises reliability concerns. There is no copper foil on top of the dielectric film and the copper layer has to be built starting with an electroless copper seed layer of less than one micron. Traditionally, one has relied on the “swell and etch” chemistry to create a micro-roughness on the filled epoxy surface ( $R_a > 0.5$  micron) to allow mechanical anchoring of the electroless copper and to yield reasonable copper adhesion. As very fine conductor widths on the build-up dielectric layers of flip-chip packages approach 10 micron, and are expected to become even smaller in the future, such micro-roughness is deemed too rough and smoother dielectric surfaces are demanded. This is not only desirable because of the signal integrity needed at high frequencies, but also to avoid high resistance shorts between fine lines due to residual palladium catalyst particles between copper tracks on the dielectric surface.

It is more difficult to remove the palladium particles from recessed areas of a rough dielectric surface than it is to remove them from a smoother surface. Designers of advanced flip chip packages now target dielectric build-up multilayer (BUM) films with a very low surface roughness  $R_a$  of about 0.1 micron without sacrificing good copper adhesion (10N/cm). The dielectric layer surface roughness is basically the result of the desmear (swell & etch) process and chemistry. To achieve a smoother dielectric surface, improved resins need to be developed and the filler particle size has to approach nano dimensions. The smooth dielectric surface causes problems with electroless copper adhesion as

**Damascene-type architectures: recessed lines, three-face bonding of metal, flat surfaces. Fabrication by imprint patterning, injection molding, transfer lamination (e.g. U.S. Patent 4,606,787), or laser ablation.**



Figure 4: Damascene-type structures.

well as dry film resist adhesion to the electroless copper.

A potential solution to these problems is the use of recessed circuits, embedded in the dielectric (Damascene structures), formed by laser ablation of the dielectric, or transfer lamination, or imprint patterning (Figure 4).

Compared to conventional, raised copper circuits, the recessed copper circuits have not one, but three bonding surfaces connecting them to the dielectric, and there are no protruding sides that are subject to lateral shear forces during processing. **PCB**

### References

1. “Blind Micro Via and Through Hole Filling for Thin Core and Flexible Base Materials,” Stephen Kenny, The Board Authority, 2006, pg. 35.



Karl Dietz is president of Karl Dietz Consulting, LLC, offering consulting services and tutorials in the field of circuit board and substrate fabrication technology. To view past columns or to reach Dietz, [click here](#). Dietz may also be reached by phone at (001) 919-870-6230.

# PCB007 Market News Highlights



## [IPC TMRC Highlights Economic and Political Trends](#)

In keeping with the forward-looking theme of the conference, Gene Marks' presentation, "Economic, Political and Other Key Trends: 10 Things Happening Today That Will Affect Your Business Tomorrow," will take a thought-provoking and entertaining look at how the economy, Washington and technology affect businesses, and what successful companies are doing today to ensure future profitability.

## [Component Suppliers Struggling During Market Recovery](#)

While all leading indicators point to the return of seasonal growth in the second half of 2013, the electronic component industry, including semiconductors, is currently seeing weaker orders than expected during this phase of market recovery.

## [N.A. to Claim Nearly Half of \\$72B Tablet Spend in 2013](#)

More than 39 million tablets shipped worldwide during the first calendar quarter of 2013, representing the second largest volume of shipments to date; only bested by the previous quarter ending calendar year 2012, according to market intelligence firm ABI Research.

## [Mobile DRAM Underperforms in Q1](#)

Laboring under the combined weight of a seasonal slump and sharply lower average selling prices, the market for mobile dynamic random access memory (DRAM) posted lackluster results in the first quarter, according to a DRAM Dynamics brief from information and analytics provider IHS.

## [PC Industry Continues to Shrink; Down 10.9% in Q2](#)

Worldwide PC shipments dropped to 76 million units in the second quarter of 2013, a 10.9% decrease from the same period last year, according to preliminary results by Gartner Inc. This marks the fifth consecutive quarter of declining shipments, which is the longest duration of decline in the PC market's history.

## [TFT-LCD Industry's Capacity Increase Leads to Several Trends](#)

WitsView research manager Boyce Fan says that the newly-added capacity leads to several possible directions for the TFT-LCD industry developments. Firstly, the new capacity is concentrated on the Gen 8.5 fabs, meaning the large-sized panel supply is largely lifted, and the price pressure on the large sizes is inevitable to solve the excessive capacity problem.

## [Mexico's Cost Advantage to Drive Exports Growth](#)

Within five years, higher manufacturing exports due to a widening cost advantage over China and other major economies could add \$20 billion to \$60 billion in output to Mexico's economy annually. And thanks to the North America Free Trade Agreement (NAFTA), U.S. manufacturers of components for everything from automobiles to computers assembled in Mexico also stand to benefit, according to new research by The Boston Consulting Group (BCG).

## [N.A. Semiconductor Equipment Book-to-bill Improves in May](#)

North America-based manufacturers of semiconductor equipment posted \$1.32 billion in orders worldwide in May 2013 (three-month average basis) and a book-to-bill ratio of 1.08, according to the May EMDS Book-to-Bill Report published today by SEMI.

