APRIL 2018

I-Connect007

PCB007 MAGAZINE

AUTOMOTIVE ...AND MORE!

Download free eBooks

I-007e Books

I-007eBooks.com

See what the experts have to say...

Read an eBook Today!

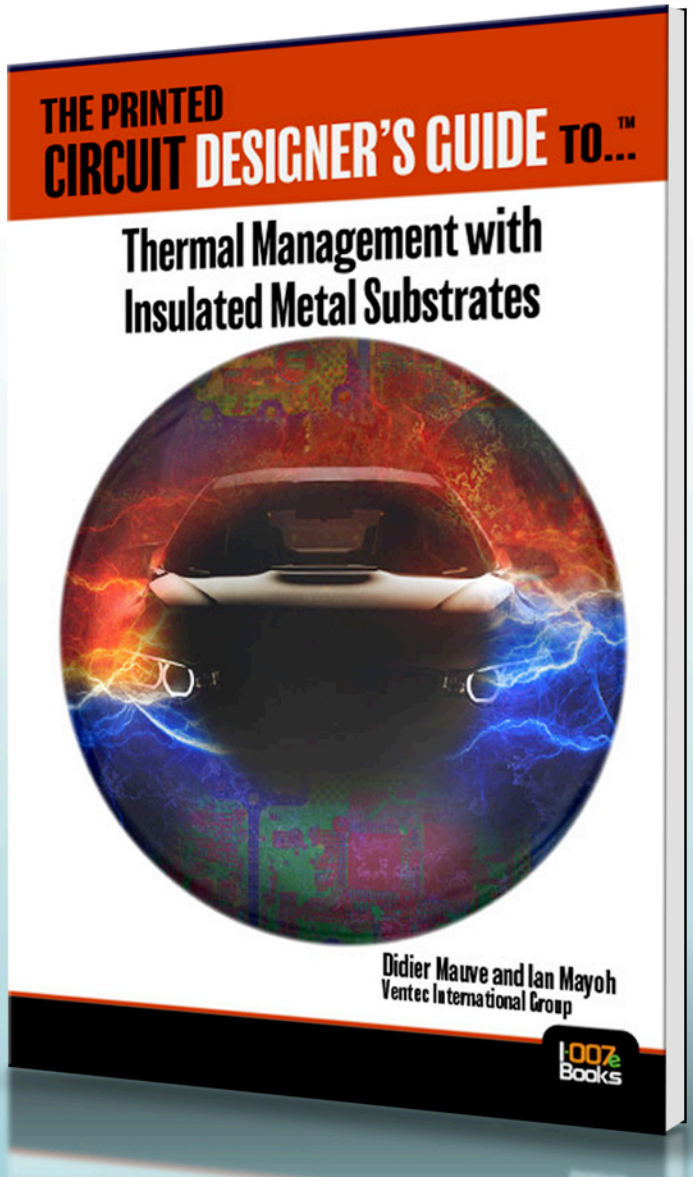
my I-Connect007
GOOD FOR THE INDUSTRY

Written by industry experts, each book contains valuable information on relevant topics in an easy-to-read format.

Log in or register to access all of our premium content at: myiconnect007.com

“A comprehensive tour through the world of thermal management. Required reading for designers and end users wishing to understand the science and practice of using insulated metal substrate materials.”

Alun Morgan
Chairman, EIPC



Download Now

Written by Didier Mauve and Ian Mayoh of Ventec International Group, this book highlights the need to dissipate heat from electronic devices.

I-007e Books

I-007ebooks.com

PCB007 MAGAZINE

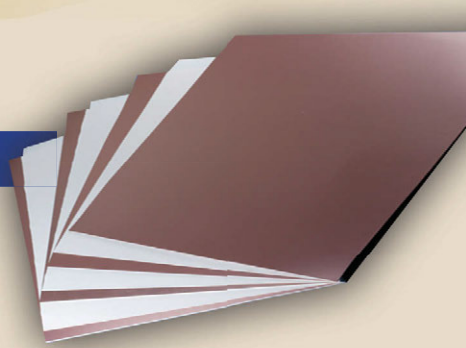
Automotive...and More!

From autonomous vehicles to e-textiles to automotive standards, our contributors take a look under the hood and kick the tires this month to bring the rapidly evolving world of automotive electronics into perspective.

Don't Let Your Temperatures Rise

Let ROGERS' Thermal Management Solutions *Keep You Cool*

COOLSPAN® TECA Film • 92ML™ StaCool™ Laminates • ML Series™ Laminates & Prepregs



Heat can be damaging, especially when it is not managed. That's why Rogers Corporation invested so much time and energy into creating an array of material-based thermal management solutions to keep heat rise to a minimum in printed circuits. From automotive circuits to LED modules to power supplies, ML Series laminates and prepregs effectively conduct heat away from the source, while COOLSPAN thermally & electrically conductive adhesive (TECA) materials enhance the thermal management of new and existing designs. And for that extra cooling edge, 92ML StaCool laminates feature a thermally conductive metal bottom plate to enhance the heat dissipation.

Product	Thickness	Thermal Conductivity (Z-Axis), W/mK	Thermal Impedance, C-cm2/W	Tg, C	CTE (Z-Axis), ppm/C		Dk, 1MHz	Df, 1MHz	Breakdown Voltage, kVAC	Flammability
					<Tg	>Tg				
92ML	8mils	2.0	0.52	160	22	175	5.2	0.013	>50	HF V-0

Don't let your temperatures rise. Use Rogers' thermal management solutions.

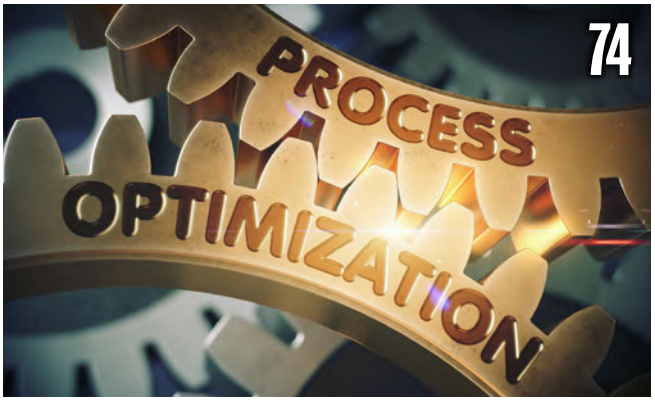
ROGERS CORPORATION

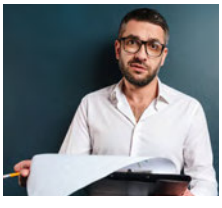
Advanced Connectivity Solutions

www.rogerscorp.com/acs

USA - AZ, tel. +1 480-961-1382
EUROPE - BELGIUM, tel. +32 9 235 3611

PCB007 MAGAZINE





AUTOMOTIVE

BY TAIYO

DRIVE YOUR PRODUCTS TO SUCCESS WITH TAIYO

PSR-4000 CC01SE SERIES

- Curtain Coat, Spray and Screen Print
- Excellent Crack Resistance / High Temperature Resistance
- Available in Green and Black
- Excellent Resistance to ENIG and Immersion Tin

PSR-4000 AM05TS

- Excellent Adhesion under High Temperature Environment
- Thermal Cycling Crack Resistance
- Excellent Solder Dam Shape
- Low Outgassing

TAIYO AMERICA

Your Ultimate Solution

Phone [775] 885-9959 • www.taiyo-america.com • info@taiyo-america.com

Automotive, the Electronics Industry's New Driver

Patty's Perspective

by Patty Goldman, I-CONNECT007

The automobile industry is becoming a combination of most of the traditional electronics segments: It's a consumer product with a computer, communications center, and a few medical monitoring-type tendencies (measuring your alertness, heart rate, etc.), all rolled (no pun intended) into one incredible machine that is influencing our industry as none other. As automotive electronics quickly becomes the number one market everyone is talking about, we realize that the actual vehicle is only one part of that—think about the massive amount of infrastructure that will need to evolve on highways, in cities and especially the more rural areas, plus the incredible computing power, cameras, etc. Then think about the level of reliability that will be required.

So, as I drive down the street in my small town (without yellow lines or yellow curbs) in the snow at dusk, I am just a little concerned that some automotive companies are looking to 2020 for the first autonomous vehicles to hit the road (another (un)intended pun). That's less than two years! Can we be ready? Have those companies really thought through the requirements, not to mention the necessary reliability of the huge number of parts that must work seamlessly and faultlessly every time without fail? The amount of electronics required (along with the painted lines and numerous other road guides) is staggering—all to basically duplicate our human brains and bodies. Feel smart and special? Scientists certainly become more amazed by our brains every day.

But let's move on and get to what's in the magazine this month.

Autonomous driving and the electronics surrounding it has always been a favorite topic of our Technology Editor, Dan Feinberg. He opens our issue with a great overview of autonomous

ENEPIG "2.0"

ENEPIG has *(at last!)* reached its ***ultimate*** performance potential!

- Uniquely flexible and stable electrolytes, with Talon electroless/alloyed palladium phos
- Lowest make-up and operating costs
- Pure palladium formulation available
- Reduction-assisted TWX-40 plates up to 8 µin of gold, with no nickel corrosion or deposit porosity

UYEMURA USA

www.uyemura.com

North America's Leading Experts in Final Finishes, Via Fills, Acid and Electroless Coppers, Immersion Silver and Tin; also MEC Surface Treatments and Auruna Gold Electrolytes.

Corporate Headquarters: 3990 Concours, #425 • Ontario, CA 91764 • ph: (909) 466-5635
Tech Center: 240 Town Line Road • Southington, CT 06489 • ph: (860) 793-4011

transportation—which will involve more than cars (think taxis trains, buses, ships, trucks, planes)—and will be a true disruptor of not just life as we know it but electronics as we know it.

Dr. Christian Klein, automotive equipment supplier for Robert Bosch GmbH, gives us a great article on the upcoming requirements for PCBs, covering testing and reliability. He also presents us with upcoming challenges that will need to be addressed.

To build for the automotive industry, certification to IATF 16949 is necessary. Steve Williams of The Right Approach Consulting outlines the major requirements that are above what is required by ISO standards, stating that it is very demanding and requires a high level of discipline to meet it.

Switching gears back to a new technology with many applications in the automotive industry, Tara Dunn, Omni PCB, gives us all the particulars of e-textiles. She spoke with Connie Huffa of Fabdesigns Inc., to learn not just what defines e-textiles, but considerations for design, the challenges of merging electronics into textiles, and the many exciting applications coming down the pike (I love these puns).

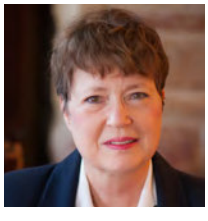
Steering us back to reality is Gardien's Todd Kolmodin, with a column on PCB voltage ratings for test engineers and others with an interest. He carefully explains the confusing "maximum rated voltage" using examples as they may appear on a master drawing.

And RBP Chemical's Mike Carano regales us with more troubleshooting of that bane of wet process engineers, PTH voids. Mike teaches us that things aren't always as they seem as he presents examples of PTH problems caused by unlikely culprits.

IPC recently on-boarded a new VP of Global Government Relations and IPC's John Mitchell devotes his column this month to an interview with Chris Mitchell (no relation, as John is happy to point out). Part of the conversation revolves around the upcoming IMPACT Washington, DC, to be held May 22 – 24 this year. If you've been paying attention to me, you know this event is where your company execs can meet with high-level government officials in the nation's capital to promote our industry—and is truly a must-attend event.

Our last item this month is a wonderful technical article by Happy Holden, on process control of fabrication processes. Perhaps not what you think, as Happy shows us some simple, practical methods using low-cost—often homemade—equipment to analyze and control just about every parameter in the myriad wet processes used in making HDI (and standard) PCBs. Read carefully so you don't miss his build-it-yourself directions!

Next month, we will be discussing 5G, that elusive, next big thing that could revolutionize the way we work and play. What is it and how it will affect you and your business—that's what we hope to show you in May. Be there or…well, you don't want to get left behind now, do you? **PCB007**



Patricia Goldman is managing editor of *PCB007 Magazine*. To contact Goldman, click here.

BÜRKLE

NORTH AMERICA, INC.

LAMINATION SYSTEMS FOR PRINTED CIRCUIT BOARDS

STATE-OF-THE-ART SOLUTIONS FOR THE PCB INDUSTRY INCORPORATING THE LATEST TECHNOLOGY.

Solutions for the PCB Industry

High quality and well proven presses and handling equipment

Contact:
Dave Howard
714-379-5090

INNOVATIVE POWER **4U**

burkleamerica.com

IMAGE: ITALDESIGN

Autonomous Transportation:

Using Disruptive Technologies to Create Social Disruption and Change

Feature by Dan Feinberg
I-CONNECT007

Those of us who have been driving for the last 50 – 60 + years have seen great change. At first, it was slow; we went from manual shift to automatic shift transmissions, then we started adding simple things such as FM radio (yes, that was a premium add-on in the early '60s), then air conditioning and power windows, fuel injection, cruise control, airbags, and in the last decade everything from GPS to LED lighting to automatic speed and distance control, back-up and surrounding cameras and so much more. Many of these additions are now considered standard features and some are still premium add-ons; however, the trend is that today's premium add-ons on a very high-end car will become standard on an economy vehicle after a few years.

Many of these features added comfort, entertainment and convenience; however, many also improved safety (e.g., airbags), driver capability and reliability (over the last few years, computer diagnostics). For example, computer diagnostics has significantly shaped the way that automobile owners maintain their cars. Since the turn of the century, cars have increasingly been built with on-board computers to warn owners regarding power train problems or other issues before any damage is done. Before the addition of computer diagnostics technology, most car owners did not know something was failing until something actually did. At first, these advances were slow to arrive—every few years there would be something new—then a few years later it would become commonplace. But lately, just as the rate of advance has accelerated for everything, so has it been for the transportation industry.

Transportation vehicles of all kinds are about to see an amazing acceleration in capability, with huge changes in not only the source of power, from liquid fossil fuel (gas/diesel) to hybrid electric, to full electric to the possibility of full electric with the power being transmit-

IT-170GRA1

COME SEE US AT IMS
BOOTH #2413

IT-170GRA1 Value Proposition

- Halogen Free
- Best in class performance in its space
- Best in class CAF performance
- Very attractive price to performance ratio
- Pass MRT-6 requirements
  - -CAF > 1000 hours
  - -0.65mm pitch equivalent, no thermal issue
- Available with RTF and 2μ copper which provides additional performance on a very solid platform
- Df = 0.0075 @10GHz

Intel Purley Mid-Loss Solution – IT-170GRA1

Futures
Halogen free mid loss, Df < 0.01
Tg 180°C by DSC, low CTE

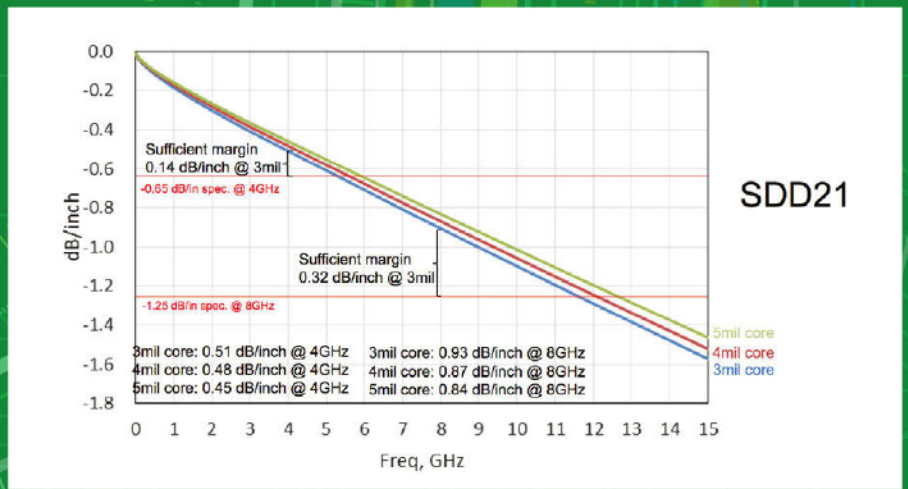
Applications
Server/Storage/Switch (10G, 40G)
Backplane, Telecom
Base station

Feature — *Purley Platform Mid-Loss Solution – Hi Tg*

General Properties

Items	Methods	IT-170GRA1
Tg (℃)	DSC	180
T-288 (w/ 1 Oz Cu, min)	TMA	60+
Td-5%(℃)	TGA 5% loss	380
CTE (%), 50-260℃	TMA	2.4
Peel strength (lb/inch)	1 oz	7.0
Water absorption	D-24/23	0.1
Dk: 2-10 GHz	Bereskin	3.96 ~ 3.99
Df: 2-10 GHz	Bereskin	0.0073 - 0.0075

IT-170GRA1 Insertion Loss



ITEQ

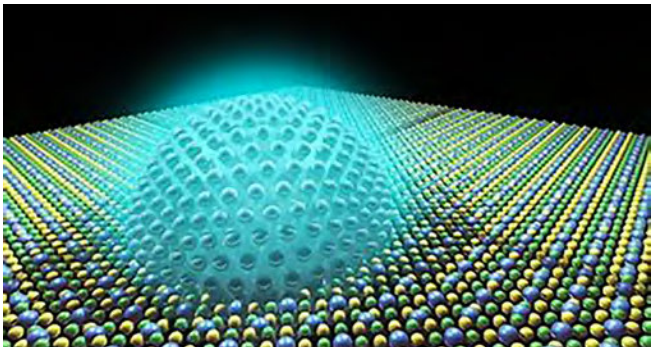


Figure 1: Nanocrystal.

ted over the airwaves using nanocrystal technology (Figure 1).

These things were, are, and will continue to be quite disruptive. Perhaps in the future airwave power transmission might be the most disruptive but, in my opinion and in the opinion of many others, the most disruptive, the biggest social and economic change from technology over the next ten years will come from autonomous transportation. Remember, disruption is not always a bad thing, in fact it can be great. Think about the technology-induced positive changes over the last 50 years in medicine, in transportation, in food production and on and on.

Let me add a quote from our coverage of autonomous transportation from CES a few months ago.

"An autonomous car (driverless car, self-driving car, robotic car) is a vehicle that is capable of sensing its environment and navigating without human input."[1] For now, the initial forays into this area have required that there be a human driver present—but that is about to change. This is a topic we have been watching for the last five years with truly driverless vehicles becoming not only viable but now expected.

"Are you looking forward to having a driverless car in the next five years or so? Perhaps use a driverless Uber or Lyft type of transportation service? Will you use a delivery service that brings you groceries, delivers dry cleaning or pizza without a human driver? Or, do you hate the thought of the entire concept. Well, like it or not it is coming."[1] And, it is coming much faster than you would have imagined just a few years ago (Figure 2).

Let's consider the change this will bring over the next 20 years. Remember, I live in California, the state that believes it knows what is best for you more than you do. I fully expect

Figure 2: Self-driving car concept.

that we will be one of the first areas where there will be roads that humans will not be allowed to drive on—and that may not be a totally bad thing. The advances in artificial intelligence (AI) and computer learning, as well as the ability of vehicles to communicate with each other, have increased at quantum levels over the last few years and that rate of increase is accelerating. The autonomous vehicles becoming available see everything around them, communicate with other vehicles, and make accurate decisions with only one variable being almost beyond prediction: humans. What will the human driver sharing the road do? What decisions will the human make? How does the computer react to that unknown?

LEVEL	NAME	STEERING, ACCELERATION & DECELERATION	MONITORING OF DRIVING ENVIRONMENT	FALLBACK PERFORMANCE OF DYNAMIC DRIVING TASK
Zero	No automation	Human	Human	Human
One	Driver assistance	Human and system	Human	Human
Two	Partial automation	System	Human	Human
Three	Conditional automation	System	System	Human
Four	High automation	System	System	System
Five	Full automation	System	System	System

Source: SAE International and J3016
Note: Level 5 has system capability in all driving modes (e.g., expressway merging, high-speed cruising, low-speed traffic jam, etc.) vs. some driving modes for levels 1-4

Bloomberg

Figure 3: Autonomous driving levels. (Source: Bloomberg, per SAE International and J3016)

It therefore makes sense that, initially, there will be roads where the autonomous computer-controlled vehicles will be walled off from the more unpredictable and therefore probably more dangerous humans. Once the statistics begin to show that the rate of accidents in the computer driving isolated road segments are very much lower, there will be an argument to increase them and reduce the access to the less capable humans. This is not going to happen tomorrow but, if you think about it, it very may well happen rapidly. In a few generations, instead of being a rite of passage, learning to drive may be something that only the few do and then only as a special interest skill with significant limitations.

Let's look at autonomous drive levels from zero to five (Figure 3). Until very recently, all transportation, be it horseback riding through 99.9% of today's vehicles, have been level zero. Starting a few years ago, higher-end cars became available with a level capability. Level two is now available and in final stages of testing, but not in use except under test or limited trial conditions. We can expect level three to be in more widespread use over the next five years, or sooner. I am afraid the limitations are now more dependent on the legislators and lawyers than the engineers. Once we get to level four, full automation is only a short step away. Look at Figure 4 and you get an idea where this will happen first, but expect that it will happen, and you can hope or fear, depending on your point of view, that it will happen.

To get an idea of the accelerating rate of progress regarding autonomous transportation in just the last few months, let's look at

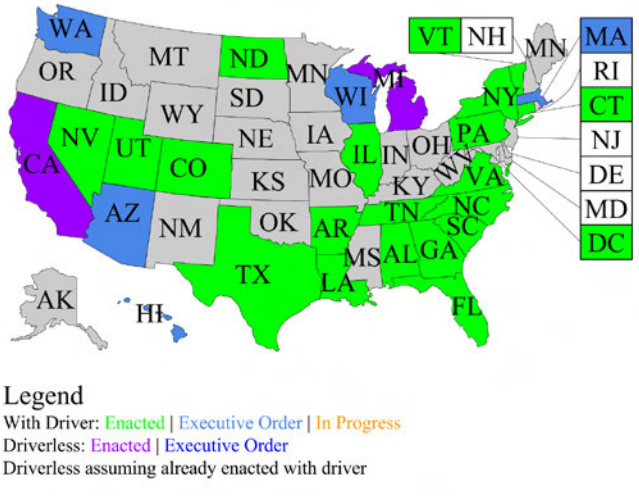


Figure 4: Driverless by state.

just some of the latest announcements made on this topic since the start of 2018. These announcements are from companies such as Intel, Nvidia, Amazon, Volkswagen, Cisco, Alphabet, Microsoft, various traditional car manufacturers, and others (Figure 5):

- Nvidia introduced powerful new chip technology (Xavier) focused on autonomous cars
- Nvidia announced that the Xavier chipset is now in production and will ship to select automotive partners and customers within the next few months (Xavier can do 20 trillion deep learning operations per second)
- Nvidia announced that its Drive IX and Drive AR software kits are in use by Volkswagen for their electric buses and they are also partnering with Uber, Baidu and the Aurora startup for their upcoming driverless cars
- Alphabet's (Google's holding company) self-driving car, now called Waymo, announced it now has over 4 million miles of real driving experience performed in cities such as Mountain View, California; Austin, Texas; and Phoenix, Arizona

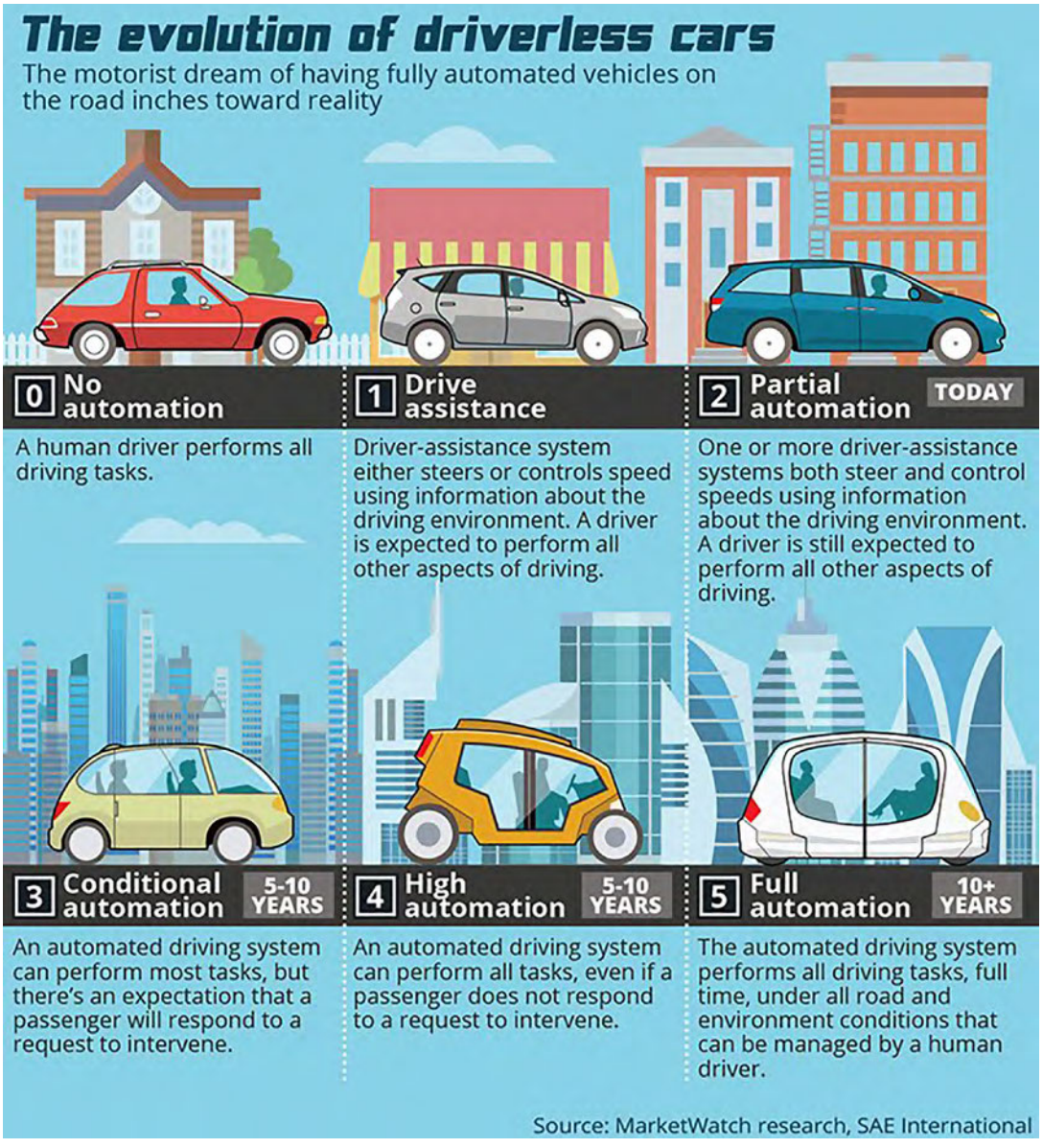
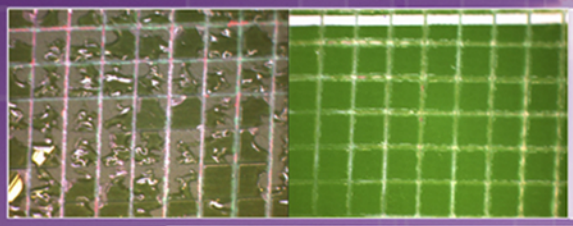
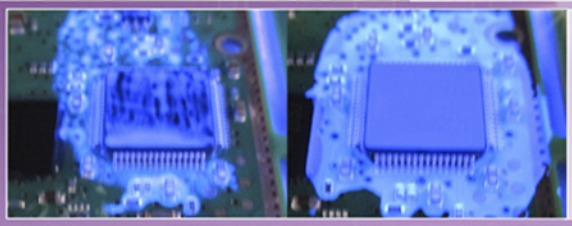


Figure 5: Prediction regarding time to implementation in the evolution of driverless cars, according to SAE International. (Source: MarketWatch)

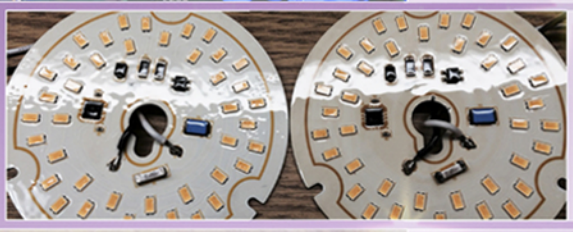
Does Plasma Prior to Conformal Coating Help?