## [Smart Grid Tech Market: \\$73B in Annual Revenue by 2020](#)

Although the market for smart grid technologies is already established, representing more than \$33 billion in revenue in 2012, it has grown with little contribution from a number of countries with populations greater than 100 million, and with almost no activity in Africa, with its population of 1 billion.

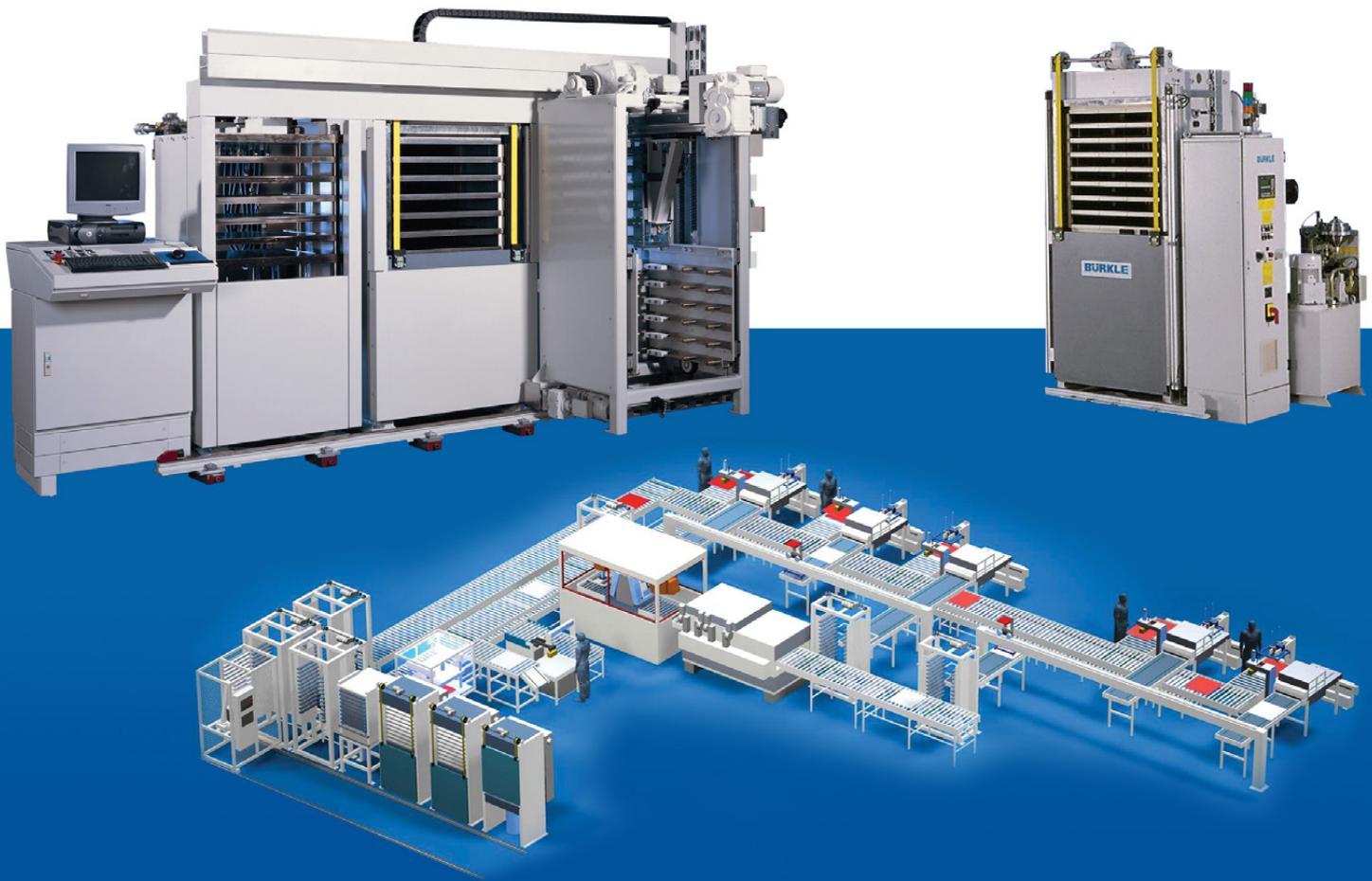
## [Tablets Remain Lucrative Market; 39M Units Shipped in Q1](#)

Tablets remain a lucrative market for the three largest world regions for consumer electronics and computer adoption: North America, Western Europe, and Asia-Pacific's Japan and South Korea. "Three regions of the world are expected to yield 97% of tablet revenues in 2013," says senior practice director Jeff Orr.

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# PTH Voids: Getting to the Root Cause, Part 3

by Michael Carano

OMG ELECTRONIC CHEMICALS

## Critical Electroless Copper Pre-plate Preparation

Recognizing that the surface topography created after desmear is less than optimum (compared to lower- $T_g$  materials), more attention must be directed to electroless copper pre-plate chemistry. First, ensuring sufficient coverage and distribution of the catalyst is a critical success factor. Basically, sufficient concentration of the palladium catalyst on the hole wall provides nucleation sites with which to initiate the deposition of copper. When a high surface topography is available, the catalyst is more readily able to adsorb onto the resin. However, the higher

performance materials (as previously stated) are more chemically resistant to alkaline permanganate chemistry. Thus, there is less topography and by default, less catalyst adsorption.

To counter this effect, new cleaner/conditioners must be utilized to enhance catalyst adsorption. The key is to improve the flocculation of the catalyst to the hole wall as well as the adhesion (resin and glass) without building excessive thickness on the copper interconnects. Thus, the cleaner/conditioner acts as an adsorption modifier. These cationic polymers are believed to either change the charge density of the surface and/or provide chemical bonds for

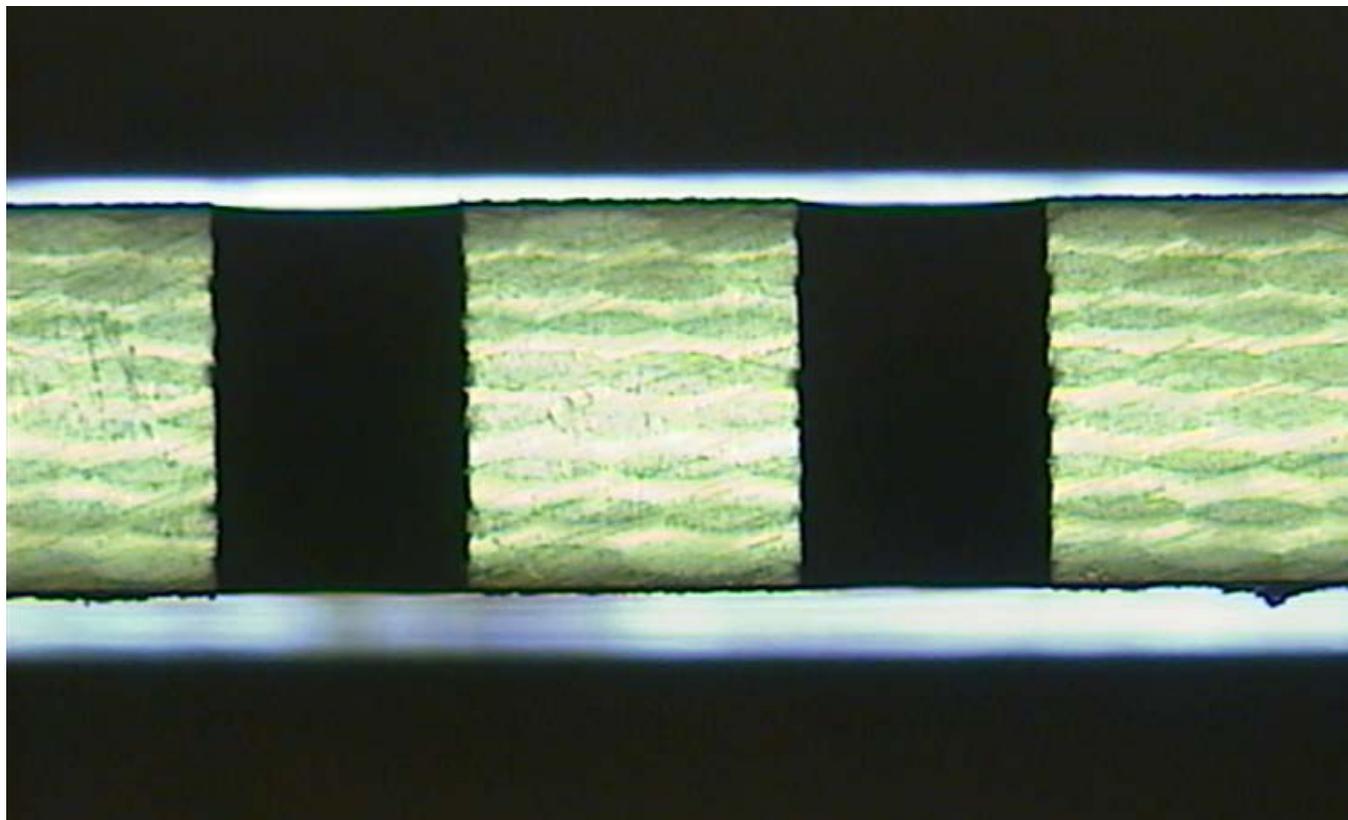


Figure 1: Backlight coverage of 45 μm of electroless copper.



# IPC Conference on Component Technology: Closing the Gap in the Chip to PCB Process

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attracting the catalytic species. To further complicate the issue, the author believes that different types of surfactants are more beneficial than others with respect to adhesion of the plated copper. Why is this critical? This is critical, based on the fact that excessive copper thickness or too rapid of a plating deposition rate can lead to reduced adhesion. While the high plating rates may guarantee perfect void-free coverage, there is no guarantee that adhesion will not be compromised. It has been demonstrated over and over that a slow and even deposition rate will not only give excellent coverage of copper on the most difficult to metalize substrates, but will ensure better adhesion as well.

At the very outset, it was stated that achieving excellent adhesion on these substrates is

made more difficult. Thus, providing an electroless process that promotes excellent coverage and adhesion is achievable. From a chemical standpoint, this means understanding the relationship between adhesion, plating rates and catalyst adsorption.