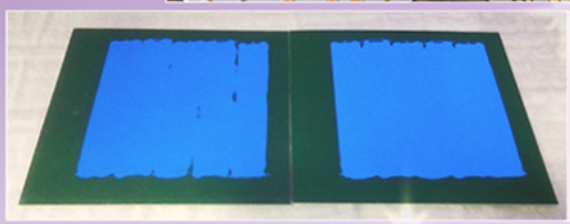
✓ Improve adhesion



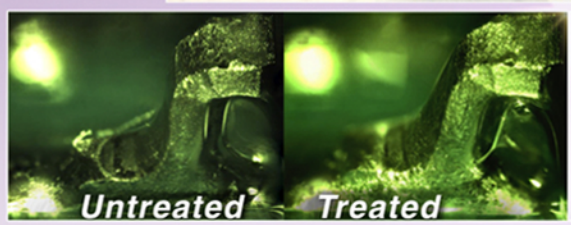
✓ Eliminate flux & mold release residue



✓ Remove organic contaminants



✓ Enhance surface wettability



✓ Enhance lead coverage

See what the Experts say!

nordsonmarch.com/PPCC | +1 (925) 827-1240

Nordson MARCH

Figure 6: Nuro self-driving delivery vehicle.

- Intel has acquired Mobileye (an Israeli company) that makes systems for collision avoidance in self-driving vehicles and has also announced a partnership with Waymo
- Microsoft has announced partnerships with automakers developing autonomous Internet-connected vehicles including BMW, Ford, Volvo, Renault-Nissan, and Toyota as well as Chinese company Baidu
- Amazon is focused on getting purchases to customers as quickly and as cheaply as possible; therefore, they are part of a Toyota announcement revealing a self-driving food delivery vehicle called the e-Palette
- IBM received a patent in March for a "machine learning system that can dynamically shift control of an autonomous vehicle between a human driver and a vehicle control processor in the event of a potential emergency." IBM has multiple patents that tie together machine learning and driving. Whatever road technology we see from IBM will likely be connected to its AI engine Watson
- Nuro's self-driving R-1 delivers what you need to where you need it (Figure 6)
- GM will make an autonomous car without steering wheel or pedals by 2019 (Figure 7)
- Audi and Nvidia *Working on Fully Autonomous Car for 2020 Rollout to consumer market*[2]
- *Ford Targets Fully Autonomous Vehicle for Ride Sharing in 2021*[3]

Overall, the general feeling is that as we become more and more a society dependent on autonomous vehicles, and as we remove the human factor and depend more on AI and

computer learning, that the roads will become safer and that the number of accidents will be greatly reduced.

However, there will be a transition period. Let's look at a commonly discussed scenario:

An autonomous car identifies children running into the road. There is no time to stop. To swerve around them would cause the car to crash into a speeding truck on one side or over a cliff on the other, bringing certain death to anybody inside.

To anyone advocating for autonomous cars, this question is the elephant in the room. It is argued over incessantly by lawyers, regulators, and ethicists; it has even been at the center of a human study by *Science*. Happy to have their names kept in the background of the life-or-death drama, most carmakers have let Google or other involved (but not auto company) technologists take the lead while making passing reference to ongoing research, investigations, and discussions. Still, if the overall death and injury rate is greatly reduced there may be justification.

Figure 7: GM self-driving concept.

An announcement by Mercedes published in *Car and Driver* some time ago indicates that this factor is being taken seriously: "Rather than tying itself into moral and ethical knots in a crisis, Mercedes-Benz simply intends to program its self-driving cars to save the people inside the car. Every time. All of Mercedes-Benz's future Level 4 and Level 5 autonomous

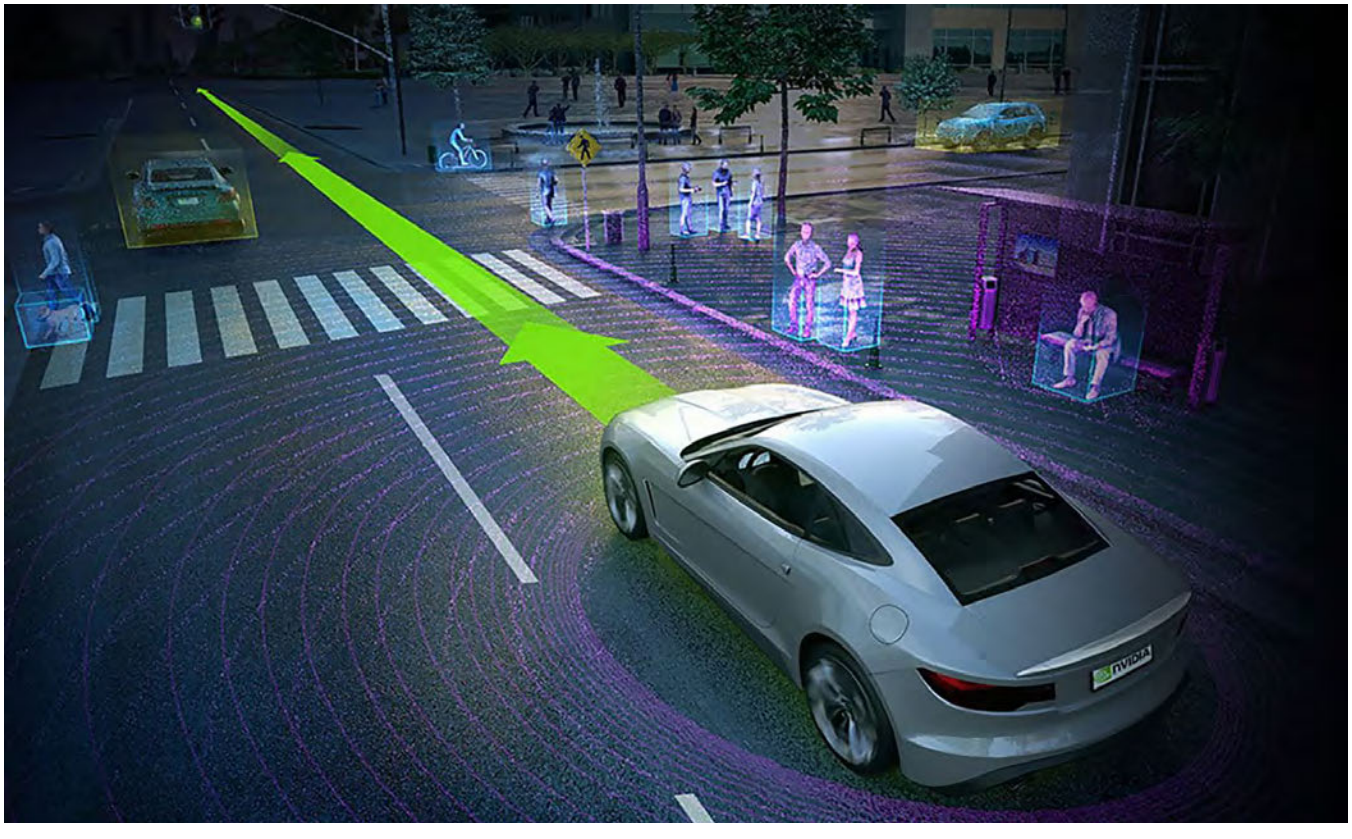


Figure 8: Graphic of autonomous vehicle sensing people and vehicles nearby.

Figure 9: Mercedes concept car.

cars will prioritize saving the people they carry," according to Christoph von Hugo, the automaker's manager of driver assistance systems and active safety. According to a U.S. Department of Transportation study, 94% of U.S. car crashes are caused by human error, so while there will be incidents where the computer AI may be blamed, it is probable that the accident rate will be greatly reduced.

From an economic standpoint, autonomous transportation is already having a major effect on our industry. There is no doubt that there has been a very large increase in electronic components on a cost basis in automotive manufacturing over the last few years.

It is my understanding that over 25% of the cost of a modern mid- to high-end automobile is now due to the level of electronic content. It is being predicted by some that 50% of the cost of a modern vehicle in the mid- to late-2020s will be due to electronics. Autonomous vehicles will be a significant factor affecting the increase of electronic content in the next generation's vehicles.

There is no doubt that this will be one of the most disruptive technologies ever and we can all hope that it will be for the better. Just imagine taking a road trip 25 years from now, compared to the same journey 25 years ago. **PCB007**

References

1. CES 2018: Disruptive Technologies and Fun PC Stuff.

2. Audi and NVIDIA team up to bring fully automated driving to roads in 2020.

3. Ford Targets Fully Autonomous Vehicle for Ride Sharing in 2021.

Dan Feinberg is the owner and president of FeinLine Associates Inc. and the technology editor for I-Connect007. To read past columns or to contact him, click here.

Ucamco
Former Barco ETS

SOFTWARE | PHOTOPLOTTERS | DIRECT IMAGERS | NEWS | SERVICES | COMPANY | DOWNLOADS | CONTACT

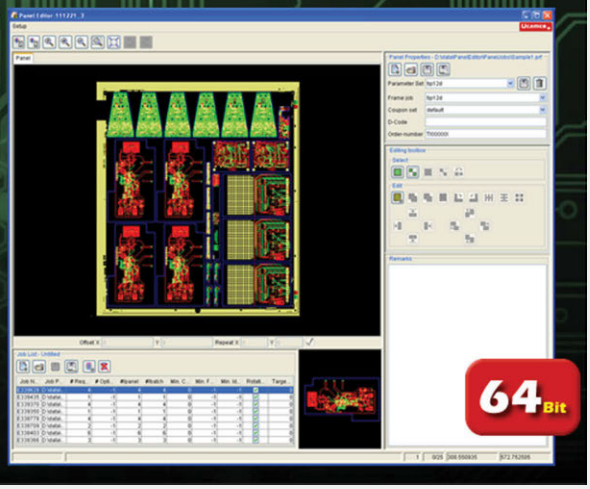
Software

Multi Job Panelizer

High-yield multi-job panel generation made easy ...

- Combines different PCBs into a production panel
- Optimizes material utilization
- Reduces material costs
- Interactive or 24/7 automated operation
- Hotlinkable to ERP or Planning systems

Read more



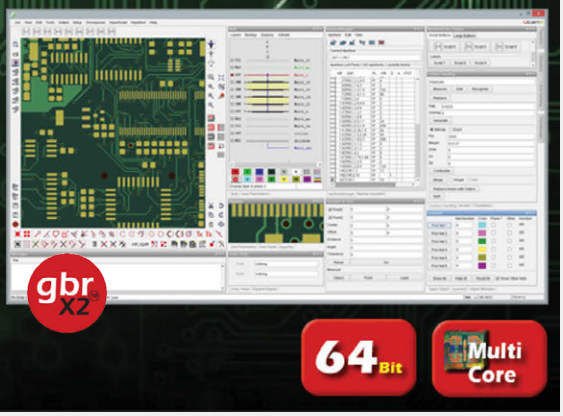
Software

UcamX

New ground-breaking CAM Software

- For Rigid, Flex and HDI PCBs
- New Graphical User Interface with Workspaces
- Optimal performance using Parallel Processing
- Multi Job Processing via load balanced Sessions
- Support for Gerber version 2 (X2) format

Read more



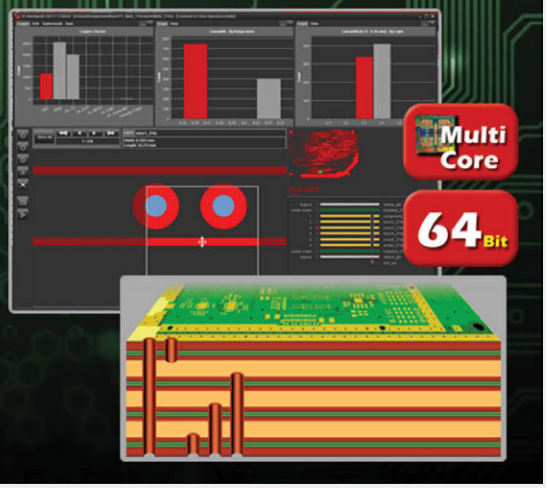
Software

Integr8tor

Automated data entry and design analysis

- Ucamco's 9th Generation Sales & Engineering Tool
- Field proven with more than 250 installations in daily production
- Seamless integration into any environment

Read more



For more information please contact info@ucamco.us,
call (415) 508-5826 or check out our website at www.ucamco.com

Future Automotive Requirements for PCBs

Feature by Dr. Christian Klein
ROBERT BOSCH GMBH
AUTOMOTIVE ELECTRONICS, PCB TECHNOLOGY GROUP

Introduction

The Bosch Group is a leading global supplier of technology and services. They also develop and manufacture automotive electronic components and systems. In addition to the standard product testing, the PCB Technology team always qualifies new PCB technologies before going into product testing. In the past, we found failures in PCBs during these qualifications along with the potential for design and stackup improvements together with the supply chain. These findings were incorporated into our specification and brought to international standards committees.

In the automotive electronics industry, a huge change in functional and environmental requirements will be visible during the next few years. This is driven by three major trends: connected mobility, automated mobility, and the increasing electrified mobility.

All three trends will increase the added value of electronics in the car. For PCBs, the applied technologies will change to deal with high currents of several 100 A and information processing in a range of several GHz. From a functional performance standpoint, this is far beyond the current PCBs in the cars and new concepts are needed. Figures 1 through 4 illustrate the three major trends of connected mobility, automated mobility, and powertrain systems and electrified mobility.

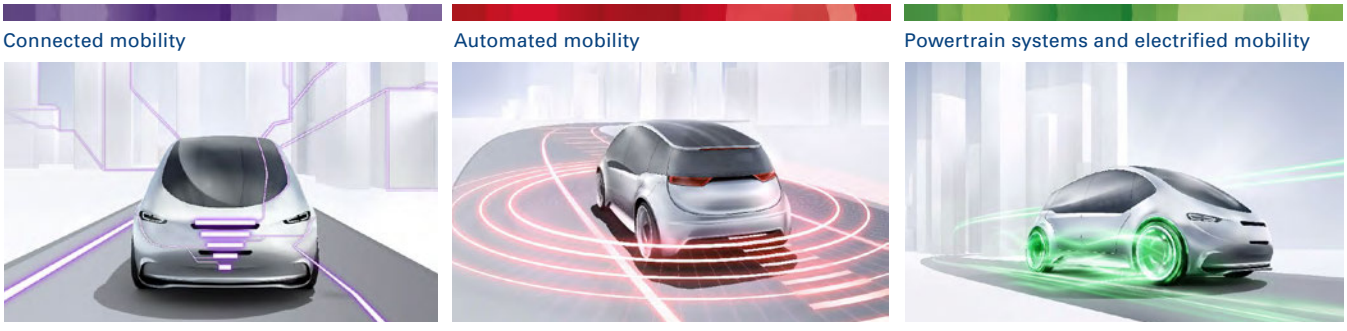
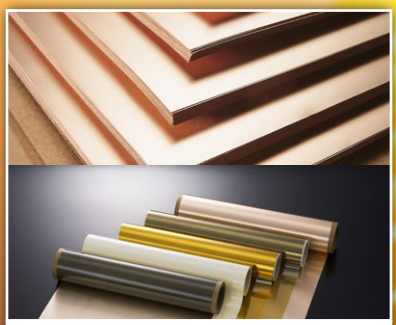


Figure 1: The three major trends for automotive electronics. (Source: Bosch)

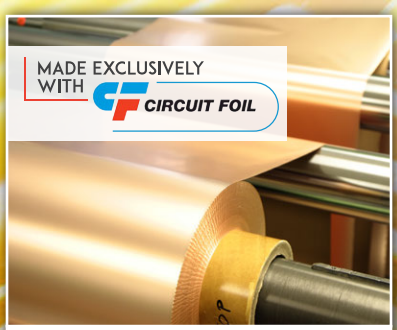
MATRIX
CIRCUIT BOARD MATERIALS

The Gold Standard in PCB Materials and Services



Panasonic

Multilayer & Flex Laminates

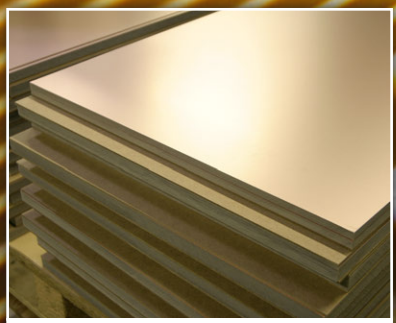


ADVANCED COPPER FOIL

High Quality ED Copper Foils

JINZHOU

Drills, Routers & Endmills



KB
KINGBOARD

Rigid CCL

Hakuto

Film Laminators

AE ADVANCED ENGINEERING

Panel Handling Automation

1-800-668-5447 • www.matrixusa.us

TORONTO • SANTA ANA • SANTA CLARA • CHICAGO • MINNESOTA

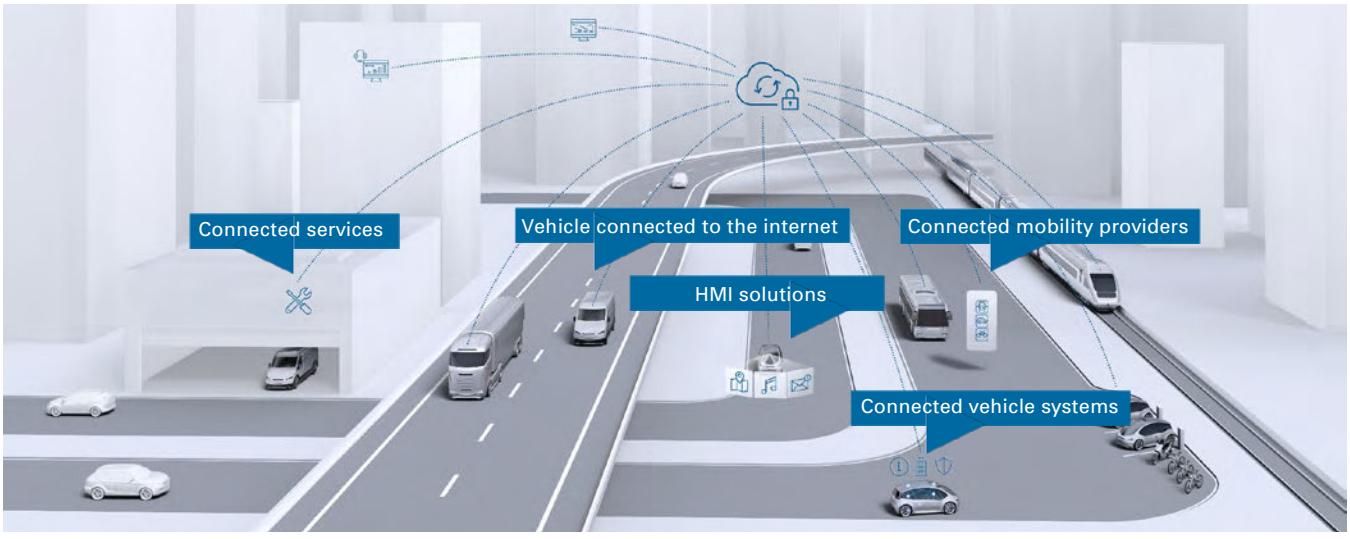


Figure 2: Examples of connected mobility. (Source: Bosch)

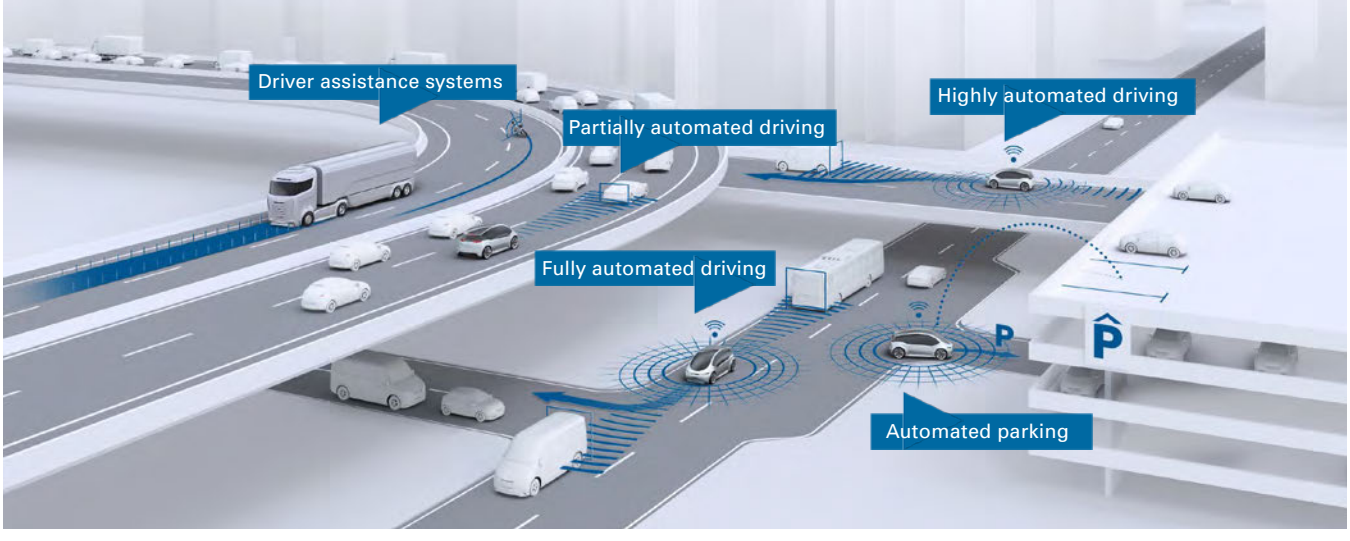


Figure 3: Examples of automated mobility. (Source: Bosch)

Most of the technology regarding signal processing in PCBs is available in the consumer industry and must be transferred to the automotive industry, with its necessary quality and reliability requirements. Regarding power electronics, new PCB developments are necessary to enable volume production of power electronics for a big market. Until now, power electronics were mainly produced only with low production volume.

The PCB is a crucial part in these electronic systems, and considering high-speed requirements, is not just a connecting part between the devices. Special attention must be drawn to the failure modes in PCBs which can result in shorts or opens. In an autonomous car, which is powered by several hundred volts, the PCB must be understood very well to guarantee a reliable service. Figure 5 shows typical loads on the PCB during production and product lifetime, with selected critical failure modes. Figure 6 shows an organizational chart of required PCB properties for automotive electronics.