**Plating Line Modifications to Minimize or Eliminate Voiding**

While chemical interactions are very important with respect to achieving a quality copper deposit, one must never underestimate the impact of plating line modifications on plating. As vias shrink in diameter and PWBs increase in thickness, ensuring sufficient solution flow remains a critical success factor. In addition, the hydrogen gas that is a by-product

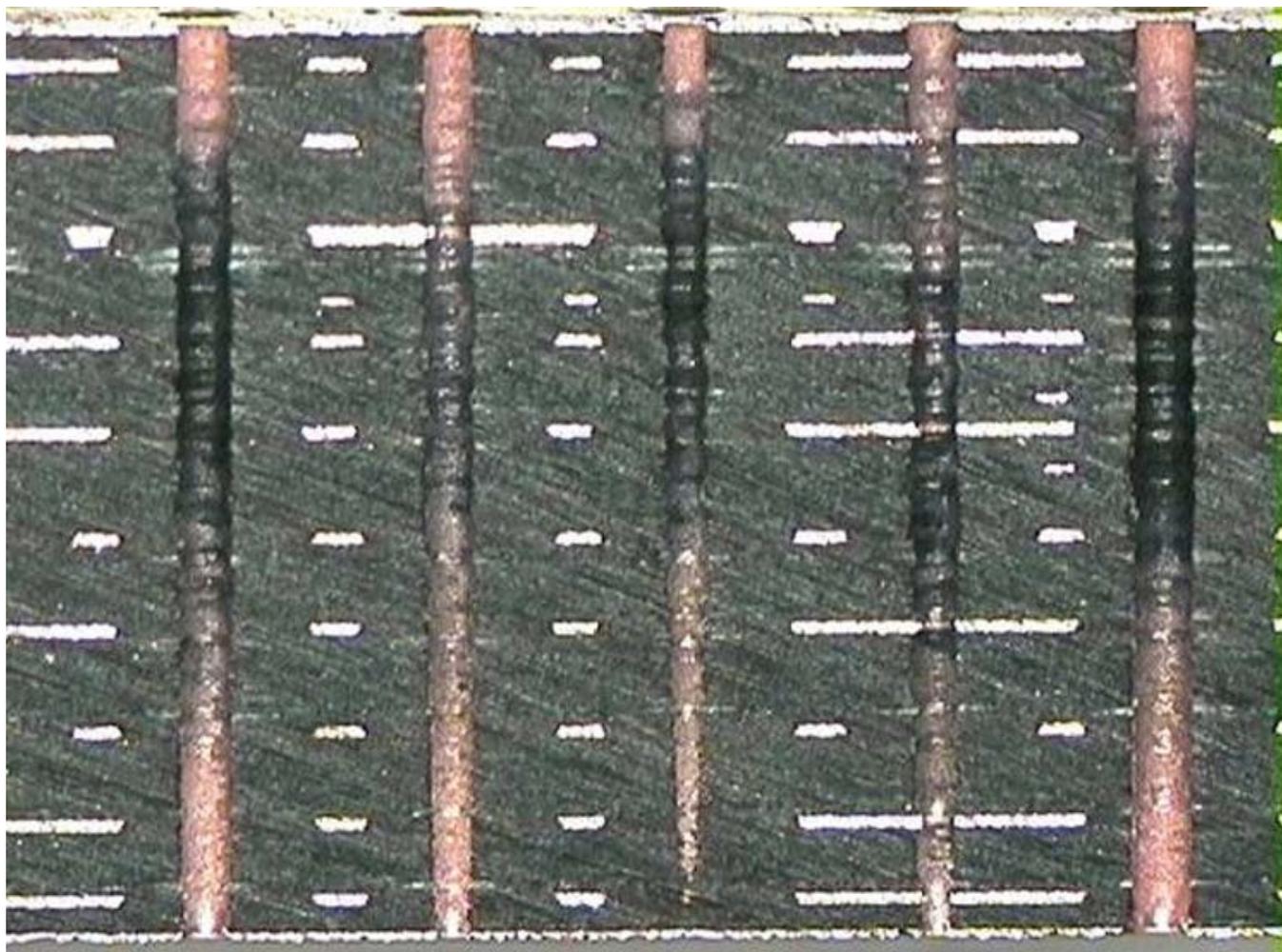


Figure 2: Small-diameter void created by the lodging of the hydrogen gas bubble or bubbles.

of the electroless copper reaction is known to create voiding in small holes. It is understandable that as diameters decrease and board thicknesses increase, the opportunity for gas bubbles to remain entrapped are much greater. As hydrogen gas is generated through the plating reaction, the gas bubbles formed within the vias have the tendency to remain. However, modifications to the cell, if designed properly, will reduce the tendency for the gas bubbles to remain within the hole, leading to voids. An example of a void attributed to gas bubble formation is shown in Figure 2.