Automotive Requirements for Future Electronics

The automotive-specific requirements for the PCB are driven by the environmental load such as temperature, humidity and vibration-

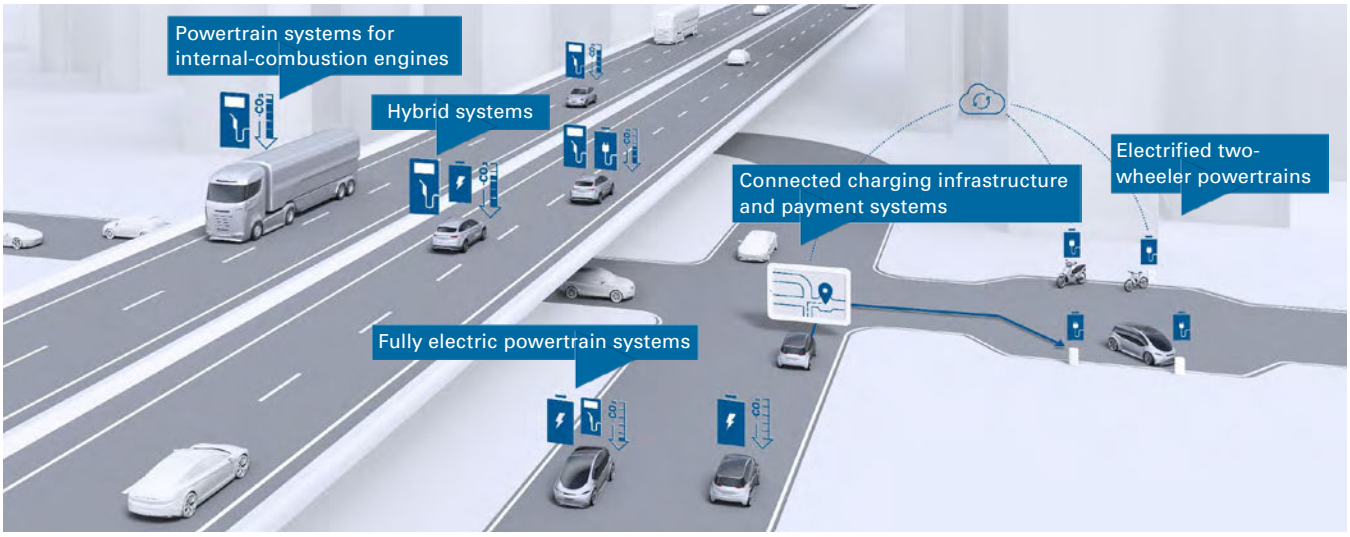


Figure 4: Examples of power train and electrified mobility. (Source: Bosch)

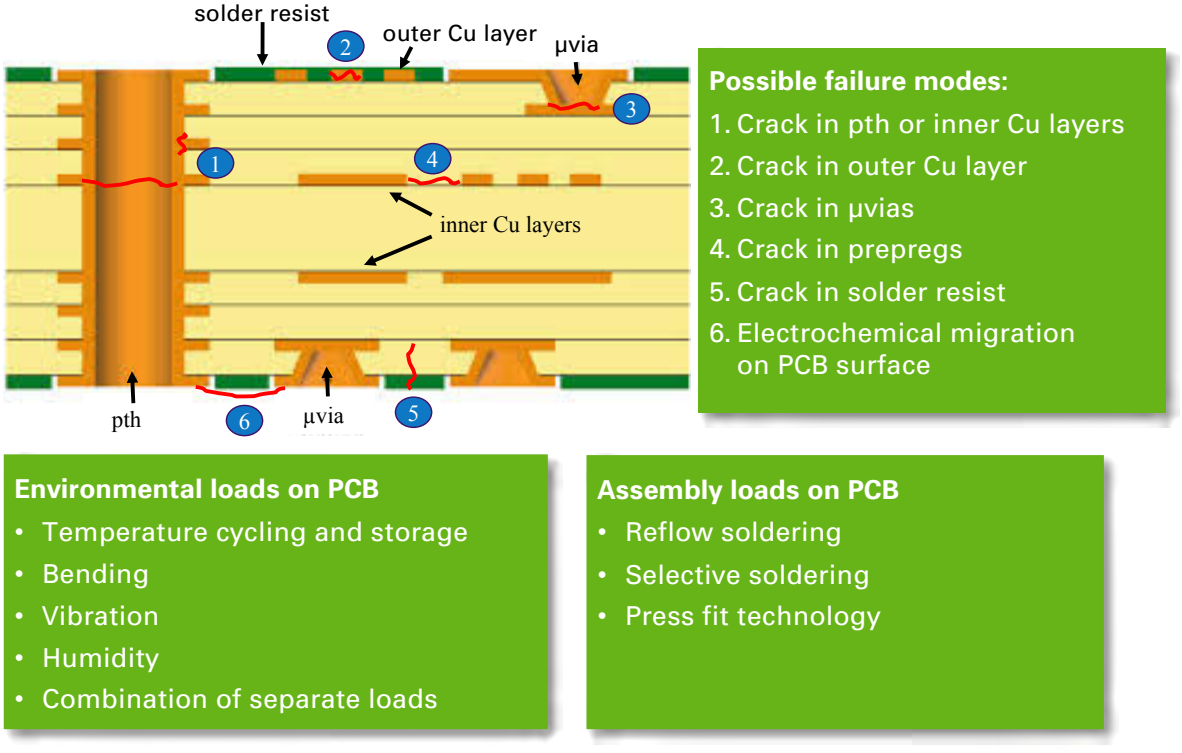


Figure 5: Environmental and assembly loads versus possible failure modes in PCBs. (Source: Bosch)

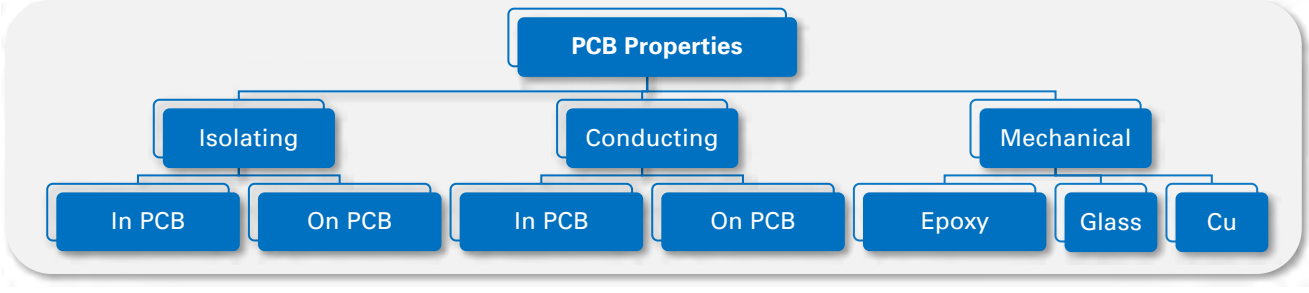


Figure 6: Chart showing the critical properties of PCBs. (Source: Bosch)

al load over lifetime. The diversity of requirements will increase, depending on the applications. On the one hand, electronics are getting smaller, coming closer to the actuators, and will see higher temperatures like power electronics. On the other hand, electronics such as vehicle computers can be better protected against external stress, but have longer lifetimes due to charging times and 24/7 services. Some of the requirements for PCBs and substrates are shown in Figure 7.

The functional requirements are manifold as well. Using PCBs in the electric power train can be a cost-effective solution, but PCBs must cover several hundred amps and up to 1000 volts over lifetimes of greater than 100,000 hours in the automotive environment.

To cover the signal processing requirements of autonomous driving and connected cars, the automotive HDI technology must make a big step forward to enable the use of processors and memories with several thousand I/Os and BGA pitches of < 0.8 mm. High-speed requirements need new materials, which must cope with the environmental requirements, especially humidity and temperature. Figure 8 shows a summary of important functional requirements.

Failure Modes Due to Humidity and Temperature in the Automotive Environment

In automotive electronics, the industry has been focused for a long time on failures in-

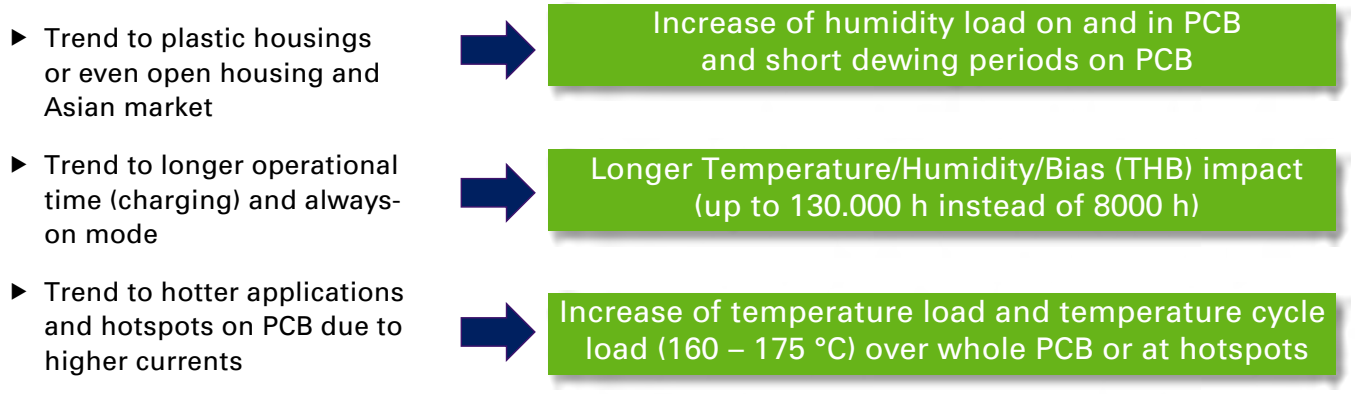


Figure 7: Increasing environmental loads require adaptions of materials and concepts for automotive electronics. A very good understanding of cause and effect relationships is essential. (Source: Bosch)

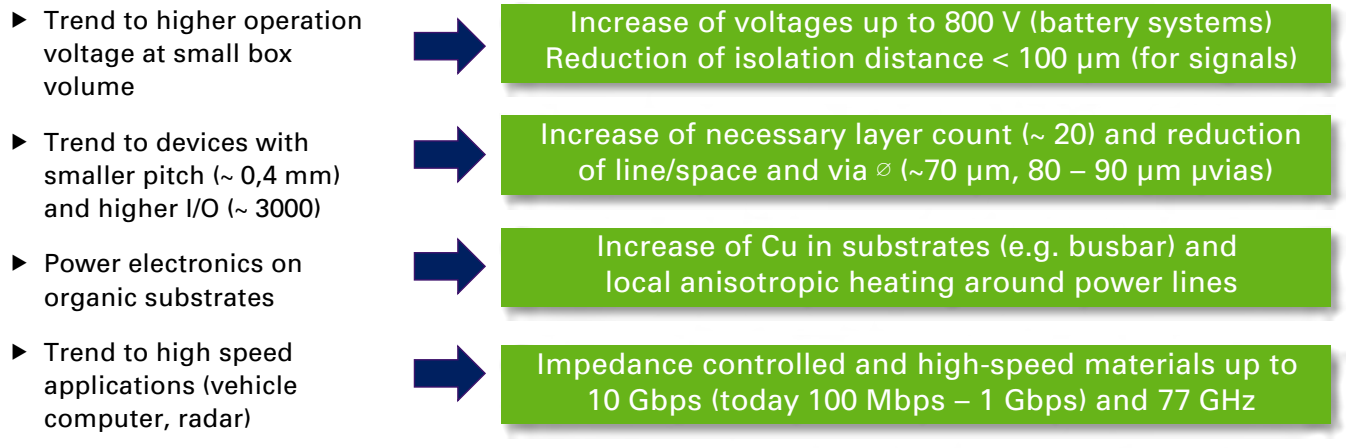
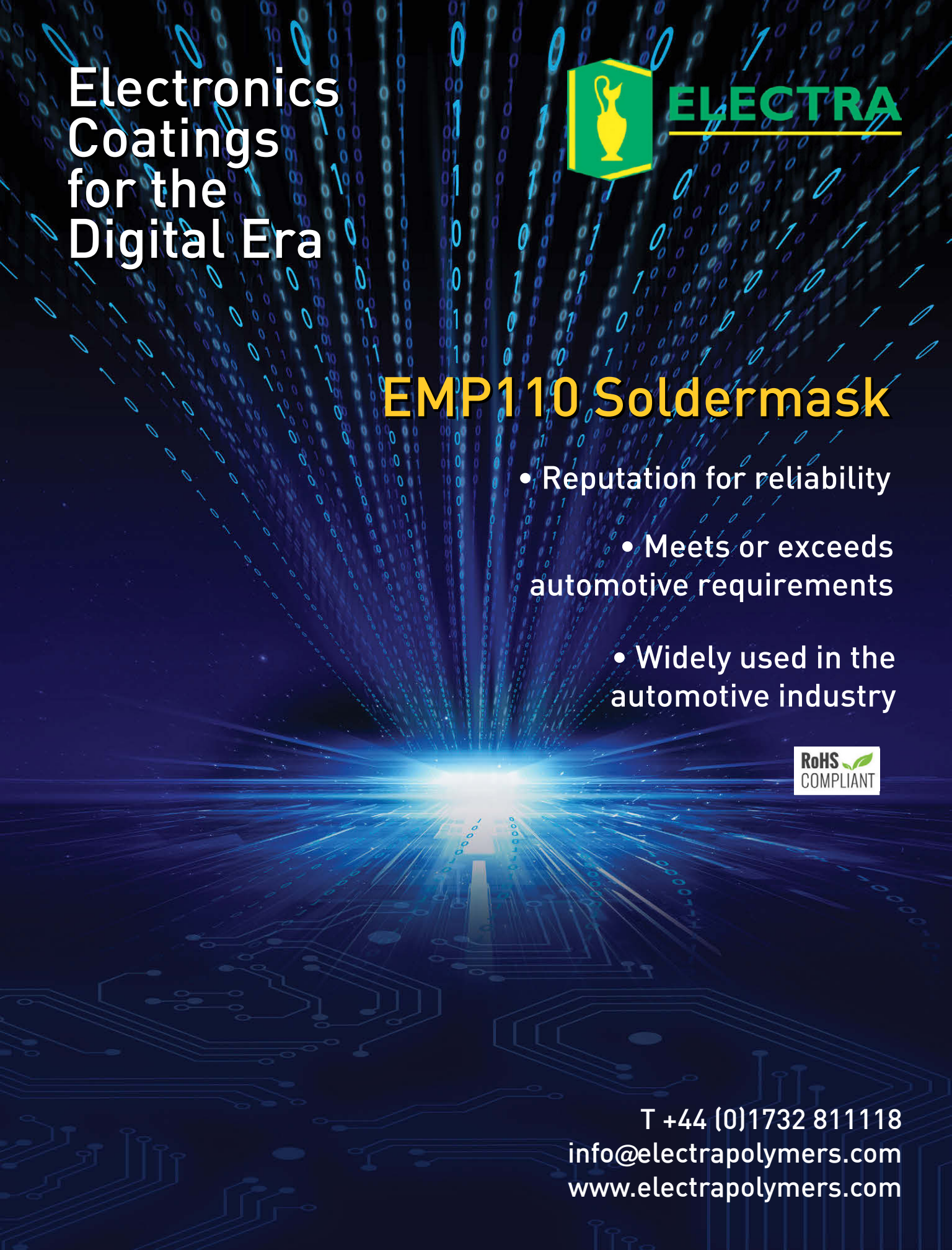


Figure 8: New functional requirements necessitate new PCB concepts such as power PCB and highly integrated logic PCBs. (Source: Bosch)


Electronics
Coatings
for the
Digital Era
ELECTRA
EMP110 Soldermask
• Reputation for reliability
• Meets or exceeds automotive requirements
• Widely used in the automotive industry
RoHS COMPLIANT
T +44 (0)1732 811118
info@electrapolymers.com
www.electrapolymers.com

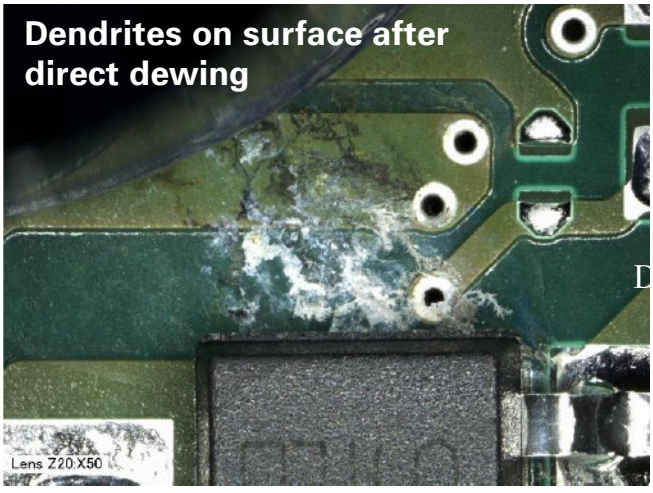


Figure 9: Failure mode on a PCB. (Source: Bosch)

duced by temperature cycling and materials have been optimized for this failure mode. However, humidity and temperature are critical as well, although many applications in the car demonstrate self-heating during operational mode. Before switching on the system, cars may be parked for days or weeks in a humid environment and humidity finds its way into the electronics via plastic or barometric pressure compensations elements.

The effects of humidity, both on the surface and within the structure of the PCBs, are areas of critical concern, and the possible failure modes have been studied in great detail. Therefore, this article highlights failures due to temperature, humidity and bias voltage (THB). Figure 9 shows conductive dendritic growth during dewing (water condensation) on a PCB, something which must be avoided.

Even high humidity without dewing can produce electrical shorts if the materials are not selected carefully. Surface isolation resistance (SIR) can drop and may result in failures in the electronics.

Our approach is to understand very well the climate conditions in the protected (metal or plastic housing) electronics by simulation and experimental tests.

On the other hand, we qualify the materials used (like PCB, devices, flux, thermal interface materials or conformal coating) and design elements according to the IPC-9202 SIR method at different temperature and humidity conditions. With this approach, which is shown in Figures 10 and 11, we are on the safe side regarding the selected design elements and materials, ensuring a proper function during product life cycle.

Inside the PCB, humidity is also critical and lead to a different class of failure modes resulting from electrochemical migration (ECM). Conductive anodic filaments (CAF) or hollow fibres are already well-known in the industry.

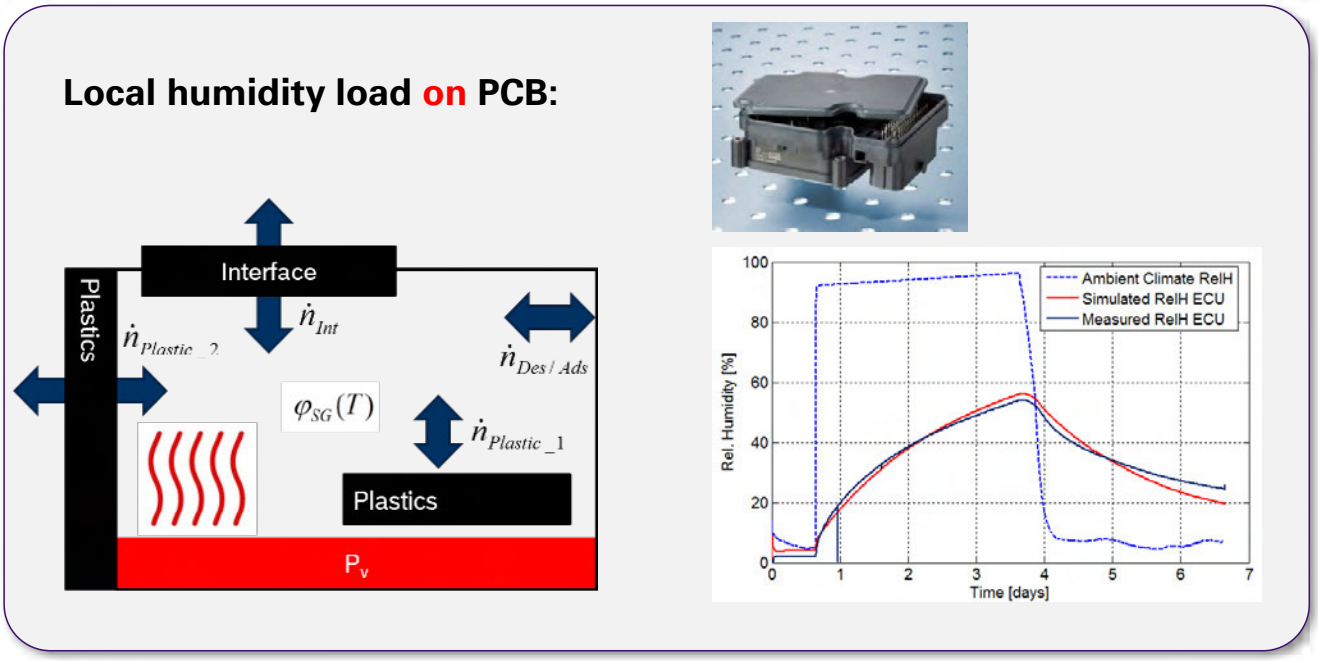
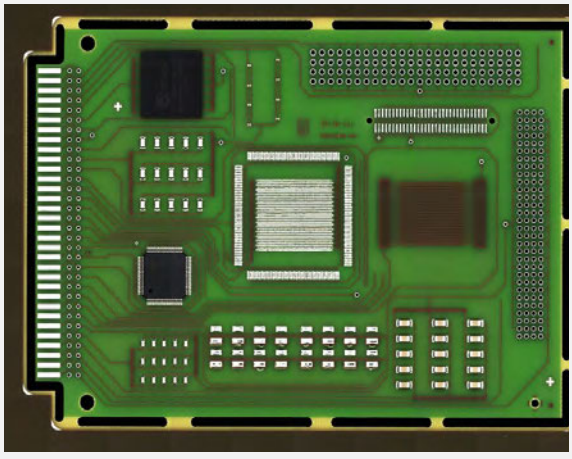
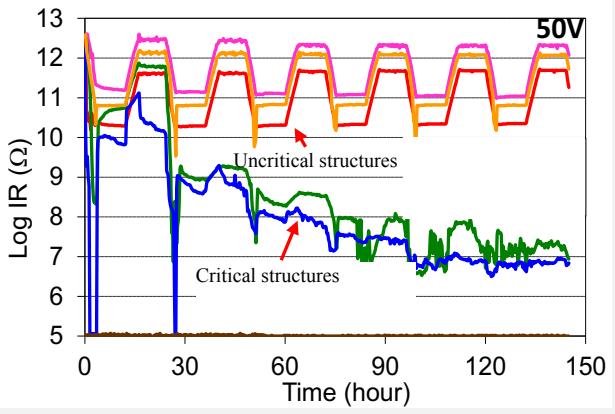


Figure 10: Realistic prediction of local humidity in ECUs by validated simulation models. (Source: Bosch)

Load capability of design elements on PCB:



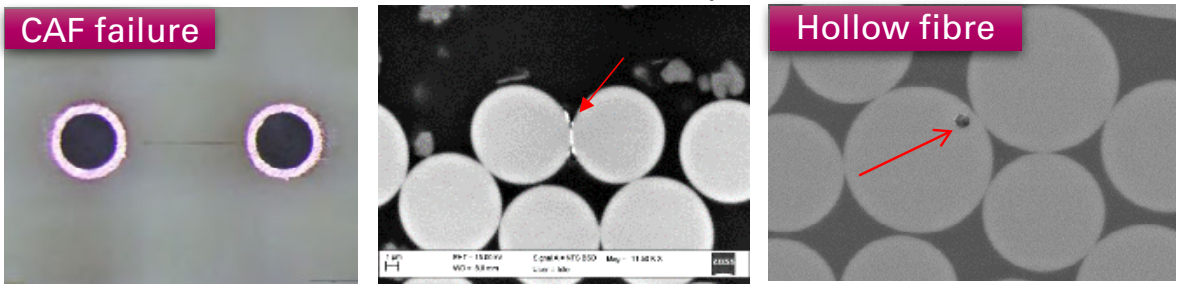
Test vehicle according to standard IPC-9202



Heat dump cycle (25/55 °C, 90-100% r.h.)

Figure 11: Material and design qualification by SIR measurements at worst case conditions in closed housings. (Source: Bosch)

▶ Conductive anodic filament (CAF), hollow fibres



▶ Cracks in resin by mechanical load and T-degradation

Figure 12: Failure modes inside the PCB. Humidity-induced failures will gain importance due to increased field load (especially in Asian markets). (Source: Bosch)

Cracks in the PCB such as distorted zones around plated through-holes (PTH), at interfaces, or in the bulk material must be studied. Cracks in the resin could result from temperature degradation, high pressure, bending and/or mechanical load. In addition, the performance of the PCB material at high voltages needs to be investigated. All of this is necessary to guarantee the isolating properties of the PCB. Figure 12 shows an overview of typical failures in PCBs which could produce shorts and current leakage.

To guarantee robust PCB substrates in automotive electronics, we simulate the local environmental conditions like temperature and humidity in the PCB in an electronic system. This will be compared with the load capability of the materials used, as well as designs. Derived lifetime models help to transfer the PCB qualification test results to real conditions in the electronic systems and to define the adequate distances in the design rules inside the PCB.

This is already done for the CAF failure mode and is ongoing regarding other cracks in PCBs. Here, qualification tests and lifetime models are still under development. If no lifetime model is applicable, the materials or failure modes must be eliminated by material restriction or strict process control (e.g., in case of hollow fibres). Figures 13 and 14 show an overview of this approach.