What can be done to minimize the void formation concerns with gas bubbles? There have been numerous methods employed to battle small-hole voiding. Some of methods are as follows:

- Increased work-bar agitation
- Double passing through electroless copper
- Angled racking of panels
- Lifting and dropping rack midway through the electroless cycle
- Vibration
- Thump agitation
- Increased panel spacing to aid in solution transfer

Extensive practice has shown that vibration, increased panel spacing and increased work-bar agitation significantly contribute to the reduction of plating voids. The principle is quite simple: If one is able to generate a pressure differential sufficient to increase fluid flow through the vias, voids can be eliminated at least kept to a minimal noise level. Thus, some type of stroke or paddle agitation for the plating rack is beneficial.

While stroke (paddle) agitation is helpful with respect to increasing fluid flow through the

vias, it is highly recommended that vibration be added to the agitation frame of the plating cell. This will ensure that the rack containing the printed wiring boards receives sufficient energy with which to dis-

lodge gas bubbles entrapped in the vias. Careful design of the vibration system is required. The engineer must consider the total weight of the rack, the weight of the panels in the rack and the weight of the agitation frame.

It is quite obvious that a combination of rack agitation and vibration provide significant benefits to PTH quality than either can do alone. And increased panel spacing should also be considered at a third leg of the modification.

### Summary

Achieving a void-free deposit through the PTH line need not be an elusive goal. Instead, careful thought should be given to line design and the critical interactions of chemical param-

eters. In addition, the fabricator and supplier must work closely to ensure high-performance materials can be processed with the highest levels of reliability. Certainly, a void-free deposit of electroless copper is a key indicator of PTH quality. Of course, while void-free deposits are a must, one cannot compromise plating adhesion to the hole wall or interconnect. **PCB**

Follow these links to read [Part 1](#) and [Part 2](#) of this series on PTH voids.



Michael Carano is with OMG Electronic Chemicals, a developer and provider of processes and materials for the electronics industry supply chain. To read past columns, or to contact the author, [click here](#).

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# PCB007 Supplier/New Product News Highlights



## **Eagle Purchases LDI Machine from Orbotech**

Mike Kalaria, president and CEO of Eagle Electronics of Schaumburg, Illinois, has announced that his company has acquired an Orbotech 8800 Hi LDI machine. The purchase of LDI system marks another milestone in Eagle's ongoing commitment to lead the industry in both service and technology.

## **Excellon Delivers 136L Intelli-Drill to Advanced Circuits**

The Excellon 136L Intelli-Drill System offers high speed axis positioning and a large work area of 30 by 36 inches for those companies running larger panel prototypes and production PCB's. The Intelli-Drill vision system offers capabilities such as post lamination tooling optimization as well as drilling and routing relative to surface targets and features to provide high accuracy and precision hole placement.

## **Graphic Installs Outer Layer Strip-Etch Line from WISE**

Graphic PLC has announced the installation and commissioning of an outer layer strip-etch line from WISE s.r.l. This equipment is used in the production of plated layers, where laser defined photoresist is removed in the stripping chamber to expose the underlying base copper material. This copper layer is subsequently removed in the etch chamber.

## **Rainbow Expands Presence in Asian Electronics Sector**

Leading specialist PCB equipment manufacturer Rainbow Technology Systems (RTS) has announced a number of developments to strengthen its presence in the Asian electronics sector. RTS is the company behind a revolutionary new Rainbow System for PCB manufacture, which is more cost-effective, faster, and greener than traditional methods.

## **Lightworks Begins Next Project for Maskless**

Maskless Lithography's CEO, William Elder, stated, "We are very pleased to have an optical development partnership with LightWorks Optical Systems. Their unique expertise helped provide significant cost and performance improvements to our

manufacturing process, which has already made a positive impact on production yields."

## **Isola Expands Production of IS680 in Germany**

"I am very pleased that IS680 is now in production in Europe. Isola is committed to servicing our RF and microwave customers on a global basis, as demand requires, and improving our delivery times for the European market," stated Karl Stollenwerk, president of Isola Europe and managing director of Isola GmbH, Germany.

## **Orbotech Eyes Growth Opportunities; Forms New Units**

The company has created two new corporate units: Strategy and Business Development and Global Product Organization. These changes are designed to benefit customers by improving the time to market for new and innovative products that will enable them to meet increasingly difficult challenges in the manufacture of sophisticated electronic components and devices.

## **Quadra Receives Zuken's Distributor of the Year Award**

Zuken has recently awarded its European CAD-STAR Distributor of the Year Award to recession-beating reseller Quadra Solutions for the fifth time. Quadra Solutions had a record year in 2012-13, growing 20% on the previous year and achieving ISO 9001 accreditation.

## **Gardien Europe is Exclusive Distributor of InScantech AVI**

Born out of a company with arguably some of the best electrical test equipment credentials, Gardien Germany has partnered with InScantech to bring leading automated visual inspection (AVI) systems to Europe and CIS countries.

## **Park Electrochemical Reports Q1 Sales Drop**

Park Electrochemical Corporation has reported net sales of \$43,438,000 for the first quarter ended June 2, 2013, compared to net sales of \$46,046,000 for the first quarter ended May 27, 2012. Park reported net earnings before special items of \$5,129,000 for the first quarter ended June 2, 2013 compared to net earnings before special items of \$4,940,000 for the first quarter of last year.

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# Rooting out the Root Cause

by **Martin Gaudion**

POLAR INSTRUMENTS, LTD.