High-Speed Requirements

High-speed applications like radar (77 GHz) and signal processing for connectivity or image recognition (in future up to 10 GHz) need well-defined substrates and design rule elements. Impedance-controlled PCB stackups and controlled processes at PCB suppliers are standard in the consumer industry and have to be used by the automotive industry to guarantee excellent signal and power integrity with good electromagnetic compatibility. The material choice needs special attention to guarantee

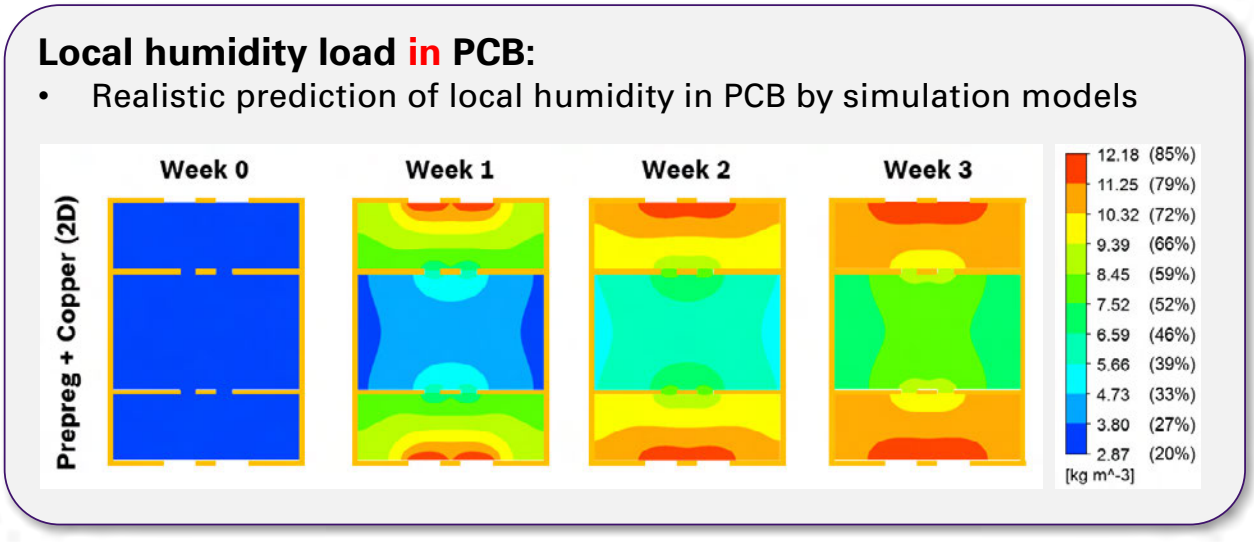


Figure 13: Realistic prediction of local humidity in a PCB by simulation models. (Source: Bosch)

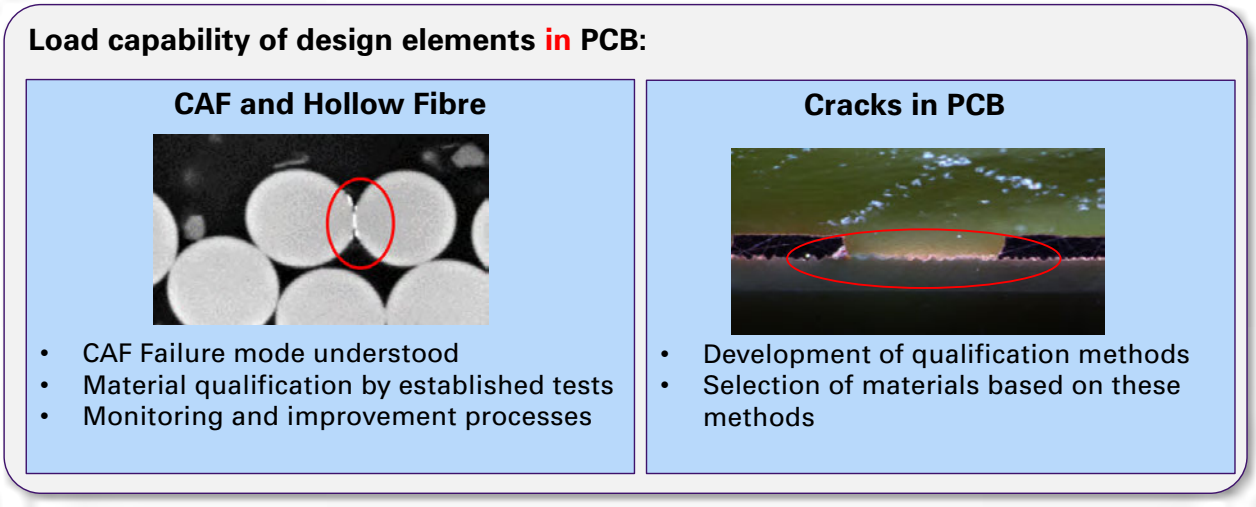
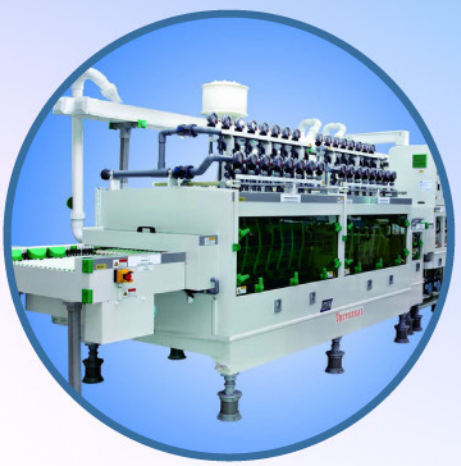


Figure 14: Environmental load in a PCB and load capability of the materials used. (Source: Bosch)

UCE WET PROCESS LINE

Etchers

Scrubbers



Developers

PTH

Oxide Replacement

THIN CORE HANDLING • PC CONTROL • RELIABLE • LOW COST

CLICK TO VIEW OUR UCE WET PROCESS LINE

The leading European PCB Equipment and Parts Supplier

www.vikingtest.com
sales@vikingtest.com

Viking

robust materials regarding temperature, humidity and bias voltage, and electrical performance. In the future this can result in restrictions in material choice and design rules. To guarantee the necessary electrical performance, PCB supplier should be qualified for high-speed applications.

Regarding the electrical properties of the PCB base material (Dk, Df), production tolerances and environmental effects like temperature and humidity—which shift the electrical values—must be considered for automotive applications. As an example, the relative permittivity and the dielectric loss will be reduced during thermal aging but the dielectric constant will go up by increased moisture content in epoxy materials.

Conclusion

Automotive electronics face tremendous changes in function and requirements. Solutions from the consumer industry can be modified or adapted to automotive requirements and new concepts for mass production of power electronic must be developed.

A summary of the higher automotive requirements:

- Longer lifetime (charging times, operation times)
- Higher temperature load (miniaturized electronics near applications; new applications)
- Smaller distances (miniaturization; function—connectivity, automation)
- Higher humidity load (Asia)
- Higher frequencies

Upcoming challenges:

- PCBs are optimized on temperature load (TC classes up to 150°C; in the future, will need 160°C and higher)
- Material even at higher temperatures must stay stable regarding crack formation between electrical potential
- All materials used must not interact at humidity, temperature and bias (to avoid ECM)
- High-speed design up to now possible with existing materials; in the future, new materials will be necessary (> 10 GHz)

Dedicated automotive environmental conditions especially must be considered to design and produce reliable electronics with PCBs. Adequate new PCB material qualification strategies are necessary and under development. **PCB007**

A presentation on this subject was originally made at the EIPC 2018 Winter Conference held in Lyon, France, February 1, 2018.

Dr. Christian Klein is group leader of the Automotive Electronics PCB Technology Group at Robert Bosch GmbH.

ETRI's Cup Holder Charges Phones Wirelessly

A cup holder that wirelessly charges electronic devices in a 3D space has been developed by ETRI in South Korea. It is dubbed as 'E-Cup' and can charge multiple devices placed inside the 10 cm-wide holder at the same time, at the same rate as wired chargers, regardless of orientation or position of the devices.

Shaped just like a circular cup holder, the wireless charger generates and maintains a constant and uniform magnetic field. The electric current wirelessly flows to the batteries inside the electronic devices based on the magnetic resonance.

The Road to Outsourcing CAM Engineering is Paved with VALUE!

	In-House	With Entelechy
Availability	48 weeks	52 weeks, 24/7
Overhead Cost	>30%	0%
Scalability	Limited	Unlimited
Redundancy	Variable	100% Bulletproof
Operational Efficiency	Status Quo	Continual Improvement
Total Cost	Fixed	Significantly lower

> "In our company, the CAM department was the bottleneck. As a result of our working with Entelechy, we can now accept orders that we had to refuse in the past."
>
> *-Thomas Hofmann, CEO/Owner*

HOFMANN LEITERPLATTEN

Click here to check out our risk-free Quick Start program»

We deliver the highest quality PCB CAM and Mechanical CAD engineering services to customers around the world.

ENTELECHY GLOBAL

www.entelechyglobal.com

We love our sponsors!

Thank you to our *Real Time with...* IPC APEX EXPO 2018 premium level sponsors:

TAIYO AMERICA
Your Ultimate Solution

ventec
INTERNATIONAL GROUP
騰輝電子

BÜRKLE
NORTH AMERICA, INC.

SUPER DRY®
Totech EU

And our Exhibitor Product Showcase sponsors:

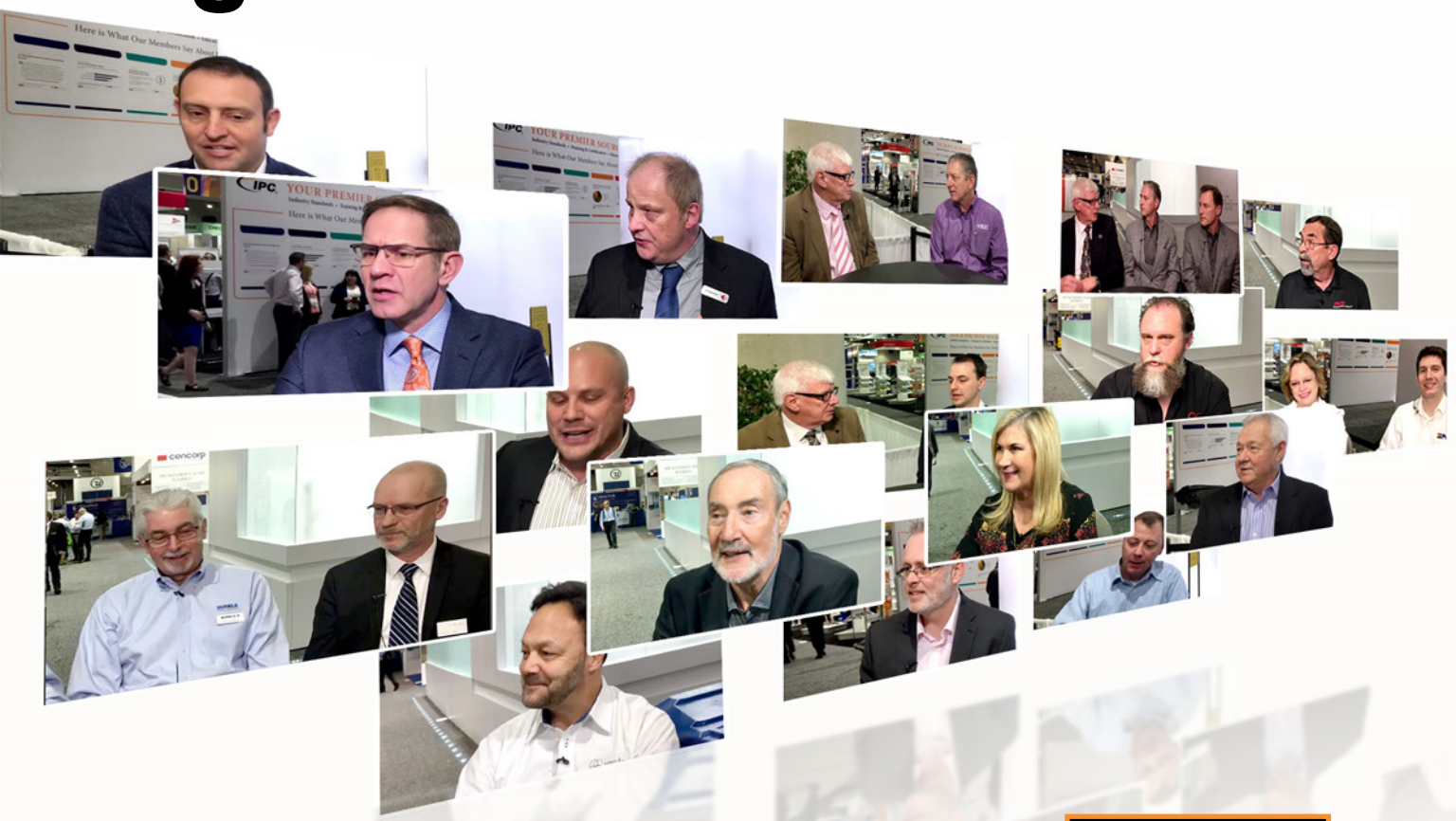
Advanced West
AIM Solder
Bowman Analytics
CIMS USA
CML USA Corp.
Lab ONE (Comet Group)
Heraeus Electronics
Koh Young Technology
Kyzen
MEK Americas LLC
Rogers Corporation
Saki America
Uyemura International Corp.

IPC APEX EXPO 2019 is only 9 months away! Sponsorship seats are limited.

Click to reserve your space for next year!

realtimewith.com

Another year of great conversations!



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

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

Download our post-show coverage magazine!

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

Supply Line Highlights

Panasonic Revises Pricing for Copper Clad Laminates, Prepregs ▶

Panasonic Corporation announced revisions to the prices of its PCB materials. The price increase will affect its copper clad laminates, prepregs, and "PreMulti" mass laminations with innerlayer circuits.

Bridging Knowledge and Understanding of Thermal Management Materials ▶

At IPC APEX EXPO, Pete Starkey and Ian Mayoh, Ventec International's technical support manager, discussed the I-Connect007 Micro E-book: The Printed Circuit Designer's Guide to Thermal Management with Insulated Metal Substrates.

RTW IPC APEX EXPO: Insulectro Showcases New Low-Loss Materials ▶

Norm Berry, director of laminates and OEM marketing for Insulectro, discusses the company's new low-loss products and resin systems that benefit high-speed, high-frequency PCB designs.

A Plug-in that Connects CAD Software to 3D Printer ▶

Nano Dimension USA President Simon Fried discusses the innovative DragonFly 2020 Pro 3D Printer, a highly accurate and versatile inkjet deposition and curing system for printing multilayer PCBs and more.

RTW IPC APEX EXPO: Benefits of Outsourcing Quality Assurance Options ▶

Niraj Patel describes the benefits of outsourcing quality assurance operations, with specific reference to the alternative business models offered by Gardien for electrical testing.

Four IPC APEX EXPO Exhibiting Companies Push Boundaries of Technology and Earn 2018 Innovation Awards ▶

IPC—Association Connecting Electronics Industries—announces the winners of the IPC APEX EXPO 2018 Innovation Awards, a celebration of the innovators and forward thinkers who are changing the technological landscape of the electronics industry.

Cirexx Purchases Third DI system from Technica USA ▶

Technica USA reported that Cirexx International Inc., of Santa Clara, California, purchased their third CBT/MLI DI system recently.

Lenthor Engineering Purchases Two Wise Wet Process Systems from Technica USA ▶

Technica USA reported that Lenthor Engineering Inc. recently purchased two Wise Wordwide wet process systems. One was the Utraflex Conveyorized Alternative Oxide Line. The other is a Ultraflex Surface Preparation Line.

Rigiflex Technology Purchases DI System from Technica USA ▶

Technica USA reported that Rigiflex Inc. recently purchased a CBT/MLI DI system.

TECHNICA, U.S.A.
Fulfilling Manufacturing Needs Throughout the Electronics Industry

Celebrating 33 YEARS

Halogen-free Very Low CTE EM-370(Z) Laminate for High Power and EV/ HEV Applications

For more info, contact
Jason Perry
Director of Sales
JPerry@technica.com
503-318-0617

KEY FEATURES

Ideal for multiple lamination cycles (>4x)

Excellent Anti-CAF performance, surviving 100V/85°C/85%RH/1K hrs with 0.4mm wall-to-wall distance

Excellent Thermal Properties, passing LF260 IR reflow 6X and TCT(-40° to 160° C) over 2K cycles

Outstanding Choice for 6oz Heavy Copper Designs

UL RTI/ MOT: 150 ready for EM-370(Z)-15 material

IST> 3K cycles

Available exclusively through Technica, U.S.A.
1-800-909-8697 • www.technica.com

EMC
ELITE MATERIAL CO., LTD

International Automotive Task Force (IATF) 16949 Standard, Explained

The Right Approach
Feature Column by Steve Williams, THE RIGHT APPROACH CONSULTING LLC

Introduction

If you are building for the automotive industry (or want to be), you will eventually need to be certified to the IATF 16949 standard. It is extremely important to understand the requirements, which can often be daunting and confusing.

Degree of Difficulty

In terms of quality management systems, here is my ranking of the international standards as measured by requirements and the level of discipline required to meet them. In order of increasing degree of difficulty: ISO 9001, ISO 13485, AS9100, IATF 16949. What follows is an outline of some of the major requirements that are over and above what ISO requires.

Customer-Specific Requirements

This requirement specifically addresses the need to evaluate your customer-specific requirements and include them where applicable in the quality management system. This means that a process is needed to evaluate each customer's "customer-specific requirements" and integrate them into your QMS.

Product Safety

These are enhanced requirements that require a process for proactive awareness and mitigation of current and emerging product and process safety issues facing the automotive industry. This includes a focus on statutory and regulatory requirements to identify and control product-safety-related characteristics during design (if applicable) and manufactur-

ing including defining responsibilities, escalation processes, reaction plans.

Corporate Responsibility

Expands the leadership responsibilities to include the requirement for an anti-bribery policy, an employee code of conduct, and an ethics escalation policy to address increasing market and governmental expectations for improved integrity in social and environmental matters in the automotive industry.

Risk Analysis

There are additional requirements for risk analysis recognizing the continual need to analyze and respond to risk which consider specific risks associated with the automotive industry. You need to periodically review lessons learned from product recalls, product audits, field returns and repairs, complaints, scrap, and rework, and implement action plans to address them.

Plant, Facility and Equipment Planning

Preventive maintenance is only the beginning. This updated section includes an increased focus on risk identification and risk mitigation, evaluating manufacturing feasibility, re-evaluation of changes in processes, and inclusion of on-site supplier activities. Many risks can be avoided by applying risk-based thinking during operational planning activities, which includes optimization of material flow and floor space. Automotive-specific capacity planning evaluation is required during manufacturing feasibility assessments and must consider customer-contracted production rates and volumes, not only current order levels.

Total Productive Maintenance

This section strengthens the requirement for equipment maintenance and overall proactive management of the total productive maintenance (TPM). TPM is a system for maintaining and improving the integrity of production and quality systems through machines, equipment, processes, and employees that add value to the manufacturing process. TPM should be fully integrated within the manufacturing processes and any necessary support processes. Metrics need to be more than on time completion of PMs and these are inputs into Management Review.

Documented maintenance objectives including but not limited to:

- OEE (overall equipment effectiveness)
- MTBF (mean-time-between-failure)
- MTTR (mean-time-to-repair)

Internal Auditor Competency

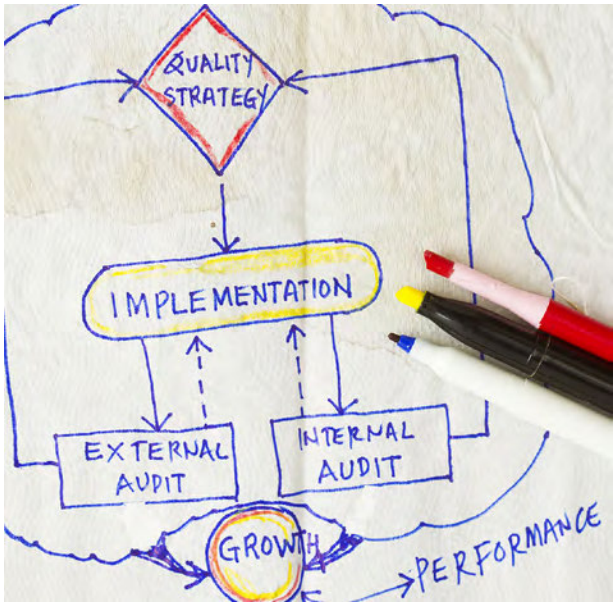
This section features greatly-enhanced requirements to the organization's internal auditor competency to ensure a more robust internal audit process. You must go much further than auditor internal training and need to establish a documented process that considers the competencies required by this clause, take actions to address any deficiencies, assess the effectiveness of actions taken, and record a list of the approved auditors.

Development of Products with Embedded Software

This new clause, where applicable, adds requirements for embedded software development and software development capability self-assessments. If your company develops embedded software, you must have a process for quality assurance of products. The software development process must also be included within the scope of the internal audit program; the internal auditor should be able to understand and assess the effectiveness of the software development assessment methodology chosen by your organization.

Supplier Selection Process

Automotive specifically calls out supplier selection process criteria, in addition to clarifying that it is a comprehensive process much more detailed than ISO. The assessment used to select suppliers needs to be extended beyond typical QMS audits and include aspects such as: risk to product conformity and uninterrupted supply of the organization's product to their customers, etc.



Type and Control of External Providers

Simple scorecards are not adequate as this requirement implies a constant monitoring of performance and assessment of risk based on the established criteria, triggering the actions to increase or reduce the types and extent of control. This applies to all Suppliers.

Statutory and Regulatory Requirements

Identification of applicable statutory and regulatory requirements needs to consider the country of receipt, shipment, and delivery. Consideration should be developed for the product "Life Cycle". When special controls are required, the organization must implement these requirements and flow those requirements down to their suppliers.

Supplier Monitoring

Organizations should continuously review inputs and introduce improvement actions regarding supplier monitoring data, as needed. Documented and non-documented yard holds and stop ships should be considered customer disruptions, and the number of premium freight occurrences need to be monitored.

Second-Party Audits

You will need to ensure that supplier monitoring includes a second-party audit process. The organization shall demonstrate the competence of the auditors undertaking the second-party audits. When supplier monitoring requires periodic second party surveillance audits, the audits shall be conducted at least annually. Records of the second-party audit reports shall be retained.

Supplier Development

This section adds an emphasis on performance-based supplier development activities. Supplier monitoring processes should be considered an input to the supplier development activities and consider both short-term and long-term goals. Short-term efforts focus on supplier products and would require defining suitable methods to assure the quality of purchased product from each supplier. Long-term efforts focus on the supplier's QMS and manufacturing processes to reduce risk.

Preservation

Preservation controls include: the preservation of identification during the product shelf life; a contamination control program appropriate to identified risks; design and development of robust packaging and storage areas; adequate transmission and transportation considerations; and measures to protect product integrity.

Control of Reworked Product

This increases the scope of control of reworked product requirements to include: customer approval, risk assessment, rework confirmation, traceability, and retention of documented information. The risk analysis and customer approval requirements are interrelated; FMEAs should identify and address risks related to each possible rework of the characteristics stated in the control plan.

Repaired Product

The changes in this section clarify the requirement and the need for follow-up with detailed information for reworked product. The repair process should be addressed in the FMEA.

Monitoring and Measurement of Manufacturing Processes

This clarifies the requirement for targeting process effectiveness and efficiency (measuring, monitoring and improving the processes). This includes the competencies required for personnel performing the measurements. Cpk analysis is helpful here.

Manufacturing Process Audit

Shift handover is considered a significant process event; internal auditors should look for objective evidence of an effective process to communicate and address relevant information. The audit must also evaluate the effective implementation of the process risk analysis (PFMEA), control plan, and associated documents.

Conclusion

While this list is not all-inclusive, it will give organizations an idea of what they are signing up for by pursuing IATF 16949 QMS certification. The standard is very demanding and requires a high level of discipline, but as they say, "What doesn't kill us makes us stronger!" **PCB007**

Steve Williams is the president of The Right Approach Consulting LLC. To read past columns, or to contact Williams, click here.

A Charging Electric Car

An alternative to traditional batteries has moved a step closer following the announcement that Rolls-Royce has signed a collaboration agreement with Superdielectrics Ltd, in partnership with the Universities of Bristol and Surrey. The agreement is designed to explore the potential of using polymers to create next-generation high-energy storage technology, and it will see Rolls-Royce combine its world-class material science and technical expertise with Superdielectrics' novel hydrophilic polymers that have been shown by Superdielectrics Ltd, in collaboration with researchers from both universities, to have potentially outstanding energy storage properties.

Dr. Dave Smith, Director of Central Technology, Rolls-Royce, said: "We are very pleased to be working with Superdielectrics Ltd. at a time of rapidly-evolving developments in the energy storage industry. We bring deep experience of materials technology and advanced applications that require high-energy storage capabilities with controllable rates of recovery.

We believe that electrification will play an increasingly important role in many of our markets over the coming years and by working with partners on potential new technologies for energy storage we can ensure that Rolls-Royce is well positioned to take advantage of new developments."

Jim Heathcote, CEO of Superdielectrics Ltd, added: "We are delighted to be working with Rolls-Royce in the global race to develop advanced energy storage systems. This agreement gives us access to their unparalleled scientific and technical expertise. I hope this agreement will ultimately create new jobs and business opportunities in the UK."

IPC Global Marketplace

Delivers Intelligent Search Technology

IPC Global Marketplace is an innovative buyer's guide that enables electronics industry professionals to easily locate the products and services they need to effectively run their business.

With its intelligent search technology, mobile responsive design, and enhanced company profiles, IPC Global Marketplace take the user experience to the next level, all while putting your company in front of the "right" professionals in our industry. It's the place to see and be seen.

IPC Global Marketplace is available on IPC's website, www.ipc.org or directly through ipcglobalmarketplace.com.

E-Textiles—the Wild Frontier

Flex Talk

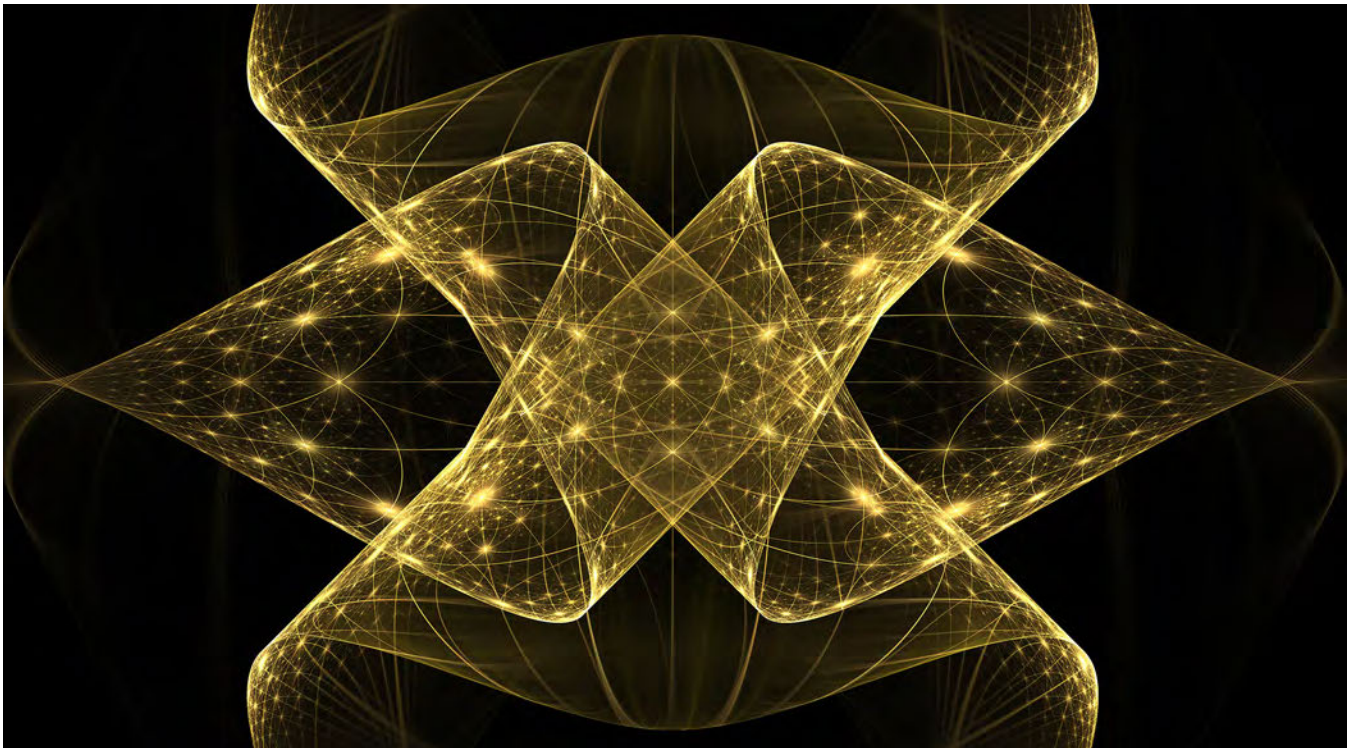
Feature Column by Tara Dunn, OMNI PCB

How many hours is your car sitting idle outside in your driveway or a parking lot? What if your car was used for solar harvesting—converting heat to energy? What about biometric sensors in automotives: skin sensors for preventing DUI, posture identification to monitor driver fatigue, monitoring exposure to hazardous materials in a load for truck drivers. Consider adjustable lumbar, using fabric that changes shape on demand or carbon fiber knit to shape components with shape memory (NiTinol) embedded that change shape to improve aerodynamics. What do all these automotive applications have in common? They are all supported by e-textiles.