When your measured trace impedance is significantly different from the calculated/ modeled trace impedance, be careful before jumping to conclusions.

Sometimes, your intuition can lead you astray—especially when analysing engineering problems. This makes it worth taking a step back to consider possible alternatives. Maybe, as my colleague Neil Chamberlain puts it, “That came from left field!”

I’ll set the scene for this month’s column topic with a non-electronics experience of my own. Polar Instruments is based on a small island with tiny roads lined with unforgiving stone walls that make driving an interesting challenge. Because I need to take equipment to shows and visit customers occasionally, I use a minivan for my commute—despite its unsuitability in local traffic. Recently, my wife persuaded me to look for an alternate vehicle—something that is small, economical, reliable, and practical. After several weekends of hunting the new and used car lots, we came to the conclusion that although there were plenty of possibilities, nothing had leapt out and said “Buy me!”

The cars we were seeing only fulfilled one of the criteria each. Being an engineer at heart I suggested to my wife that we replace “and” with “or” and run the math again in our heads: small or economical or reliable or practical. With an “or” function, only one criteria has to be true for a “Yes!” outcome. We found that car, and I asked my wife, “Shall I buy it?” She replied, “I am not saying yes and I am not saying no,” which I took as a maybe, and I bought it for myself on impulse. It didn’t really help that it happened to be her birthday, but it was pure coincidence; and I wasn’t going to lose the car to another buyer.

Again, my wife gently reminded me that the last time I bought a 10-year old car on impulse it ended badly with a burst transmission inter-cooler filling the gearbox with rusty water at 3 a.m. with two young children asleep in the car in the middle of nowhere. “Lightning doesn’t strike twice,” said my internal logic. Needless to say, when I arrived at the office with my new toy I suffered endless “mid-life crisis” and “hairdresser’s car” jokes, but it seemed like a good investment to me.





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### *New Studies this Summer*

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\$1,350 (standard), \$675 (IPC member) — published in May 2013

#### *World PCB Production Report for the Year 2012*

\$975 (standard), \$250 (special IPC member discount) — coming in August

#### *On-Shoring in the Electronics Industry: Trends and Outlook for North America — 2013 Update*

\$300 (standard), \$225 (IPC member) — coming in August

#### *2012–2013 Analysis & Forecast for the Global EMS Industry*

\$600 (standard), \$450 (IPC member) — coming in September

### *2012–2013 Analysis & Forecast for the PCB Industry in North America*

This annual study, just published in July 2013, is a comprehensive overview of the market and business of PCB manufacturing. Current data and analysis cover rigid PCBs and flexible circuits separately, including:

- Market size
- Sales growth
- Sales by product type
- Product mix (high-volume vs. quick-turn vs. prototype)
- Revenue trends from value-added services
- Trends in materials
- Financial metrics
- Vertical end-markets
- U.S. imports and exports

Forecasts of total PCB production in the Americas and globally through 2016 from Dr. Hayao Nakahara are a special feature of this report. The 70-page report is available for immediate download from IPC's online store at: [www.ipc.org/PCB-Study-2013](http://www.ipc.org/PCB-Study-2013).

Single-user prices are \$600 (standard) and \$450 (IPC member). Site and global licenses are also available.

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When the next day dawned, a cold spring morning, I sparked up my new investment, only to see a plume of white smoke from just one exhaust in the rear view mirror. My heart sank. After all, the dealer had been honest with me and said the previous owner was only selling the car because of the horrendous repair bills. I started to run through the possible (expensive) consequences...

In Asia, I often field questions from customers and prospective customers who say things like, "My impedance model doesn't match my measurement!" They are often armed with one or two powerful, accurate field solvers plus a measurement system that the vendor specifies as giving traceable results, calibrated against national standards. Why, oh why, is the calculated trace impedance significantly different from the measured one? Something must be wrong! The answer is, maybe and maybe not. If the contact is convinced that measurement and modeling tools are both trustworthy, then the finger of suspicion points at the dielectric constant—even though logic says that impedance only varies as the root of  $\epsilon_r$  so it really is only a second-order effect. Often, it is assumed that because of the cost and the traceable capability of the measurement system, the measurement must be correct and the error lies elsewhere. A little thought from left field might be worth pausing for here, before putting too much blame on our old friend,  $\epsilon_r$ . Most impedance controlled PCB specs assume lossless traces, and even if the trace is only specified at moderate speeds long before dielectric loss comes into play, another factor has crept in, primarily driven by the reducing geometries being used and thinner boards and/or more layers in a given overall thickness; the result of this is that the DC resistance of the PCB trace, which could reasonably be ignored with the geometries and copper weights in use five to ten years ago, has crept up on us and is interfering with the measurement of instantaneous impedance.