E-textiles are a hot topic right now with exciting, emerging applications, and efforts to bring together the textiles industry and electronics industry in new, innovative ways. I recently had the opportunity to sit down with Connie Huffa, textile engineer and principal of Fabdesigns, Inc. She is an alumna of The Philadelphia College of Textiles and Science, where she was also an adjunct professor of textiles in the master's program. Connie's specialties are comfort, anatomically correct compression, sustainable materials development, protective support structures, elastomers, inlaid kinetics, building infrastructure and best practices for nearly zero waste manufacturing. Her current work is focused on photovoltaic, conductive and smart fabrications. Connie shared some thought-provoking e-textile applications and her experience in this developing market. Here are some of the things we discussed:

First, how do you define E-Textiles?

E-textiles include woven textiles, knitted textiles, non-woven textiles, laminated textiles, braided textiles, embroidered textiles, and printed textiles that have electronically-integrated components. These can include con-

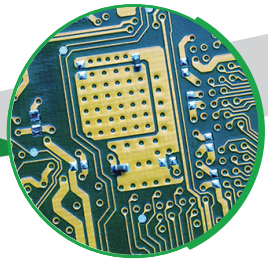


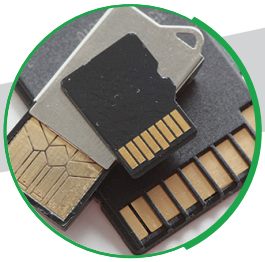
Only **BOWMAN**

› GUARANTEES

that its XRF System meets **IPC-4552A** and is

"accurate and reproducible for the thickness range specified."





6 models; chamber sizes for every part geometry. All made in the USA.

IPC's new performance standards for ENIG mean that deposits meet the highest coating durability rating as specified in the J-STD-003 printed board solderability specification.

Whether you're measuring ENIG / ENEPIG, HASL, electroless nickel %P, or elements from aluminum to uranium, Bowman coating measurement systems are uniquely suited to your needs and budget.

- Precision instrument measures up to 5 coating layers instantly, including alloys.
- Systems simultaneously provide coating thickness, elemental analysis, and single and mixed metal solution analysis.
- Poly-capillary optics achieves >100X higher flux than a collimation system at equivalent distance
- Supported by the industry's most knowledgeable and most experienced LOCAL support team.

BOWMAN
Coating Measurement Instruments

Talk with us today!

847.781.3523
sales@bowmanxrf.com
www.bowmanxrf.com

XRF Equipment • Local Tech Support, Worldwide • Standards • ISO/IEC 17025 Accredited Lab

ductive fibers, conductive yarns, conductive coatings, conductive embroidery, and conductive laminations. The electronic components can be sensors (physiological and environmental), wearable computing, wearable actuators and control elements, integrated circuits, LEDs, OLEDs, batteries, etc. The components can be passive (e.g., fiber optics) or active, and even interactive.

What is the most exciting technology development since you started?

One exciting technology that Connie described is interactive textiles where there may be a sensor or an electrical or thermal trigger for the fabric to assemble or disassemble itself. One of the other applications that she has heard of but not yet seen is interactive camouflage[1,2].

Fabdesigns has played with combining electricity and thermal chromic inks. They have knit a jacquard into a fabric on industrial knitting machinery, painted it with black thermal chromic ink, and then used a heat source to reveal the underlying jacquard on demand. We presented this fabric and self-disassembling fabric, using NiTinol at IFAI in September.

Another is touch switches, using spacers. A spacer is a double-faced fabric, which is separated by Vs or Xs of another yarn that connects the two faces together. It forms a cushion in traditional fabric manufacturing, usually warp or circular knit roll goods. But in smart or e-textiles, a grid is knit into the fabric face and a different one on the reverse. Depressing the cushion in a particular area creates a circuit and can give location of that depression or act as a switch (capacitive sensor). If a sensor is added, the pressure rate of that depression can also be monitored. This can be used in Piezo electronic energy harvesting, security, and biomedical applications such as bedding applications in geriatric situations (bed sores), pediatric, and veterinary applications.

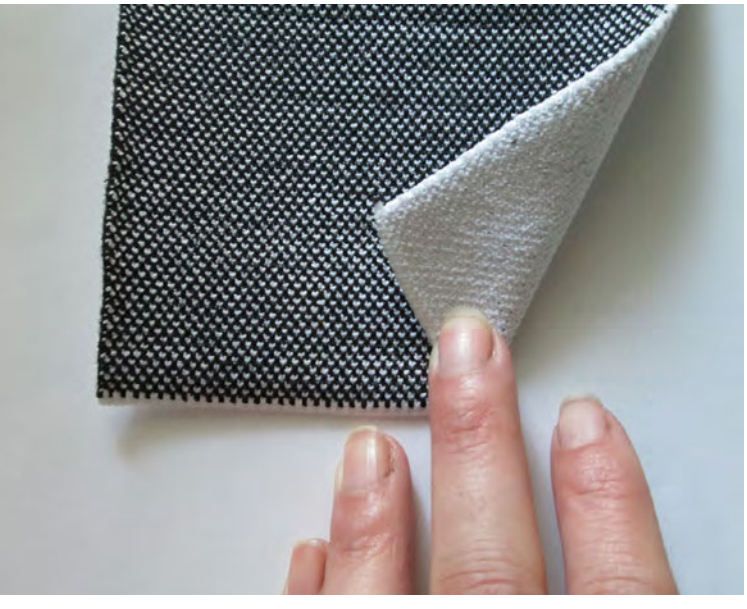


Figure 1: Double-faced spacer fabric (shielding yarns).

What do you see as some of the challenges of merging electronics and textiles?

Textiles and electronics are very deep fields. It's difficult to find people with both skill sets at the level needed to build projects. Almost all—98%—of textile equipment sold is for conventional apparel. Building technical textiles in and of itself is a specialized skill set, and mentality. To build technical textiles, one must start from the polymer and build upward. There are few if any plug-and-play components (fibers, yarns, fabrics, coatings, etc. that are off the shelf) for building technical textile, let alone smart/e-textiles. Each project is different.

The main issue is washability. Electronics do not take kindly to water. Battery size—depending on what the product is supposed to do—is also an issue. The size required to do complex actions might be too large and cumbersome to wear.

Another issue is recyclability. What do we do with these textiles once they are not working, obsolete, or have reached their end of life? Can we repurpose them, recycle them or reuse them? At the moment, 85% of all our clothing ends up in the landfill. It's an environmental crisis[3]. Electronics has a similar track record. There are electronics pick-up days and designated places to bring them, even waste disposal fees for getting rid of old and obsolete products. In building smart textiles, we are blending two problems, unless we can devise exit strategies and build those into the design process.

What are some of the variables to consider when designing and developing a new product?

Building an e-textile/smart textile is dependent upon a few factors before even getting started making the textile part. Using the medical field for example, there could be three types of external products: post-operation, rehabilitation, and chronic treatment. Each of those has different end use expectations, price points, and warranty/durability needs. Most people don't ever see the price of a post-operative product that is covered by insurance. That product may be needed for a couple hours, or days. They might see the price of a rehab product if it's not covered. These might last days or weeks. Most times, OTC or prescription items for chronic situations must be price-competitive and need to last a longer amount of time—weeks, months, a year.

Sensors for medical products are more expensive because they need to go through the FDA process (ISO 13485). This could take a year and a lot of money for clinical trials. There is also a lot of documentation and risk management in both auditing design and production processes to ensure quality, precision, defects are captured, the product does no harm, etc. Recalls mean class action lawsuits.

The same non-prescription product that is sold for sports applications is developed along the lines of other consumer products: three to six-month development to sales. Maybe there are safety protocols in place, maybe not. The goal here is sell-through. The biggest risk is mark downs, charge backs and returns. Recalls are few and far between. The entire product development process and accountability is completely different for both industries, yet both might develop similar projects.

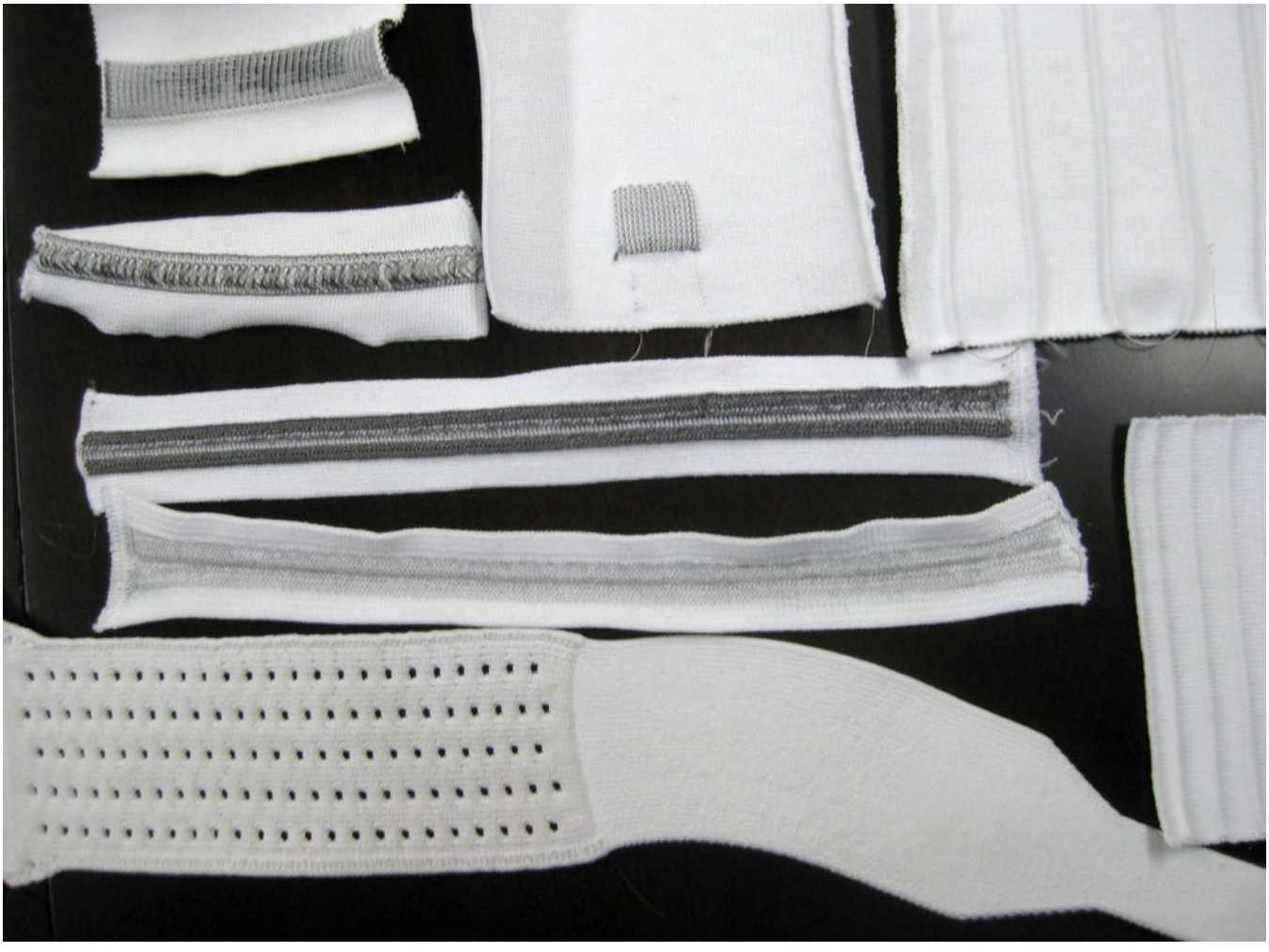


Figure 2: Fabrics that are 2D and 3D knitted with conductive fibers.

Depending on the application and performance required for the end product, the 'e' or 'smartness' can be built in several ways along the product development process:

- Fiber cross-section: conductivity can be the core, the exterior, striped
- The conductive fiber can be blended with other fibers: it could be a filament (one continuous) or a staple fiber (cut) or that filament or staple can be splayed into a non-woven (directional, amorphous, as a layer, a surface, needle-punched, felted)
- The conductive fiber could be twisted into a yarn either homogenous or part of a yarn
- The conductive fiber could be braided
- The conductive yarn can be:
  - knit
    - warp knitted: warp direction, weft direction segmented in warp or weft, vertical, horizonal, diagonal, or any combination of all of the above
    - Weft knitted, circular: striped, all over, spacer (face, reverse, interior, any or all of the above), plaited, jacquarded, terry, sliver knit

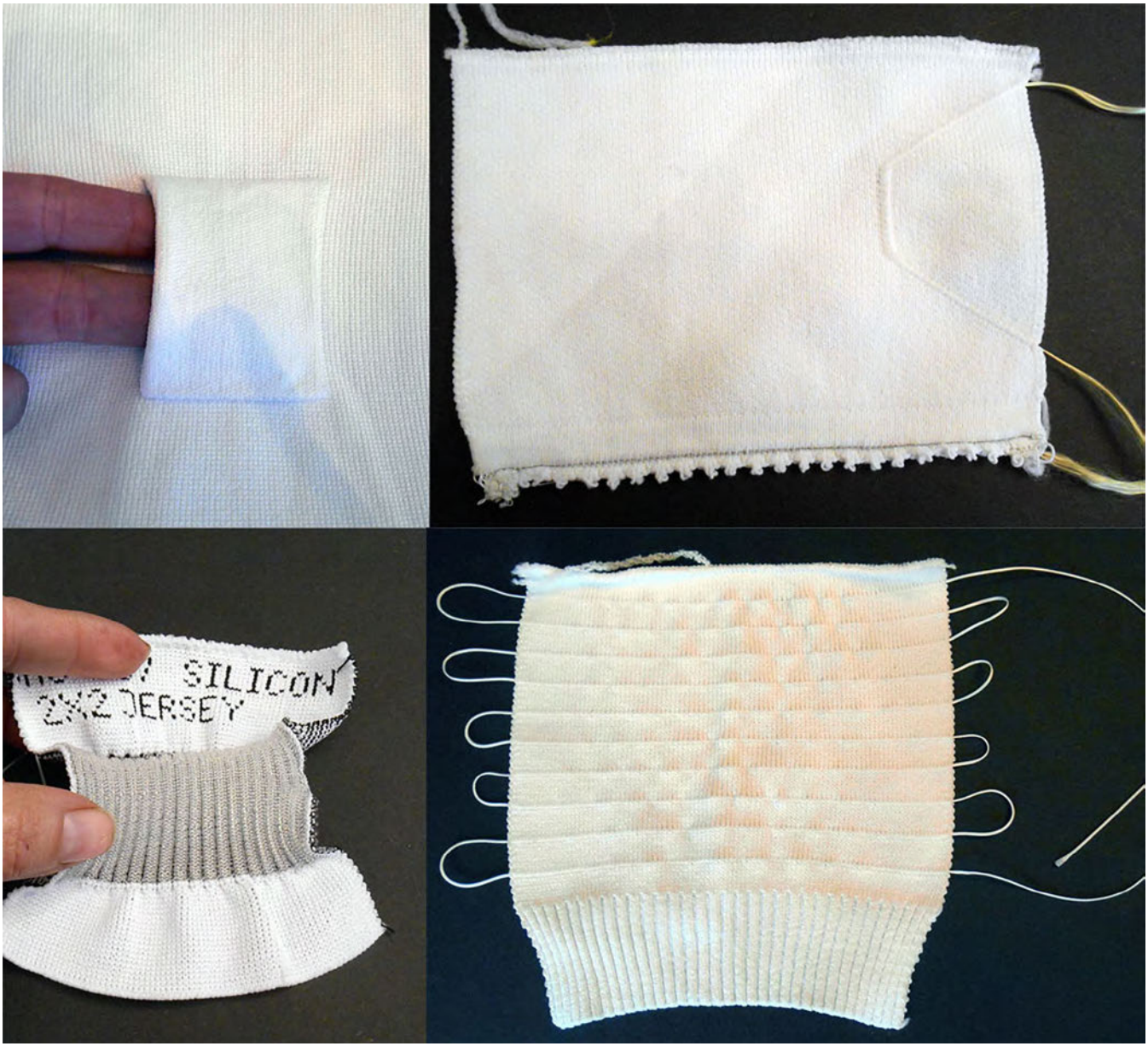


Figure 3: Several ways to integrate electronic components and shielding into knitting.

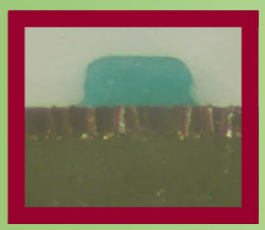
MivaTek Global

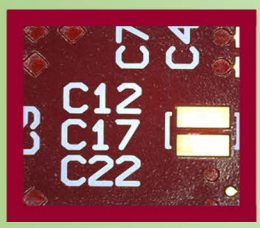
MIVA TECHNOLOGIES

MIVA: LED DIRECT IMAGING

LED Direct Imaging

We give a dam...2.0 mil solder dams





- > 2.0 mil solderdams
- > 4 mil mask defined pads
- > Colors: GRN, WHT, BLK, BLU, RED
- > Excellent camera registration
- > Legend printing using white SM
- > Inner and outerlayer imaging
- > Extensive North American support
- > 20 machines sold in North America

MivaTek Global, LLC formerly *Kuper Technology, LLC*

Now Hiring : *Sales Engineers, Applications Engineers and Technical Support*

MivaTek Global, LLC, PO Box 893, Concordville, PA 19331, Ph: (610) 620-3795

Eastern US: Brendan F. Hogan, M:(610) 620-3795, B.Hogan@MivaTek.Global
Western US: Kurt Weber, M:(714) 767-6367, Kurt@MivaTek.Global

    - Weft knitted, flat machine: intarsia, zones, striped, spacer, plaited, 3D structured (numerous types too many to list here), spacer (face, reverse, interior, any or all of the above)
  - Woven: warped, weft inserted, or both; jacquarded, brocade, striped, etc.
  - After processes:
    - Laminated
    - Coated
    - Embroidered
    - Printed

These fabrications may or may not stretch, depending on their end uses. The conductivity needs to stretch, flex, and recover with the fabric, and the performance in motion, all for a given amount of time based on the warranty and how that product is to be used and cared for (washing the elements, bending, flexing, stretching, etc.).

What exciting things can be seen on the horizon?

Here's a few that Connie described:

- Energy harvesting[4], Geotextiles and piezo-electric
- Carpets and tiles that harvest energy[5,6] and piezoelectric agility in transportation[7]
- Magnetostrictive fabrics that change shapes[8]
- Conductive inks: wall coverings that act as speakers
- Smart building materials like concrete[9]
- Electro ooblecks that take the place of canes to assist in walking[10]:
  - Next generation will change color, emulate muscles, respond to light, heat, radiation and magnetic fields
  - Materials will become more lightweight with super strengths and multiple functions varying with their environment
  - Materials which can discriminate whether the loading is static or shock and can generate a large force against shock stresses (mega and micro shock absorbers)
  - Materials possessing self-repairing properties which can heal damage in due course of time (self-healing materials)
  - Materials that can be used in ultra-high temperatures by changing the composition through transformation (application in space shuttles which encounter high-temp in reentry to atmosphere)

The E-Textiles Buzz Session at IPC APEX EXPO was very active with lively debate and discussions about a technology that may be new to electronics but is certainly something we should be aware of. IPC has established an e-textiles standards committee and is hosting an e-textiles workshop in September[11].

It will certainly be interesting to see how the integration of electronic and textile technology develops over the next several years. Using just the automotive industry alone, Connie has described possible applications for energy conservation, driver safety and driver comfort. Both industries need to design for mishaps such as your child (or yourself) spilling a milkshake on the seat of car without letting that impact the electronics. Learning how a textile engineer might approach that scenario has been eye-opening and I look forward to learning more about the textile industry and how electronics will play a role in future product development. **PCB007**

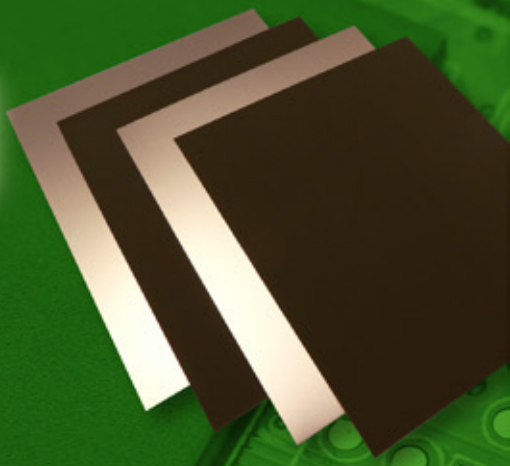
Figure 4: Connie Huffa at the E-Textiles Buzz Session at IPC APEX EXPO 2018.

Panasonic

Low stress, Low CTE, Ultra-thin IC substrate materials

MEGTRON GX

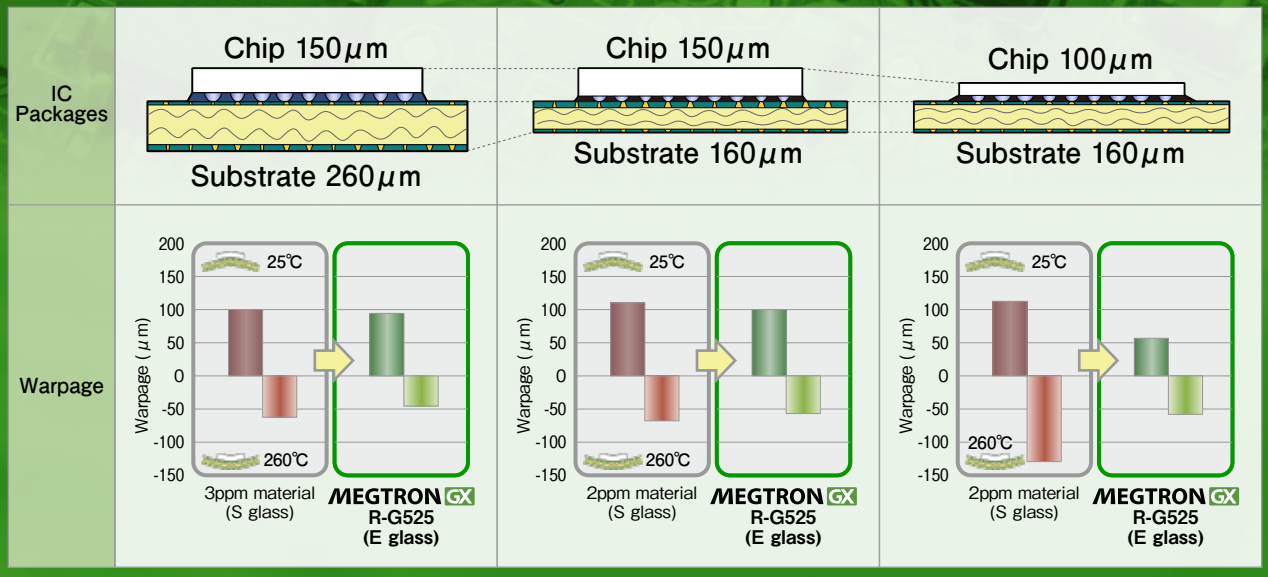
Laminate **R-G525** Prepreg **R-G520**



Features

- **Decrease the warpage by low stress**
- **Available to wide range of IC packages**

Comparison of warpage in various IC Packages



May 29 - June 1

ECTC 2018

Our Booth **#708**

- **Place: Sheraton San Diego Hotel & Marina**
- **Product: IC substrate materials, Encapsulation materials**
- **Poster session (at Northern Hemisphere Foyer)**

May 30, 2018 2:00-4:00 pm
- Low Dielectric Properties Encapsulation for High Frequency Devices

May 31, 2018 9:00-11:00 am
- 3D Stacking Process with Thermo-Sonic bonding Using Non-Conductive film

Contact us

More information

Partnering to go beyond.

Electronic Materials
Panasonic Corporation

References

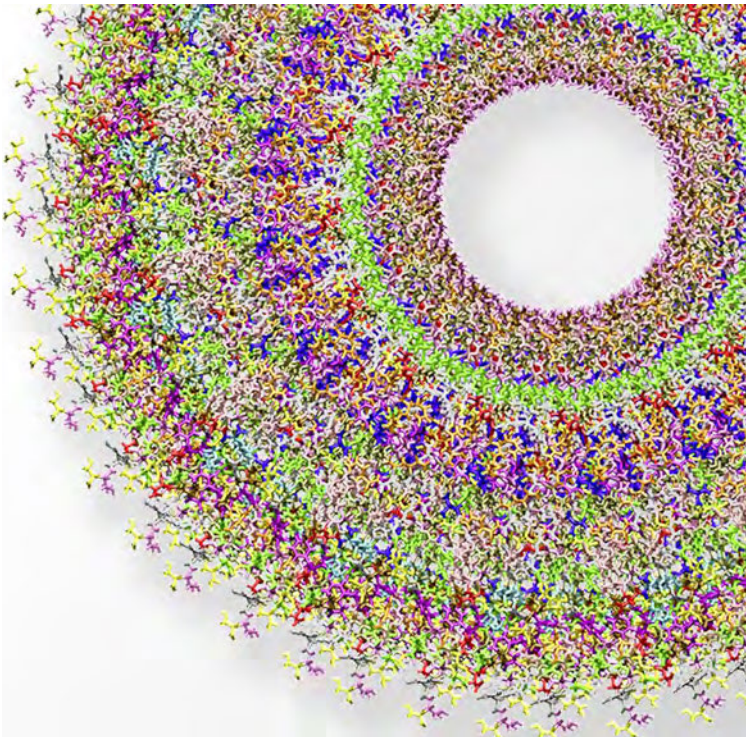
1. A chameleon-inspired stretchable electronic skin with interactive colour changing controlled by tactile sensing, Nature Communications.
2. Electronic Textiles: Wearable Computers, Reactive Fashion, and Soft Computation, Textile, Vol. 3.
3. Fast Fashion is Creating an Environmental Crisis, Newsweek, Sept. 1, 2016.
4. Good Vibrations? California t Test Using Road Rumbles as a Power Source, IEEE Spectrum, 19 April 2017.
5. Veranu.
6. Energy Floors.
7. Smart Materials (3 of 5): Shape shifting material, YouTube.
8. Application of Magnetostrictive Films in Astronomical X-ray Telescope, Northwestern Engineering, Advanced Manufacturing Processes Laboratory.
9. Science of Innovation: Smart Concrete, Science 360 video.
10. Shape-Morphing Smart Materials; the Future of Assistive Technology, Mark C. Ransley,Tedx UCL.
11. IPC E-Textiles 2018 Workshop.

Tara Dunn is the president of Omni PCB, a manufacturer's rep firm specializing in the printed circuit board industry. To read past columns or to contact her, click here.

From the Quantum Level to the Car Battery

New developments require new materials. Until recently, these have been developed mostly by tedious experiments in the laboratory. Researchers at the Fraunhofer Institute for Algorithms and Scientific Computing SCAI in Sankt Augustin are now significantly shortening this time-consuming and cost-intensive process with their "Virtual Material Design" approach and the specially developed Tremolo-X software. By combining multi-scale models, data analysis and machine learning, it is possible to develop improved materials much more quickly. At the Hanover Trade Fair from April 23 to 27, 2018, Fraunhofer will be demonstrating how the virtual material design of the future looks (Hall 6, Booth A30).

In almost every industry, new materials are needed for new developments. While an automobile used to consist of just a handful of materials, modern cars are assembled from thousands of different materials. Whether it's making a car lighter, getting better fuel economy or developing electric motor batteries, every new development requires finding or developing the material with the right properties. The candidates have usually been selected from huge material databases and then tested. Although these databases provide insight into specific performance characteristics, they usually do not go far enough into depth to allow meaningful judgments about whether a material has exactly the desired properties. To find that out, numerous laboratory tests have to be performed. The scientists at the Fraunhofer SCAI have chosen a different approach. The requirements for the substance are broken down to the inner structure of the material: that is, down to the atomic level.



tracqms

THE RIGHT APPROACH CONSULTING LLC

Now is the perfect time for you to take the right approach to quality management.

The single best improvement you can make to your business is to update your QMS. I can help you upgrade to ISO 9001: 2015 or AS9100 Rev D in six months - guaranteed!

LEARN MORE ABOUT MY CERTIFICATION GUARANTEE

tracqms.com

Electronics Industry News and Market Highlights

'Micro-ized' High-Tech Yet Fashionable Jewelry is Emerging ▶

Apple Inc., known for its design sophistication, elegance, and component density, set a new standard with its iPhone X; it utilizes stacked printed circuit boards (PCBs), which is a first for smartphones.

Tiny Electronics Could Solve Security Issues ▶

A University of Sydney engineer has developed a new nanotechnology-based component that could sit at the heart of anti-counterfeiting technologies for the fashion and defence industries and fraud-proof verification techniques for online machines.

Inspired by Nature: Design for New Electrode Could Boost Supercapacitors' Performance ▶

Mechanical engineers from the UCLA Henry Samueli School of Engineering and Applied Science and four other institutions have designed a super-efficient and long-lasting electrode for supercapacitors

EPTE Newsletter: Nano Tech 2018 and Printable Electronics ▶

Nano Tech 2018 was held at Tokyo Big Sight on February 14. The three-day show is one of the largest events for nanotechnologies.

Magnetic E-Skins Usher in New Era in Sensor Engineering ▶

A team of researchers has developed the first-ever magnet-sensitive electronics that can track body movements, opening exciting prospects for a wide range of industries.

Student Develops Novel Low-Cost, High-Performance Transmitter for Radar ▶

A Khalifa University Master's student has developed a novel wideband transmitter that can receive and transmit high-frequency radio waves at a much lower cost and physical footprint than traditional radar technology.

A Power Boost for Mobile Technologies ▶

Imagine you're shopping on your iPad for a new merino wool sweater. When you visit a retail site, you not only see countless views of your prospective purchase, you can reach out and feel the texture of the fabric.

High Demand for Wearable Lifestyle Devices Drives Growth ▶

The high demand for wearable lifestyle devices is one of the major factors driving the global wearable sensors market. Consumers use smartwatches, smart bands, and smart rings to monitor daily fitness and health, to track activities, listen to music, watch virtual/3D videos, play virtual games, and access social networking websites.

VISION

MULTIPLE PLATFORMS

Drill/Rout/Optimizer
X-Ray Vision

MORE INFO

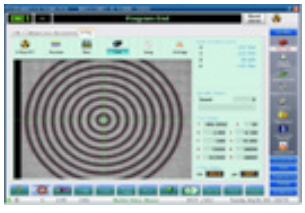
Drill/Rout Multi-Spindle
CCD/RGB Vision

MORE INFO

Dual Spindle All in One
Vision System

MORE INFO

SEEING IS BELIEVING



X-Ray - 8X Faster!
with NEW concentric target

See inside your PCB
measure your results!

Drill/Rout/Optimize
Entry level *"Smart Drill"*

MORE INFO

TIME-TESTED FEATURES

Vision Simplifies

Post Etch Slot/Drill

X-Ray Optimization

CCD Camera Optimization
"Smart Drill"

BarCode Job
Data Management

Panel Marking/Serialization

1700 Tool Library per spindle

Control Depth Drilling and
Routing to 15 µm

Lights out Automation

Up to 6 Spindle
Configurations

Automated Panel Prep
(Flash Routing, Edge
Beveling, Corner Champer,
Panel Thickness Measuring)

pluritec

www.pluritec.com | info@pluritec.com

How are the Ratings?

Testing Todd

by Todd Kolmodin, GARDIEN SERVICES USA

Hello, readers! Thank you for stopping by again. Let's talk about ratings. No, I'm not talking about the latest Facebook likes or Twitter retweets, but a topic that confuses many final QA technicians the world over. I'm talking PCB voltage ratings.

If you are an electrical test engineer/technician, I'm sure you have seen many master drawings that use the term "Maximum Rated Voltage is XXX Volts," where XXX is a number. I have seen many final inspection areas that will reject a final ET certificate of compliance (CoC) because they read the master drawing and see a statement such as "maximum rated voltage = 24V" but the CoC says it was tested at 250 volts! The manufacturing specification is also stated as IPC-6012D(DS). Is the CoC wrong? In most cases, no. "Todd, can this be?" you ask. Well, in this case, it is correct.

Master drawings carry a gambit of information for the manufacture of printed circuits. Many notations are specific instructions and call-outs for the PWB. However, there are many "statements" on the master drawing as well. The term "maximum rated voltage" is one of those statements. In many cases, when you read that statement, you can think, "Thank you for that. Good to know." Does that mean that I have to test that PWB at the rated voltage? In many cases the answer is no. What that statement is telling you is that in that PCB's duty cycle (life) it will never see a voltage higher than what is stated. Again, good to know, right?

Let's break down our example above:

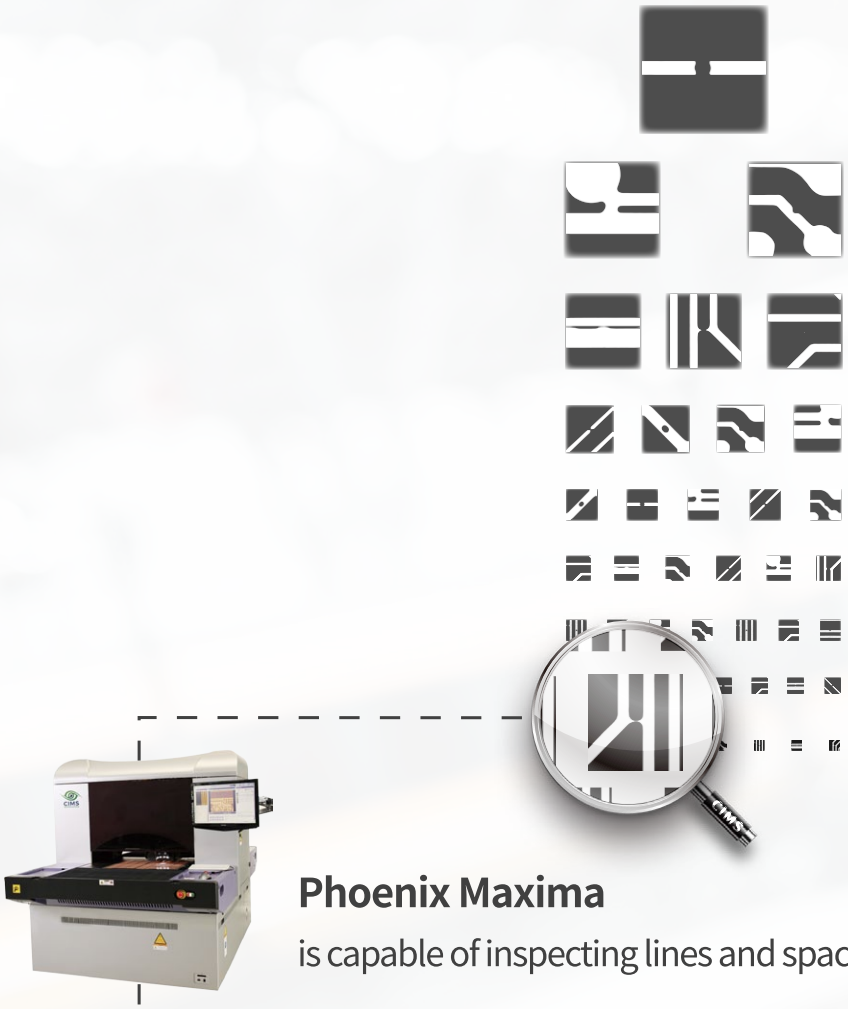
1. Maximum rated voltage = 24V on the master drawing
2. Specification = IPC-6012D(DS)
3. Certificate of Compliance states 250V

Who's right? The certificate of compliance is correct. Why? As we reviewed above, the max-

CIMS
By Camtek technology

Can your AOI see all the defects?

CIMS AOI can detect even the smallest and darkest shorts!



Phoenix Maxima

is capable of inspecting lines and spaces down to 10 micron.

+2DM +3Dh +2Cd +3Dp

Optional add-on
2D and 3D metrology capabilities

CIMS USA | WWW.CIMS.COM

Please contact your local sales representative to get more information.

imum rated voltage is a statement in this case. However, item 2 is significant because it expressly calls out the IPC-6012D amendment specific to space and military avionics. That specification has a specific ET requirement for 250V. See what I did there?

Okay, now is where it can be a little tricky. What if our example is a standard build to IPC-6012 and the statement "maximum rated voltage = 40V" is observed? What should the PCB be tested to? In this case, referring to IPC-9252, if the rated voltage is specified rather than a test voltage on the master drawing, the rated voltage shall be used or 40 volts minimum, whichever is greater. So in this case the 40V is correct.

Another statement that can be seen as briefly noted in the above example is "test voltage = XX." Now in this case, the statement is significant as we are being told specifically what the test voltage shall be. However, what if the test voltage stated is less than 40V? Houston, we have a problem. With automated test equipment, to be compliant to IPC-9252, MIL-PRF-31032, MIL-PRF-50884 and MIL-PRF-55110, a minimum voltage of 40V must be used. In fact, in the case of IPC-6012D(DS) the minimum is 250V!

But what if there is a statement on the master drawing of "maximum rated voltage = 24V" and the Certificate of Compliance states the test voltage was 100V? I know, you just thought the CoC should state 40V? Not necessarily true. Remember the specifications state a minimum of 40V shall be used. Testing the PWB at 100V is completely valid.

To summarize:

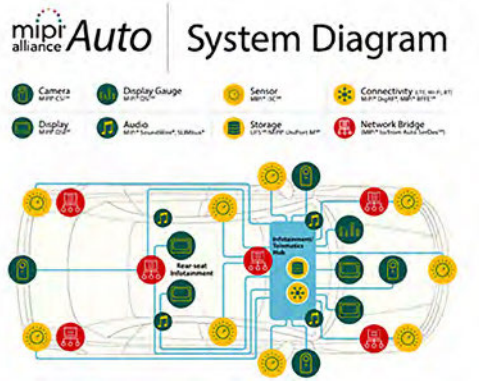
1. Maximum rated voltage shall be used to test the PWB if it is 40V or greater. Otherwise a 40V minimum default is to be assumed.
2. Test voltage shall be used if it is 40V or greater and needs to be IPC/MIL-compliant. A test voltage statement of less than 40V needs to be clarified by the customer; if used it will not be military/IPC-compliant.
3. If neither a maximum rated voltage or test voltage is stated, a minimum of 40V shall be used. Higher voltages are acceptable.
4. If a maximum rated voltage is stated as less than 40V, a minimum of 40V shall be used. Voltages above that minimum used are valid for the certificate of compliance.

See you next month! **PCB007**

Todd Kolmodin is the vice president of quality for Gardien Services USA, and an expert in electrical test and reliability issues. To read past columns, or to contact Kolmodin, click here.

MIPI Alliance Expands Reach with New Automotive Working Group

The MIPI Alliance, an international organization that develops interface specifications for mobile and mobile-influenced industries, recently formed the MIPI Automotive Working Group (AWG) to address the needs of the automotive ecosystem. As the number of sensors continues to increase in the automobile to support passive and active safety, infotainment, advanced driver assistance systems (ADAS) and autonomous driving systems, the need for interface specifications is apparent. The group will collaborate with other MIPI working groups on an automotive physical layer specification for longer reach applications.



"The approval of the MIPI Automotive Working Group marks a significant milestone for MIPI Alliance's development activity," said Joel Huloux, chairman of MIPI Alliance. "While MIPI's focus is foremost on developing interface specifications for mobile devices, automakers already rely on MIPI's industry-standard interfaces. This additional focus on automotive is a natural extension to broaden MIPI specifications' applicability."

Excellon

Manufacturers of precision Micro-Machining Solutions for over 50 Years

COBRA II

Hybrid laser system

689

6-station precision drilling and routing system

HS-1L DS

Single-station, dual spindle high-speed system

136L

High accuracy and speed

154L

Large panel applications

HS-2L

2-station, high-speed

129

Single-station precision system

Move into the future with the latest innovations in Fabrication Technology from the Industry Leader!

www.excellon.com

Looking at PTH Voids

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

Introduction

Several columns have been published in this space describing the origins of voids in the plated through-hole. However, not all voiding is caused by or has its genesis in the electroless copper (PTH metalization) process. For this edition of "Trouble in Your Tank," I present another look at voids and additional root causes that may be less understood.

Pre-electroplating Causes of Voids

One of the areas often overlooked as a cause of plating voids is a discontinuity in the electroless copper deposit. However, what if the panels were void-free after electroless copper only to void later in the manufacturing process? Several possibilities must be considered when such voiding is discovered. These include:

- Scrubbing prior to resist lamination
- Excessive copper removal caused by the microetch prior to electrolytic copper plating
- Photoresist residue in the via

In general, the type of void one would see is shown Figure 1. The defect depicted is often referred to as a corner void. In this case, copper plating is missing on all four corners of the hole.

Again, keep in the mind that there was no voiding related to electroless copper. So what could be the root cause of the void shown in Figure 1? It is easy see to the bare dielectric at the corners. Yes, there is sufficient copper plating in the via, however, the slope of the copper adjacent to the void has the appearance of an etched copper trace. There is the overhang of the plated etch resist (tin or tin-lead). The genesis of this etch void is due to the thin knee. That is, the tin or tin-lead on the corner or knee of the hole is less than optimum thickness. The thin deposit will not withstand the attack from the etching process, allowing the copper to be etched away.

Thin etch-resist plating at the knee of the via can be attributed to improper solution agitation in the tin plating process. In addition, when the organic addition agents are out of

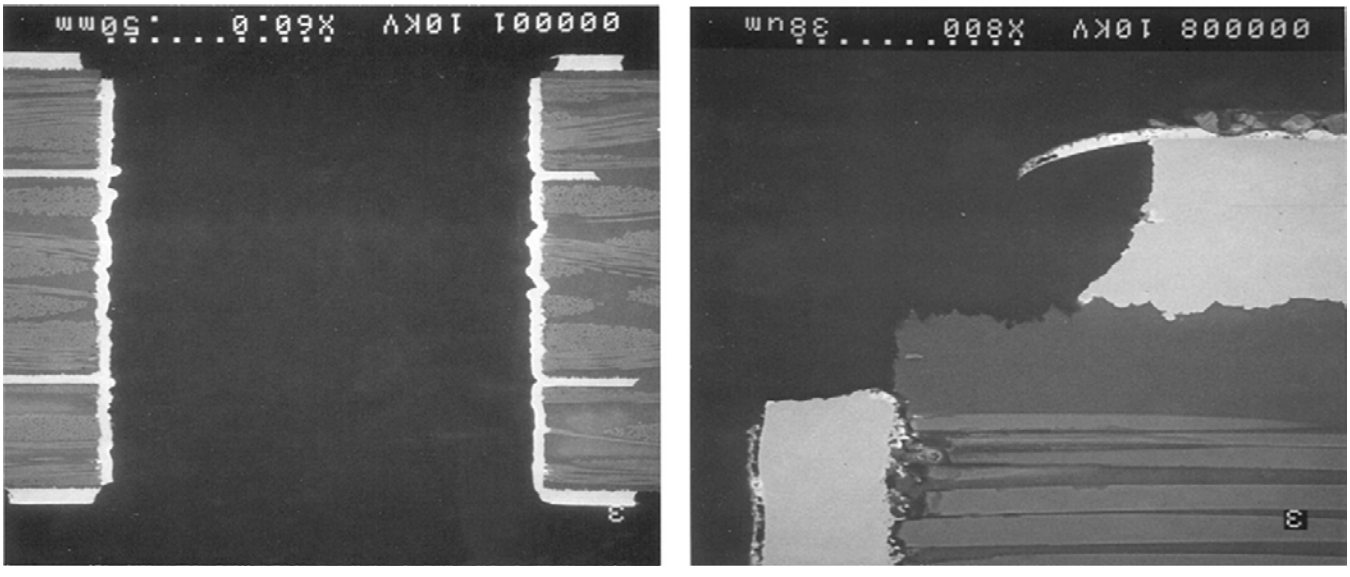


Figure 1: Example of a corner void. (Source: IPC-9121)

Integrate QA Solution

Because everyone's QA needs are just a little bit different.

Integrate is a fully customized solution, and no two contracts are exactly the same. No matter what size customer you are, we can tailor AOI, testing, final inspection, or a combination of all three services to fit you. And you only pay for the product that actually passes quality assurance, not on panels produced or tested.

Find out if our Integrate solution is right for you!
www.gardien.com/why-integrate

GLOBAL FOOTPRINT
WITH A LOCAL PRESENCE

30+ YEARS
EXPERIENCE

30 YEARS OF PCB
INDUSTRY EXPERIENCE

balance, thin tin deposits are often the result. Excessive turbulence in the plating solution leads to excessive suppression of the deposition of metal at the knee.

At the same time, additive imbalance in the electrolytic copper plating solution leads to thin copper plating at the corner (Figure 2). It has been theorized that levelling components, carrying a positive charge, migrate preferentially to high-current density areas, just like metal ions, and inhibit metal deposition. If too much leveller is present, either because the bulk concentration is too high or the replenishment rate of leveler to the through-hole corner is higher than its consumption rate, then metal deposition at the corner will be suppressed leading to the thin knee condition. (I will present more detail on plating processes and the functioning of addition agents in a future column.)

As the micro-section on Figure 3 shows, it is also possible to get micro-voids in the via due to the action of the pre-plate microetch. When the microetch removes a portion of the electroless copper, there will be sporadic voids in the via. Since these voids create a discontinuity in the via, the electrolytic copper deposition will face an extreme resistance through the via. It will be nearly impossible for the plated copper

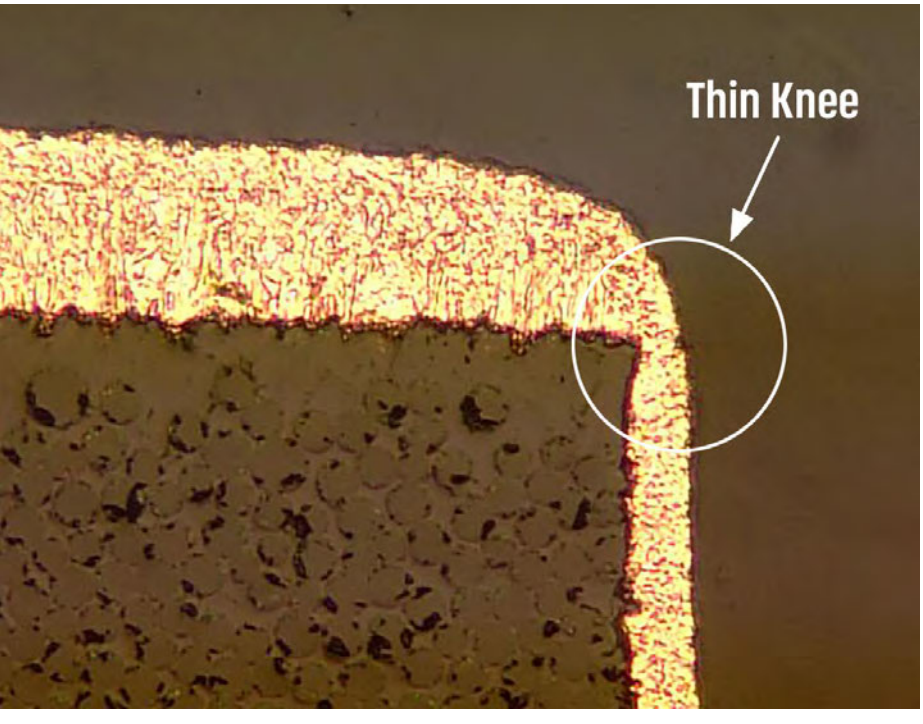


Figure 2: Thin knee in copper plating.

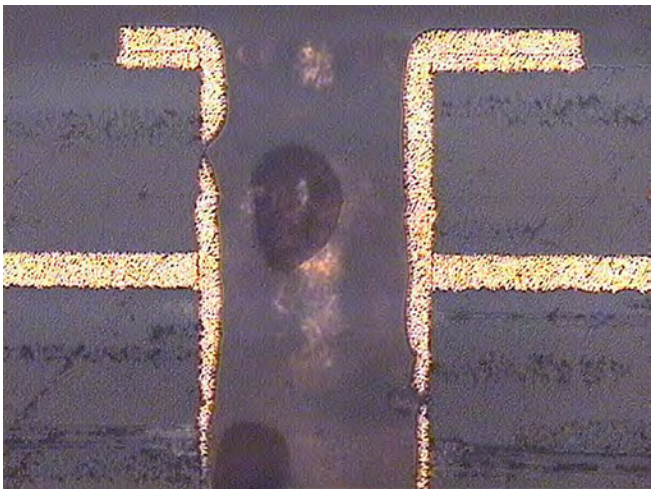


Figure 3: Pre-electrolytic plating-microetch issue.

to bridge these voids. It is not that one type of chemical microetch is more beneficial than another. What the engineer must ensure here is that the microetch chemistry is maintained within critical operating limits.

Finally, some voids can be attributed to the photoresist process. Although this is a rarity, one should not discount the possibility that resist can flow into the holes. When this situation occurs, rim voids are possible. The resist flows in such a way that the developing solution cannot remove the resist. The resist thus acts as a barrier, preventing the deposition of electroplated copper (Figure 4).

How did this situation occur? One plausible cause is moisture entrapment in the via. Moisture remaining in the via creates a vacuum during the resist lamination process. Resist flows into the via (remember moisture makes things flow more), creating a situation where the developer is not effective at removing the unexposed resist. This resist then prevents subsequent electroplating. However, the electroless copper is present. And that is the clue that the void was not present after electroless copper. Thus, with the resist lodged into the via, electroplated copper will not deposit in that

Innovation:

it's what leaders do.

For over a decade, the world's top flex PCB processors have relied on ESI's advanced laser processing solutions to drive innovation and stay ahead.

Can you afford to make the wrong decision? Future-proof your investment in flex PCB with ESI's family of laser processing solutions, and maintain your innovation advantage.

Align yourself with the industry leader and let ESI take care of your flex PCB drilling needs.

esi®

ESI's family of FPC laser processing solutions.