It is quite possible that the impedance trace has developed a significant upward slope, and when the average impedance is taken after the initial aberrations have been allowed to settle, the impedance reading is composed of the instantaneous impedance, plus a slug of DC resis-

tance. (Hint: Design the coupon with probe access at both ends and measure the DC resistance with a precision meter and you will get an idea of how much resistance per inch is being added as an error component on top of the instantaneous impedance; on differential traces the value is doubled.) At Polar we notice this—especially on flex coupons. Some board shops have got into the habit of measuring the impedance, ignoring the DC resistance component, and then sectioning the sample and using a solver to "goal seek" for  $\epsilon_r$ . While  $\epsilon_r$  may be a partial contributor, it could be a fallacy to blame  $\epsilon_r$  for all observed mismatches, which takes me back to the original story. Here,  $\epsilon_r$  may be innocent, but because it is relatively hard to measure, it is used as a convenient adjustment factor to null out measured and modeled accuracy. If you are doing this it might be worth taking a casual look at the DC trace resistance before you draw an incorrect or partially incorrect conclusion.

So the smoke coming from one exhaust? Was it a head gasket on one bank of cylinders? Here comes the repair bill my wife cautioned me about...or maybe not, upon closer inspection. When cold, a valve seals off the right-hand exhaust to allow the catalyst to reach operating temperature, but also, under the close supervision of the engine management system, opens in spirited driving, but shuts off in traffic to meet noise regulations. Just as well, I looked a bit deeper before deploying the tool box to fix something that was never to blame in the first place. **PCB**

### References

1. Polar app note [AP156](#)
2. Istvan Novak, Senior Principle Engineer at Oracle, et al. "Determining PCB Trace Impedance by TDR: Challenges and Possible Solutions," DesignCon 2013.



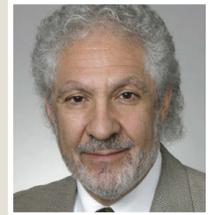
Martyn Gaudion is CEO of Polar Instruments Ltd., and a regular participant in IPC high-speed, high-frequency standards development activities. To read past columns, or to contact

Gaudion, [click here](#).

# 2013 MEPTEC MEDICAL TECHNOLOGY CONFERENCE

*Global Momentum in the Medical Industry –  
Convergence of Electronics, Biology and Health*

**Tuesday & Wednesday, September 17 & 18, 2013**  
**Arizona State University, Tempe Campus**



**Sam Bierstock, M.D.**

## Day One Keynote

**MEMS Technology and the Healthcare Industry: The Convergence of Timelines and the Perfect Storm**

*Sam Bierstock, M.D., BSEE  
Physician, Electrical Engineer,  
Medical Informaticist, Founder  
of Champions in Healthcare*

Dr. Bierstock is a nationally recognized authority on healthcare and healthcare information technology. He is the Recipient of the George Washington Honor Medal, Freedoms Foundation for his work on behalf of our nation's veterans. ♦



**Karthik Vasanth, Ph.D.**

## Day Two Keynote

**Creating Solutions for Health Through Technology Innovation**

*Karthik Vasanth, Ph.D.  
General Manager, Medical and  
High Reliability Business Unit  
Texas Instruments*

Karthik Vasanth received his Ph.D degree in Electrical Engineering from Princeton University in 1995. He joined the Silicon Technology Development group at Texas Instruments in 1995. In 2010 he became the General Manager of the Medical and High Reliability Business Unit at TI. ♦

MANY FACTORS HAVE contributed to global momentum in the medical electronics industry, with the convergence of electronics technology and biological health sciences playing a major role. Growth in medical electronic applications (yes, there is an App for that!) will parallel Cell Phone and Tablet PC markets, with increases in computing power as well as optical resolution and touch sensor technologies. Current focus for mobile, implantable and large medical systems is on improved personal health, with preventative applications and advanced early diagnostics. Various integrated circuit (IC) technologies, now complemented by MEMS bio-sensor technologies, allowed for significant development in areas such as prosthetics, combining “artificial limbs” with “artificial intelligence”, sensing and reacting to very small electrical impulses from the brain, through direct body contact.

This conference will address the many industry challenges and opportunities including safety, reliability, miniaturization, manufacturing and



**OLD MAIN on the ASU Tempe Campus, constructed before Arizona achieved statehood, will host the 8th Annual MEPTEC Medical Electronics Conference.**

A combination of technical, market and health topics will be presented through presentations and panel discussions. Topics to-date include:

- Safety and reliability of medical devices
- MEMS and Mobile Health Care market overview
- Bonding techniques of new wire alloys for medical electronics
- Wafer Level Packaging and TSV for biomedical applications
- MEMS & Sensors for Medical Applications
- Security and psychological issues in medical devices
- Miniaturized electronic packaging for wearable health monitors
- Wireless communication/solid state batteries in miniature implantable medical devices
- Designing more reliable medical products
- “Fantastic Voyage” meets medical device design

materials as well as government regulations and political healthcare initiatives. The human body is a convergence of various biological phenomena and sophisticated electrical net-

works controlled by the brain, with the health sciences and medical electronics technologies converging to meet strong global demand. ♦

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# TOP TEN

PCB007  
News

## PCB007 News Highlights This Month

### ① PragoBoard Joins FabStream's Network of PCB Makers

FabStream, the integrated PCB design and manufacturing solution developed by DownStream Technologies and targeted at the DIY electronics market, has announced that PragoBoard has become the sixth PCB manufacturer to join the FabStream network of global PCB manufacturers.