5335™ GemStone™

Flex5335™ LodeStone™

5335xi™ RedStone™

For more information, visit us at www.esi.com

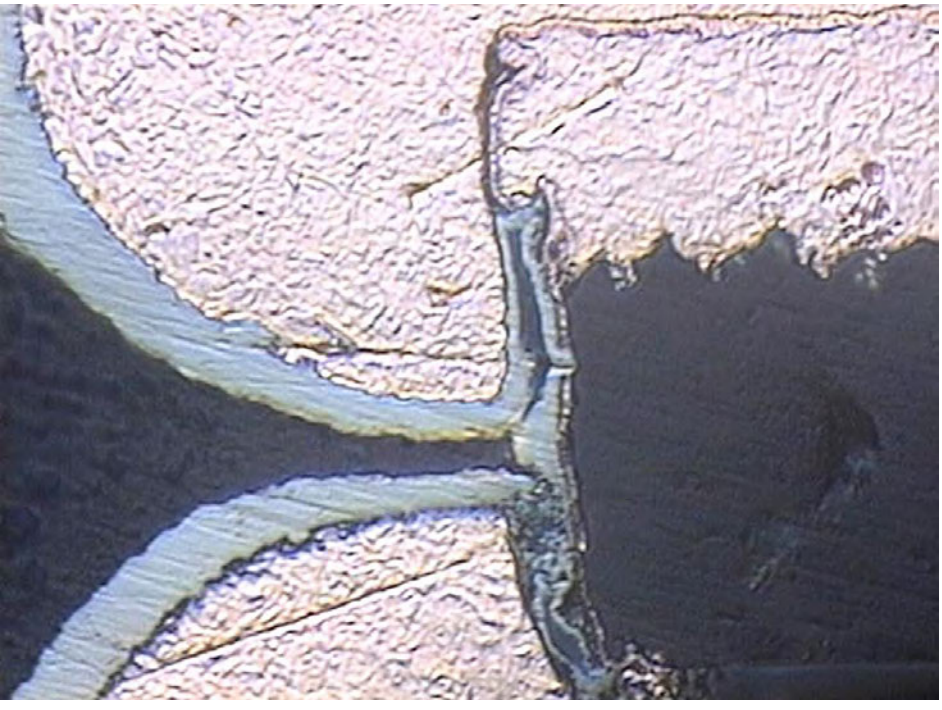


Figure 4: Rim void caused by resist flowing into PTH. Note the electroless copper is intact, but there is absence of electrolytic copper at the rim. (Source: IPC-9121)

area. The resist is removed in the stripper, and the electroless copper is etched leaving a hole void. The resist in the hole is usually difficult to observe after developing and is seldom present in the cross-section of a board after final processing.

Why does the resist flow into the hole? According to Dr. Karl Dietz, the root cause is that the air pressure in the via that is covered by the dry film resist is significantly lower than atmospheric pressure. With lower pressure the air in the hole is hot during resist lamination and the pressure drops when the air cools to room temperature. This pressure differential causes the resist to slowly flow into the through-hole, making it extremely difficult to develop out[1].

There are at least two additional factors along with entrapped moisture in the via that contribute to resist flow:

- Higher aspect ratio vias—narrow diameters and thicker printed circuit boards
- Long hold times between lamination and developing

As stated previously, water acts as a plasticizer, essentially lowering the viscosity of the resist and allowing the dry film to flow into the hole faster. As the technology continues to evolve into higher layer counts and greater circuit density, vias continue to get smaller and aspect ratios increase. It is the smaller diameter vias and thicker boards that present the greatest challenge to complete drying. Resist in a small hole is also harder to remove in the developer. Long hold times allow the resist to flow further into the holes as well. Minimize hold times by moving the panels from lamination to exposure to development in the shortest time; this is best practice. Plus, invest in a good dryer. After all, fabricating circuit boards requires water for rinsing. One cannot get around that, so improve the drying capability after surface prep or even PTH prior to resist lamination.

Summary

Getting to the root cause or causes of defects is never a simple matter. It takes skill, careful thought, and collaboration among those involved. The information presented here is a good example of how the defect noted was not related to the PTH process, as some would be quick to conclude. Recognizing how upstream and downstream processes, even as simple as drying the boards prior to resist lamination, can lead to defect formation is critical for the defect resolution team to understand. **PCB007**

References

"Tech Talk," Karl H. Dietz, *Circuitree Magazine,* January 2002.

Michael Carano is VP of technology and business development for RBP Chemical Technology. To reach Carano, or read past columns, click here.

MEPTEC2018

HOSTED BY NEXTFLEX

A Special One-Day Event Presented By MEPTEC

NEW GENERATION FLEXIBLE HYBRID ELECTRONICS

Cost-effective Assembly & Packaging Technologies

THURSDAY, APRIL 26, 2018 | 8:00AM - 4:00PM

NEXTFLEX MANUFACTURING FACILITY TOUR | 4:00PM – 4:30PM

NEXTFLEX FACILITY | SAN JOSE, CALIFORNIA

Unlike computers and mobile phones, the Internet of Things demands a wide range of different functions in different products, and most of them need flexibility, thinness, and ultralow power consumption. These requirements can only be satisfied with new methods of packaging.

This event will explore the market opportunities, emerging applications, and materials and process requirements to provide this functionality at an affordable cost. You'll hear from experts in polymers and other flexible materials, effects of complex packaging structures on signal integrity, speed and power consumption, and the latest and most promising technology for heterogeneous packaging. Topics will also include cutting edge/niche concepts in medical implantable devices and "synthetic skin", etc.

The challenges include:

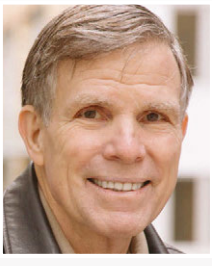
- **Handling and protecting thin and small components made from brittle materials (silicon, III-V compounds, etc.)**
- **Flexible interconnects on a wide range of scales from microns to millimeters**
- **Reliability with thermal expansion coefficients of different components ranging from a few ppm to hundreds**
- **Cost-effective process techniques for putting it all together**

KEYNOTE SPEAKER

Flexible Hybrid Electronics – Disrupting Conventional IC Packaging and System Design Solutions

WILFRIED BAIR
Senior Engineering Manager, Device Integration & Packaging
NextFlex

KEYNOTE SPEAKER



An Alternative History of the Electronics Manufacturing Industry

JOSEPH (JOE) FJELSTAD
Founder and President
Verdant Electronics

INDUSTRY SPONSOR

SMART MICROSYSTEMS™

REGISTER TO ATTEND TODAY!

Sponsorship Opportunities are Available for this Event. Email gedwards@meptec.org

REGISTER AT WWW.MEPTEC.ORG TODAY!

MEPTEC

Meet IPC's Vice President of Global Government Relations,

Chris Mitchell

One World, One Industry

by John Mitchell, IPC–ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

On March 5, IPC announced its VP of Global Government Relations, Chris Mitchell (no relation to me). In this new role, Chris will work closely with IPC's Government Relations Steering Committee and its government relations team based in Washington, D.C. Chris will represent IPC and the electronics manufacturing industry before key policymakers globally and identify issues and other opportunities where IPC can demonstrate its leadership in government relations and public policy.

We spoke to Chris recently on his background in government relations and his plans for IPC's government relations program.

John: Chris, what are your top priorities as IPC's vice president of global government relations?

Chris: IPC's government relations program has grown enormously over the last five years, and I'm committed to building on our success over the next five. In the short-term, I have four top priorities.

First, we are going to continue to grow participation in IMPACT, our annual advocacy event for member company senior executives in Washington, D.C. and Brussels, as well as the value members derive from it. Planning for IMPACT Washington, D.C. is well underway, and we expect a roster of high-profile speakers and meetings. We are also laying the policy groundwork now, so that IPC members can have maximum influence in Washington during their meetings on May 21–23. IMPACT Brussels will take place on November 28–29 and we are already initiating our plans for this event.

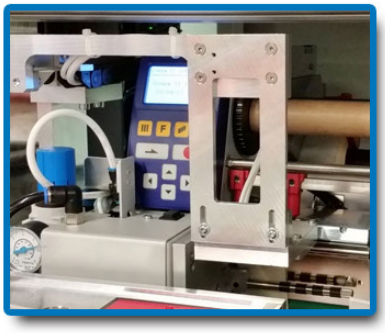
Second, IPC will be strengthening its commitment to global advocacy. We are in the process of hiring a senior director for government relations in Europe, and we will be standing up two new government relations committees—one in Europe and one in Asia Pacific. Our investments in these regions will better position the industry to identify and respond to policy developments around the world.

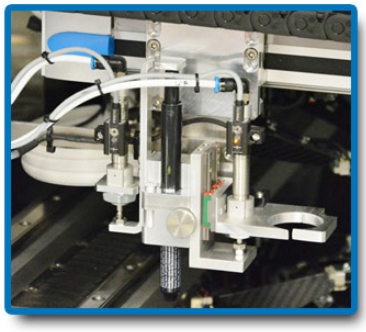
Chris Mitchell

Third, IPC will be investing more resources in thought leadership to help frame and drive the discussion on issues important to the electronics industry. To this end, we will be working more closely with industry peers, as well as academic institutions and think tanks, to generate support for IPC's policy goals.

Unrivaled Test Speed with Full Automation

Introducing the newly designed atg A8a with 8 test probes and a new high speed “lights out” automation for unrivaled throughput.





Highlights:

- Small footprint (6 square meters)
- Dual shuttle pick & place automation
- High accuracy combined with high test speed
- Pen or label marking option

Watch video

Get more info

atg

LUTHER & MAELZER

an Xcerra company

atg Luther & Maelzer GmbH
Zum Schlag 3 • 97877 Wertheim • Germany
Phone +49-9342-291-0 • Fax +49-9342-395 10
sales@atg-lm.com • www.atg-lm.com

Fourth, to amplify our voice, we will be bolstering our grassroots outreach, so IPC members can more easily and effectively communicate with their elected representatives and develop long-term relationships.

John: What policy initiatives should be top of mind for electronics manufacturing professionals?

Chris: Three issues immediately come to mind: workforce development, manufacturing competitiveness and regulatory reform.

IPC members almost universally are reporting challenges finding qualified workers. The electronics industry can't wait for governments to act. That is why IPC is leading the way with significant new investments in global education and workforce programs that will prepare a new generation of workers for our industry. We are marshalling our advocacy resources in Washington, Brussels, and elsewhere to help unlock government support that will accelerate the impact of these initiatives.

We are marshalling our advocacy resources in Washington, Brussels, and elsewhere to help unlock government support that will accelerate the impact of these initiatives.

We are also working to bolster the manufacturing base globally by championing supply chain resiliency, R&D investment, and favorable tax regimes. We expect legislative and regulatory action on these issues this year. And we are also focused on regulation—both reforming the regulatory process as well as streamlining and rationalizing the regulations currently on the books. The Trump Administration has put the brakes on many rulemakings that were in the pipeline, but we need to take advantage of this opportunity now to ensure that regulations are based on sound science and mitigate the burden on our industry.

John: What is IPC doing in these policy areas?

Chris: IPC is a solutions organization and we are bringing that mindset to our advocacy initiatives. In each of the issues I have referenced above, we are leveraging the industry's expertise to offer real solutions to policymakers. As an example, IPC and its members have been leaders in the dialogue on conflict minerals. In partnership with other organizations, we have developed and are updating guidance for due diligence and standards on data exchange—the latter of which we would like the EU to recognize as an industry scheme. I encourage industry members to reach out to me to learn more about our work on other topics.

John: How has your prior lobbying and congressional experience prepared you for this position?

Chris: I've had the good fortune to work for two Silicon Valley members of Congress on the issues that matter most to the high-tech businesses in their districts—intellectual property, trade, export controls, R&D, and IT infrastructure deployment. In these roles, I worked closely with Executive Branch officials, the congressional committees of jurisdiction, and small and large technology companies. I later joined Prime Policy Group, one of Washington's premier government relations firms. There, I had the opportunity to work with a diverse clientele—multinational firms, startups, local governments, academic institutions and trade associations. In fact, I represented IPC for close to nine years during which time I helped IPC develop and implement advocacy strategies to realize its advocacy goals in Washington. Having worked with trade associations for many years, I appreciate that my job is to deliver value to IPC's members and the electronics industry.

John: This will be your first IMPACT Washington, D.C. as an IPC staff member. What are

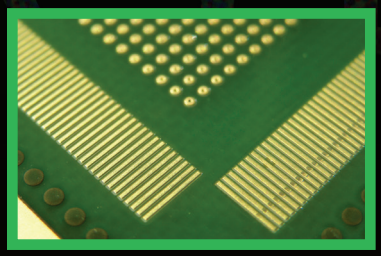
ENTER THE JET AGE

INKJET

BY TAIYO

SOLDER MASK

- IJSR-4000 JM01 Series
  - Excellent Processing
  - Available in Multiple Colors
  - Available for Rigid and Flex



IJSR-4000 JM01

LEGEND INK

- IJR-4000 FW100
  - Flexible White Legend Ink
- IJR-4000 MW300
  - Rigid White & Black Legend Ink

IJR-4000 MW300

IJR-4000 FW100

ETCH / PLATING RESIST

- IJR-3000 GE100 / BE100
  - Acid Etch Resist
  - Easy Stripping

TAIYO AMERICA

Your Ultimate Solution

Phone [775] 885-9959 • www.taiyo-america.com • info@taiyo-america.com

plans for this year's event? What policy issues will be discussed?

Chris: We are gearing up for another successful IMPACT event on May 21 – 23. Much like in past years, we'll host a welcome dinner the evening on May 21. We are arranging for a speaker who can provide an insider's view on the political landscape in Washington and what it might portend for the midterm elections. IMPACT participants will spend their first full day together on May 22, meeting with Executive Branch officials from the White House and Departments of Labor, Education, and Commerce, to name just a few. The following day, we'll head to Capitol Hill to meet with Congressional leaders in the morning. In the afternoon, we facilitate individual meetings between participants and their own members of Congress.

This year, we'll be focusing on three issues getting a lot of attention in Washington: addressing the industry's workforce needs, strengthening the manufacturing base, and reforming and streamlining the regulatory process.

John: Ok, a few personal questions. What is your favorite quote or saying?

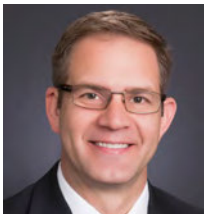
Chris: Measure twice, cut once.

John: What do you enjoy doing in your free time?

Chris: I have three children under the age of 10, so I don't have much free time between work and family. I read when I can and try to play tennis regularly. I also have a podcast with my kids, which has been great fun.

John: Chris, thank you for spending some time with me today.

Chris: Thank you, John. **PCB007**



John Mitchell is president and CEO of IPC–Association Connecting Electronics Industries. To read past columns or to contact Mitchell, click here.

BMBF Project Puts Automated Electric Vehicle on the Road

The German Ministry of Education and Research (BMBF) funded project UNICARagil aims to rethink vehicles and their development. The goal is a disruptive, modular and agile vehicle architecture and the prototypical implementation of four application cases from automated family taxis to mobile package delivery stations.

Autonomous electric vehicles will be an essential component of future mobility: They will form the basis for sustainable road transport, novel mobility, improvements in traffic safety and a boost in the quality of life in urban environments.

However, requisite vehicle concepts require a significantly more centralized and efficient data processing and transmission in motor vehicles–a departure from established architectures and processes.

The UNICARagil project builds on the latest results of research into electromobility, as well as automated and connected driving to develop autonomous electric vehicles for myriad future application scenarios. The project utilizes methodologies common in the IT industry with its fast development cycles and updating mechanisms.

This approach bases on a modular and scalable vehicle design, comprising payload and drive units that can be flexibly adapted to a variety of applications in logistics and passenger transport. A further focus lies on the development of a readily extensible and updatable software and hardware architecture.


Meet your new sales personal trainer.
Increasing sales isn't rocket science. We use proven methods to help you find the right customer, motivate your sales team, and increase your profits.
We've helped dozens of companies big and small improve their bottom line.
Learn how we can help YOU
db MANAGEMENT GROUP
207-649-0879
danbbeaulieu@aol.com

MilAero Highlights

One World, One Industry: Electronics Industry Advocacy More Important than Ever ▶

The future of the electronics manufacturing industry is shaped in many ways by government policies. This will be especially true in 2018, as legislators and regulators are eyeing policy decisions on issues such as technology research and development, taxes, workforce skills, and the environment.

Cross Border Deals: What to Look for and How to Manage ▶

My firm has been approached by foreign firms several times this year and in 2017 who want to acquire PCB, PCBA, or other electronics companies in North America.

RTW IPC APEX EXPO: Annual Update for IPC Validation Services ▶

Randy Cherry, director of validation services, provides an annual update for IPC validation services, including QML and QPL supplier listings.

IPC Honors Rockwell Collins and Northrop Grumman with Corporate Recognition Awards ▶

IPC bestowed its highest corporate honors on two companies, Rockwell Collins and Northrop Grumman Corporation, during a luncheon at IPC APEX EXPO 2018.

The Sum of All Parts: Defining Your Customer ▶

These are the most typical ways in which someone will ask us who our customers are. Many times, the purpose is to see whether we work in the same spaces as them or as a way of gauging whether we are worthy of having them as a customer.

NASA's Robert Cooke Wins IPC President's Award ▶

Long-time IPC volunteer, Robert Cooke, NASA Johnson Space Center, was presented with the IPC President's Award at IPC APEX EXPO 2018.

Three New Mars2020 Rover Technologies: What Powers the "Body Parts" on the Mars2020 Rover? ▶

The Mars2020 Rover Mission, designed by JPL, is the next NASA Mars Exploration Program mission that is planned to launch in 2020.

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

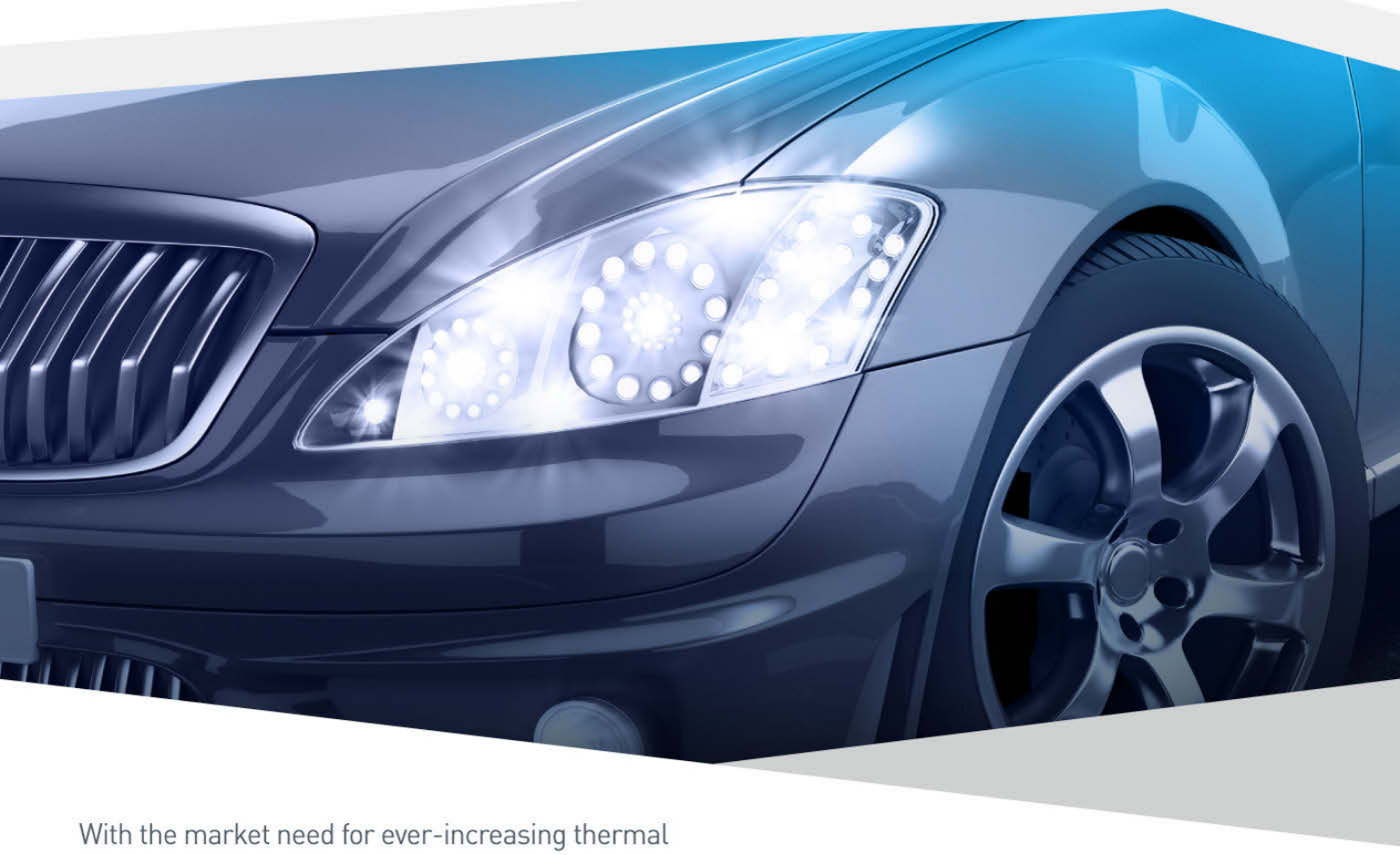
IPC—Association Connecting Electronics Industries—has issued a position paper, "IPC Priorities for an Ambitious EU Industrial Policy Strategy," in support of EU Industry Day.

RTW IPC APEX EXPO: Ventec's Jack Pattie on New Materials, Industry Upswing ▶

Ventec International Group's Jack Pattie comments on continuing growth in sales, investment in manufacturing and distribution, and new product developments in polyimides, no-flow pre-pregs and thermally conductive materials.

Meeting the demands of the latest LED lighting designs delivering an unprecedented level of thermal performance

ventec
INTERNATIONAL GROUP
騰輝電子



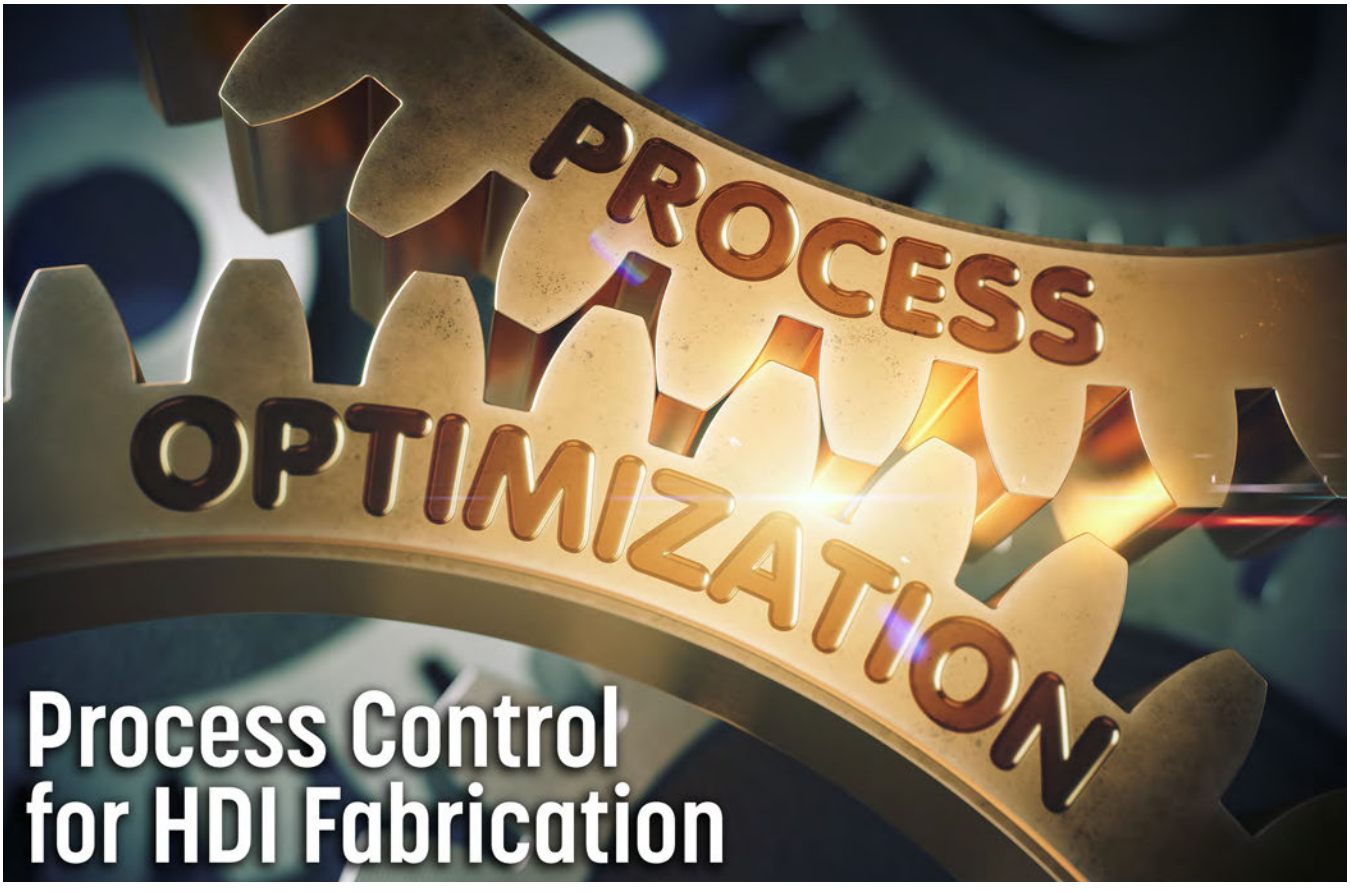
With the market need for ever-increasing thermal performance, the Ventec VT-4B family of thermally conductive IMS (Insulated Metal Substrates) deliver an unprecedented level of thermal performance through their established ceramic-filled halogen-free dielectric technology. Multilayered constructions are made possible through resin-coated foil and resin-coated film options.

Contact us to discuss your requirements.

Ventec - wherever technology takes you, we deliver

Ventec International Group
179 Ward Hill Ave,
Ward Hill, MA 01835,
United States
T: 978-521-9700
E: ordersCA@ventec-usa.com
Follow @VentecLaminates

www.**venteclaminates**.com



Process Control for HDI Fabrication

Article by Happy Holden
I-CONNECT007

Introduction

A subject that gets very little discussion but is essential to the HDI process is automation. That is the control of chemical concentrations in our many PCB processes and, especially, those that have been mechanized and can change very rapidly. HDI is one of those series of processes where control is the key to high yields. This topic has been a favorite of mine ever since graduate school, where I majored in process control theory and especially after I took a graduate course in instrumental analytical chemistry taught by a chemical engineering professor. In that class, we built over 40 analyzers and titrators using a LEGO-like modular analytical system, including the electronics. This showed me how simple this problem and its solution really is.