### ② Graphic Plc Acquires Flex PCB Maker Calflex

Graphic Plc. has acquired the assets of California-based Calflex, a flex PCB specialist with 30 years experience in supplying military, aerospace, and medical industries. The Graphic Group now has a real world presence of PCB manufacturing with specialist IMS plants in the UK, the U.S., Europe, and Asia.

### ③ Endicott Interconnect Files for Chapter 11 Protection

Endicott Interconnect Technologies filed for Chapter 11 protection in U.S. Bankruptcy Court on July 10. According to court documents, the New York-based company owes between \$50 and \$100 million; former parent company IBM is El's largest creditor, with \$5.5 million in unsecured debt.

### ④ IPC APEX EXPO 2014: 95% of Booth Space Sold

The show sold out of exhibitor space last year and 2014 is promising to sell out as well. "Our number one priority is to give our exhibitors and attendees the best return on their investments, giving them an opportunity to grow their businesses and increase revenue," said Alicia Balonek, senior director of trade shows and events.

## 5 **Multek: New Interconnect Technology Center In Silicon Valley**

"Our Interconnect Technology Center will focus on future technologies for the printed circuit board industry with the understanding that critical decisions are made specific to connections within the board and the device as a whole," said Franck Lize, president.

## 6 **N.A. May PCB Shipments Down 4.4%, Bookings Up 8.3%**

"PCB sales and orders have been below last year's levels for most months of the past year, but they have been improving in recent months," said Sharon Starr, IPC director of market research. "Order growth rates have improved faster than sales growth rates, which accounts for the positive book-to-bill ratios of past five months," she explained.

## 7 **Maskless Completes Series D Financing; Collaborates with CBT**

Bill Elder, president and CEO of MLI said, "I am very pleased to have closed this round of financing that will enable MLI to continue its rapid growth into the global PCB market. In addition to the new funding, as part of the collaboration between MLI and CBT, MLI will be able to integrate its existing direct imaging technology into CBT's vast array of lithography products, all focused on the PCB industry."

## 8 **Gorilla Circuits Lands Zeta Certificate**

Integral Technology, Inc. has announced that PCB manufacturer Gorilla Circuits is the next PCB fabricator certified to produce circuit boards using Integral's revolutionary Zeta® glass-free laminate and film solutions for rigid PCB applications. "Gorilla Circuits is a shining example of how entrepreneurial vision can guide a company to success even in a down economy," stated Integral President Ken Parent. "Gorilla's commitment to engineering quality and reliability makes them a valued member of the Zeta® team."

## 9 **Epec, Suncoast Digital Technology Join Forces**

Ed McMahon, CEO of Epec, commented, "We are very excited to welcome Suncoast Digital into the growing Epec family. Paul Knupke, Joe Frangione, and their dedicated team have built a tremendous reputation that seamlessly fits into Epec's proven business model, focusing on providing customers with high-level engineered solutions."

## 10 **German PCB Market on the Rise**

Sales of PCBs in Germany were up by 5.7% in April, year-on-year, according to the Central Association of PCB and Electronic Systems. This is the third consecutive month of growth in 2013.

**For the latest PCB news and information, visit: [PCB007.com](http://PCB007.com)**



# EVENTS

- [IPC Complete Calendar of Events](#)
- [SMTA Calendar of Events](#)
- [iNEMI Calendar](#)
- [PCB007 Online Events](#)

## [Microscopy & Microanalysis 2013](#)

August 4–8, 2013  
Indianapolis, Indiana, USA

## [Philadelphia Expo & Tech Forum](#)

August 15, 2013  
Cherry Hill, New Jersey, USA

## [NEPCON South China](#)

August 27–29, 2013  
Shenzhen, China

## [IPCA EXPO 2013](#)

August 29–31, 2013  
Gujarat, India

## [NEXTGEN AHEAD](#)

September 9–11, 2013  
Washington, DC, USA

## [International Test Conference 2013](#)

September 10–12, 2013  
Anaheim, California, USA

## [Capital Expo & Tech Forum](#)

September 10, 2013  
Laurel, Maryland, USA

## [2013 MEPTEC](#)

September 17–18, 2013  
Tempe, Arizona, USA

## [Failure Analysis of Electronics Short Course \(CALCE\)](#)

September 17–20, 2013  
College Park, Maryland, USA

## [Electronics Operating in Harsh Environments Workshop](#)

September 17, 2013  
Cork, Ireland

## [MRO EUROPE 2013](#)

September 24–26, 2013  
London, UK

## [ID WORLD Rio de Janeiro 2013](#)

September 26–27, 2013  
Rio de Janeiro, Brazil

## [SAE 2013 Counterfeit Parts Avoidance Symposium](#)

September 27, 2013  
Montreal, Quebec, Canada



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**PCB007 Presents**



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## Next Month in *The PCB Magazine:* Flex and Rigid-Flex

Flex and rigid-flex circuits have myriad applications in just about every sector of the electronics industry, where their ability to be formed into complex three-dimensional geometries, or to withstand multiple cycles during their functional life, adds a third dimension to the concept of the interconnecting substrate. In the September issue, *The PCB Magazine* focuses on the latest developments in manufacturing and testing processes for flex and rigid-flex circuits, and explores novel design and application opportunities with features from Victor Lazaro, Joe Fjelstad and Polyonics.