We all know that the most significant chemical processes are controlled by key chemical concentrations. This paper introduces to production management and technical personnel low-cost approaches to simple low-cost methods of monitoring and controlling chemical processes used in PWB fabrication, chemical coatings, sensor manufacturing and electroplating/electroforming. These are techniques like specific gravity that cost as little as $30 through ion-specific electrodes and simple color-wheel comparators (like pool chemistry chlorine analysis) to battery-powered spectrophotometers that run only a few hundred dollars. All these techniques can be taught and used by production personnel. A formal lab is not required, but these techniques can be used by labs to increase their productivity and number of chemistries controlled.

This is especially true for the crucial copper electroplating process. As shown in Figure 1, five very important characteristics of copper plating—throwing power, leveling, crack resistance, maximum current density, and appearance—are controlled by six parameters, five of which are chemical concentrations: brightener, leveler, copper concentration, sulfuric acid,

A new set of rules for PCB production

Less process steps. CAM to etch in minutes instead of hours. Maximum yield. Minimal environmental impact.These are just a few of the PCB production rules that Lunaris has redefined.

We've put together a complete set of all the new rules made possible by Lunaris ...get yours today!

Download all the new rules:
The Official Lunaris Rulebook

CLICK HERE TO DOWNLOAD

mutracx
THE BETTER WAY

www.mutracx.com

Parameter		Throwing Power	Leveling	Crack Resistance	Max. Current Density	Surface Appearance
Brightener content	↑	minimal	↑	↓	↑	↑
Copper content	↑	↓	minimal	minimal	↑	minimal
Leveler content	↑	↓	↑	↓	↓	↑
Sulfuric acid content	↑	↑	↓	minimal	↓	minimal
Chloride content	↑	minimal	minimal	minimal	minimal	↓
Temperature	↑	↓	↓	↓	↑	depends on brightener conc.
Current density	↑	↓	↑	↑	none	depends on brightener conc.

Figure 1: The influence of plating parameters and what happens if the concentration goes up. The first five parameters can be automatically analyzed and controlled.

and chloride. Temperature is the sixth parameter. Although many parameters affect plating distribution, chemical concentrations are some of the most important and most influential. These need to be controlled as they change faster than any of the other parameters.

- Better chemical control also serves to:
- Identify process problems
- Reduce human error
- Enhance product reliability
- Tighten operating windows
- Reduce chemical operating costs

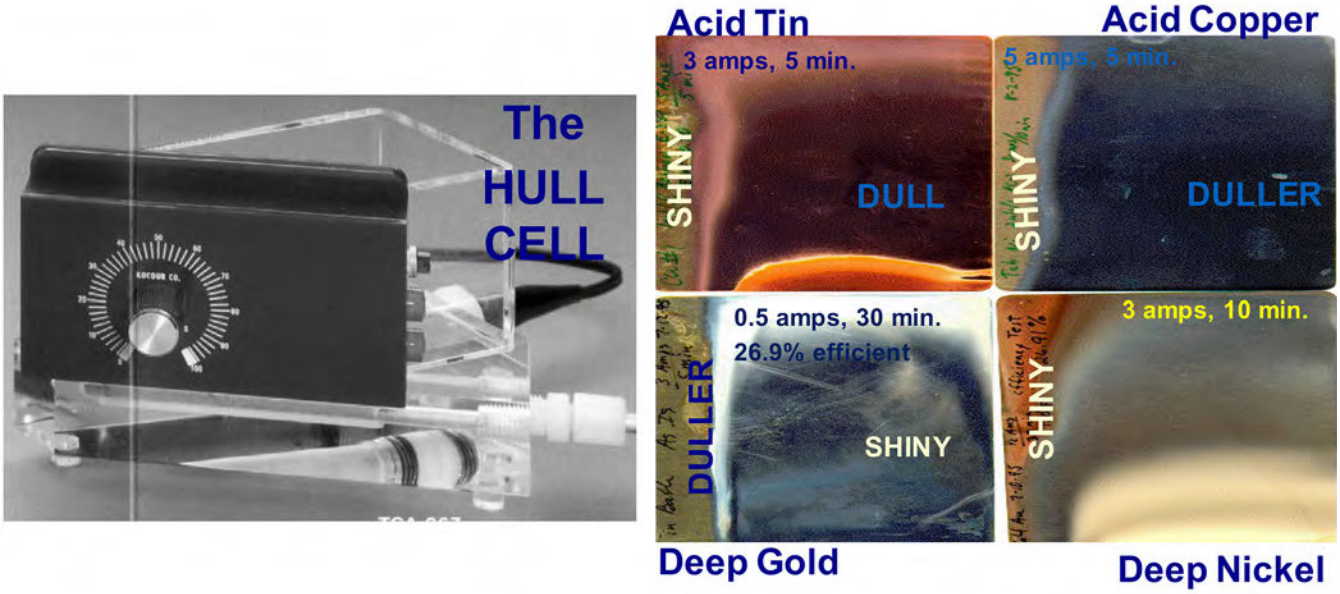


Figure 2: Visible analysis using the Hull Cell is one of the oldest analytical techniques. Additions to the Hull Cell can be scaled up to show what should be added to the production tanks.

	CAPACITANCE	CONDUCTIVITY	pH or Ion-selective	ORP	VOLTAMMETRIC
Specificity	Poor	Poor	Excellent	Poor	Excellent
Sensitivity	Fair	Good	Excellent	Excellent	Very Good
Conducting fluids	N/A	Good	Good	Good	Excellent
Nonconducting fluids	Good	N/A	N/A	N/A	Excellent
Maintenance	Low	Low	High	Medium	High
Installation problems	Low	Low	Medium	Low	Low
Cost	Low	Low	Medium	Low	Very High

Table 1: The four major types of electrochemical sensors used in industry and their characteristics as well as relative costs.

Manual Procedures

Figure 2 shows one of the oldest analytical techniques, which is the actual plating of polished brass plates in the Hull Cell. Even with sophisticated analytical methods, the Hull Cell is still a final check on plating quality and contamination. This supports and is in addition to manual titrations.

Electrochemical Sensors

Electrochemical sensors like pH are some of the most commonly used for analysis, but equally important are ORP, ion-selective probes, capacitance and conductivity sensors, illustrated in Table 1.

Conductivity sensors will measure the amount of total dissolved solids in an electrolyte. It is common to use them where the concentration of a known salt, base or acid must be determined. The concentration of these solutions will vary the resistance of the solution, or the inverse of resistance, conductance. The conductivity sensor typical measurement is in mhos per centimeter (reciprocal of ohm-centimeters). Lower conductivity ranges of 0.01 to 100,000 micromhos per centimeter are used for water purity such as boilers and chillers, or deionized water. Higher concentration of electrolytes (50 to 1000 millimhos per centimeter) use electroless probes to avoid polarization effects of electrolysis. Conductivity (dissolved ionic concentration) and pH (hydrogen-ion concentration) are very common sensors used in industry. Figure 3 shows graphs of the conductivity (in millimhos /cm) versus the concentration of dissolved

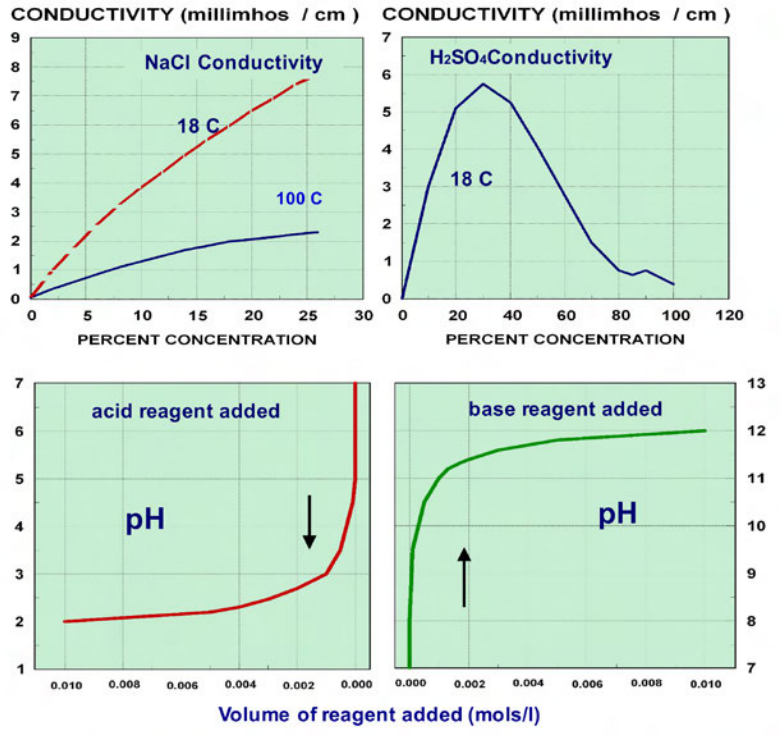


Figure 3: Conductivity and pH graphs: a) Conductivity of NaCl in water as a function of concentration and temperature; b) Conductivity of sulfuric acid as a function of concentration; c) pH of distilled water and the addition of an acid reagent; d) pH of distilled water and the addition of a base reagent.

NaCl and sulfuric acid in water. The other graphs are the pH of water as a function of dissolved base or acid in moles per liter.

Certain applications require that the activity of an ion in solution be measured. This can be accomplished with a specific ion electrode which is designed to be sensitive to the ion whose concentration is being measured. These electrodes are similar in appearance to those employed to measure pH, but are constructed of glass-membrane electrodes, solid-membrane electrodes, liquid ion-exchange membrane electrodes, or silicone rubber-impregnated electrodes. The reference electrode is the same as that used for pH. The electrode output is read on a high-impedance voltmeter very similar to that used with pH electrodes.

Many applications are possible using ion-selective techniques. In printed circuits, measurements are made of copper and chloride in acid sulfate plating baths, lead and fluoroborate in tin-lead fluoroborate plating solutions, cyanide (ductility promoter) in electroless copper solutions, permanganate in desmear/etchback solutions, chromic acid in epoxy smear removal, and the sulfate in nickel sulfate plating solutions for tab plating.

The specific ion electrodes, are made for specific ions, as listed in Table 2 with their range of sensitivity in ppm and preferred pH. Many times, specific ion electrodes use the same meter as pH electrodes.

Oxidation-reduction potential (ORP) or redox measurements determine the oxidizing or reducing properties of a chemical reaction. A reduction is the opposite of oxidation. There can be no oxidation without an attending reduction. For example, a ferrous ion may lose an electron and become a ferric ion (gaining increased positive charge) if a reduction, say, of cupric to cuprous ions (which is the reverse of this operation) occurs at the same time.

As a sensor in ACSC, ORP or redox is used in control of the oxidizer in ferric chloride, cupric chloride and hydrogen peroxide/sulfuric acid etching, in measuring the Au (III) to Au (I) in gold tab plating, and to measure the copper activity in electroless copper baths.

Specific Gravity

A second universal sensor is specific gravity. Although not a chemical analytic approach, it nonetheless can measure the concentration of dissolved solids in solutions. Six different methods are used in industry: hydrometers, displacers, hydrostatic head, radiation, weight in fixed volume, and vibrating U-tube (Table 3).

The least expensive way to measure specific gravity (SG) is with a hydrometer. These can be purchased inexpensively. They come in many ranges, but all require the use manually, as shown in the beaker.

The hydrometer is a displacer type of SG sensor; another is the total immersion displacer. The SG sensor seen in Figure 4 is made from a GEM level switch. A CPVC plastic rod is drilled out to a specific depth (Dd) and two CPVC plastic nuts are tuned

Common Ions that can be measured on a continuous basis			
Ion Sensed	**Electrode Type**	**Range (ppm)**	**Preferred pH**
Ammonia (NH3)	Gas sensing	0.02 to 20,000	10–14
Bromide (Br-)	Solid state	0.4 to 80,000	2–1
Cadmium (Cd++)	Solid state	0.01 to 11,000	3–7
Calcium (Ca++)	Membrane	0.4 to 40,000	6–8
Chloride (Cl-)	Solid state	10 to 35,000	2–11
Cyanide (CN-)	Solid state	0.25 to 250	11–14
Cupric (Cu++)	Solid state	0.005 to 65,000	3–7
Fluoride (F-)	Solid state	0.02 to 20,000	5–8
Fluoroborate (BF4-)	Membrane	0.01 to 1,000	3–10
Iodide (I-)	Solid state	0.001 to 130,000	3–12
Lead (Pb++)	Solid state	0.02 to 21,000	4–7
Nitrate (NO3)	Membrane	0.6 to 6,000	3–10
Perchlorate (ClO4)	Membrane	1 to 10,000	3–10
Potassium (K+)	Membrane	0.4 to 40,000	3–10
Silver (Ag+)	Solid state	0.01 to 110,000	2–9
Sodium (Na+)	Glass	0.02 to 25,000	8–13
Sulfur dioxide (SO2)	Gas sensing	0.01 to 100	0–2
Sulphide (S-)	Solid state	0.003 to 35,000	10–14
Thiocyanate (SCN-)	Solid state	0.5 to 60,000	2–12
Water Hardness	Membrane	0.1 to 100,000	5–8

Table 2: Many specific ion electrodes, their type, operating range and pH.

SG Method (25°/-4°C)	Minimum Span	Condition of Liquid	Accuracy as % of Span
Hydrometer	0.01	clean	+/- 1 %
Displacer	0.002	clean	+/- 1 %
Hydrostatic head	0.05	any	½ to 1 %
Weight of fixed volume	0.05	clean	1 %
Radiation	0.05	any	1 %
Vibrating U-Tube	0.05	clean	1-3 %

Table 3: Specific gravity sensors, their span sensitivity, the condition of liquids they operate in, and their accuracy.

to a specific diameter (Nd). By screwing the nuts in or out, the set-point of SG can be set over a 50X range. The calibration curve is seen in Figure 5. The SG operating setpoint is selected (horizontal axis) and the span range is selected (vertical axis). This provides the Dd and nut diameter (Nd) for the sensor. To create your own operating curve, the principle of operation is that according to Archimedes, the fixed weight of the rod and nuts is acted on by the center of gravity (CoG) based on the position of the nuts. To make the sensor float and close the switch, the volume and center of displaced mass does not change regardless of the position of the nuts, only the SG of the liquid (buoyancy force) can oppose the CoG. This SG sensor is 25X more sensitive than any that you can purchase and 1/1000 the price, as it has a minimum span of 0.02, with an accuracy of 0.04% over aqueous solutions of 0.8 to 1.5 units.

Two of the most used SG sensors have variable read-outs; the hydrostatic head based on the differential pressure of a fixed height of the liquid versus the same height of water. An SG sensor that is useable for organics, solvents as well as aqueous liquids, and at high temperatures is the variable-weight-fixed-volume sen-

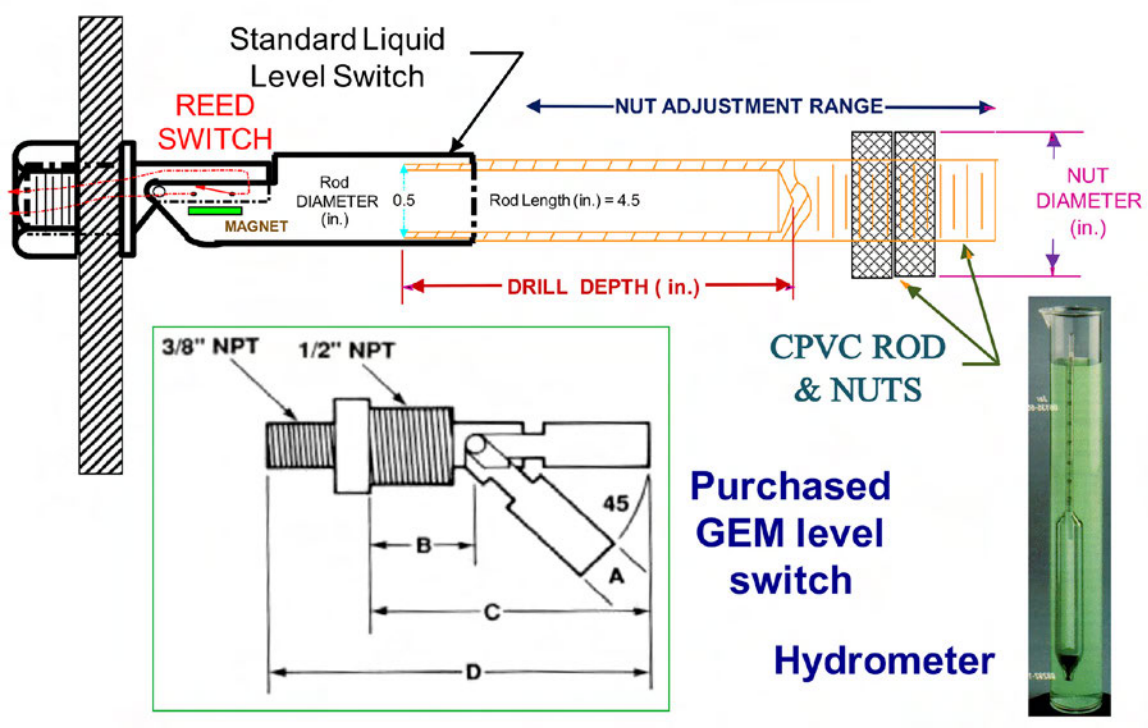


Figure 4: A very sensitive and accurate immersed SG sensor can be made from a purchased GEM level switch that has a threaded hollow rod attached and two threaded nuts. Figure 5 has the Dd and nut diameter of CPVC plastic based on the operating mid-point and total span. On the right, the standard hydrometer in a flask.

sor. It works on the principle of a fixed-volume displacer balancing a variable weight, in this illustration (Figure 6), a titanium metal chain. The height of the displacer is measured with a linear variable differential transformer (LVDT) by placing a metal core in the displacer. The differential coils provide the location of the metal core.

An example of using SG for analysis is the analysis of the sulfate acid concentration in a sulfuric-peroxide microetch. First measuring the temperature gives you the copper sulfate concentration from its temp-saturation curve. Then the specific gravity is measured. From the saturation curves of sulfuric acid and copper sulfate, the percent by volume of sulfuric acid can be determined. Or, if you know the percent by volume of sulfuric acid, say by conductivity, the concentration of the copper sulfate can be determined.

Colorimetric (Spectrometers)

A third common industrial chemical technique is color indicators. These simple chemical techniques use sensor strips or chemical additives to the solution to develop a color that is compared to the standard color wheel. Unfortunately, it requires the human eye to judge when the colors are the same. This works OK unless a person is color blind!

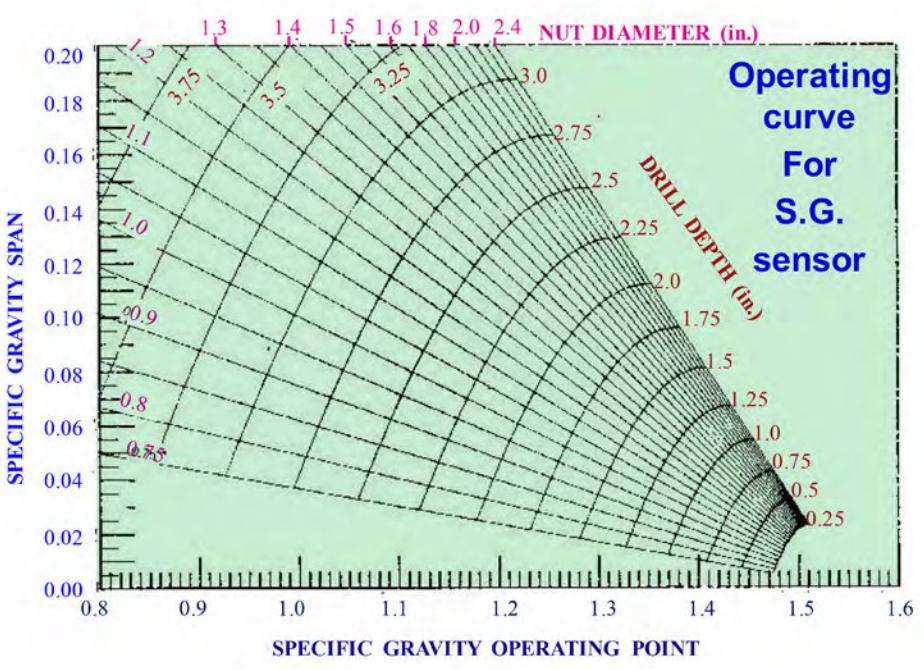


Figure 5: The calibration and operating curve for the SG sensor shown in Figure 4. Pick the operating point and span of the sensor. This will provide the outside nut diameter and the drill depth for the rod.

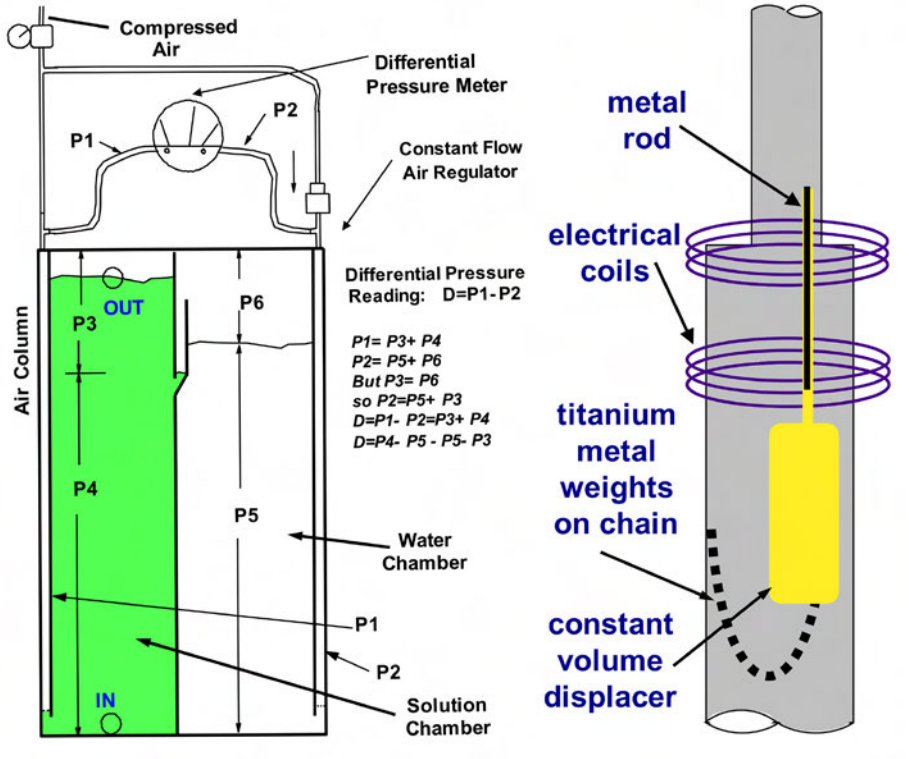


Figure 6: Diagrams of two popular industrial specific gravity controllers. On the left, the hydrostatic head SG sensor working off the principle of differential pressure of the solution compared to a column of water. On the right, the displacer has a chain with weights attached and will rise or lower until there is equilibrium. An LVDT measures the rise and lower position of a metal rod attached.

Among the spectrometric sensors, more appropriately named electromagnetic radiant energy sensors, the visible light colorimeter, the ultraviolet-visible light spectrophotometer, and the infrared spectrophotometer are the most common. Only the first two are used in printed circuit processing.

The colorimeter is used to analyze for copper in the electroless copper, acid sulfate plating bath, and hydrogen peroxide-sulfuric acid etchant, and for nickel, cobalt, palladium, and chromium in their plating baths.

The ultraviolet-visible spectrophotometer is now being employed because of their microprocessor control units. By selectively scanning wavelengths and using the first and second derivatives of the absorbance curves, these spectra can be compared to stored spectra and concentrations are calculated automatically. Many of the units can control replenishment and sampling directly.

Analysis that can be performed in this way are determining the Au (I) and Au (III) in gold plating baths; the proprietary additives, nickel and impurities in a Watts nickel bath used for tab plating, and various copper analyses.

The human can be removed, and the wavelength expanded with common UV-Visible spectrophotometers. Six common UV-Vis spectrophotometers, sensitive from 340 nm to 1000 nm, are shown in Figure 7.

Recently, with the advent of cameras in cellphones, many DIY spectrophotometers have been designed. All work on the principle that LEDs have specific wavelengths of light and eliminate the need for expensive optical wavelength filters or monochromators gratings. A graph of the wavelength of 12 different LEDs available is shown in Figure 8, along with the popular DIY LEGO® Spectrometer used by middle and high schools. The LEGO spectrophotometer is made from children's LEGOs and a wavelength grating cut from any used CD. The Raspberry Pi or Arduino camera module provides wavelength sensitivity from 400 nm to 900 nm. Design and parts are readily available online[1].

Figure 7: Six photos of common UV-Visible spectrophotometers available from laboratory supply companies.

Productive Fabrication Equipment

MDI-DT

WorkCell²

CombiDrill

schmoll optronics

BÜRKLE PROCESS TECHNOLOGIES

schmoll optronics

MDI Micromirror-Digital-Imaging

- Cost-efficient & high-quality DDI
- High-power UV-LEDs & DMD-technology
- Operator-friendly concept w/compact footprint
- Modular machine concept & field upgradable
- Flexible number of heads and head distances for shortest exposure times
- Multiple wavelength concept

Vacuum Lamination System

- Even pressure across the platen surface
- State-of-the-art heating system
- All-steel construction
- Modular machine concept & field upgradable
- User-friendly visualization system
- Affordable initial investment

Hybrid Laser Drilling/Cutting System

- Microvia drilling 50-300µm diameter
- Space saving compact design
- Best power/size ratio in market
- Pulse Stabilizer
- European technology center and USA support center

Bürkle North America supplies a full complement of productive equipment for fabricating printed wiring boards. From imaging through metrology inspection, Bürkle North America's equipment offering sets the standard in the industry for Imaging, Registration, Lamination, Mechanical or Laser Drill/Routing and Feature Metrology Inspection.

BÜRKLE NORTH AMERICA, INC.
11105 Knott Ave., Cypress, CA 90630

Contact Dave Howard for more details.

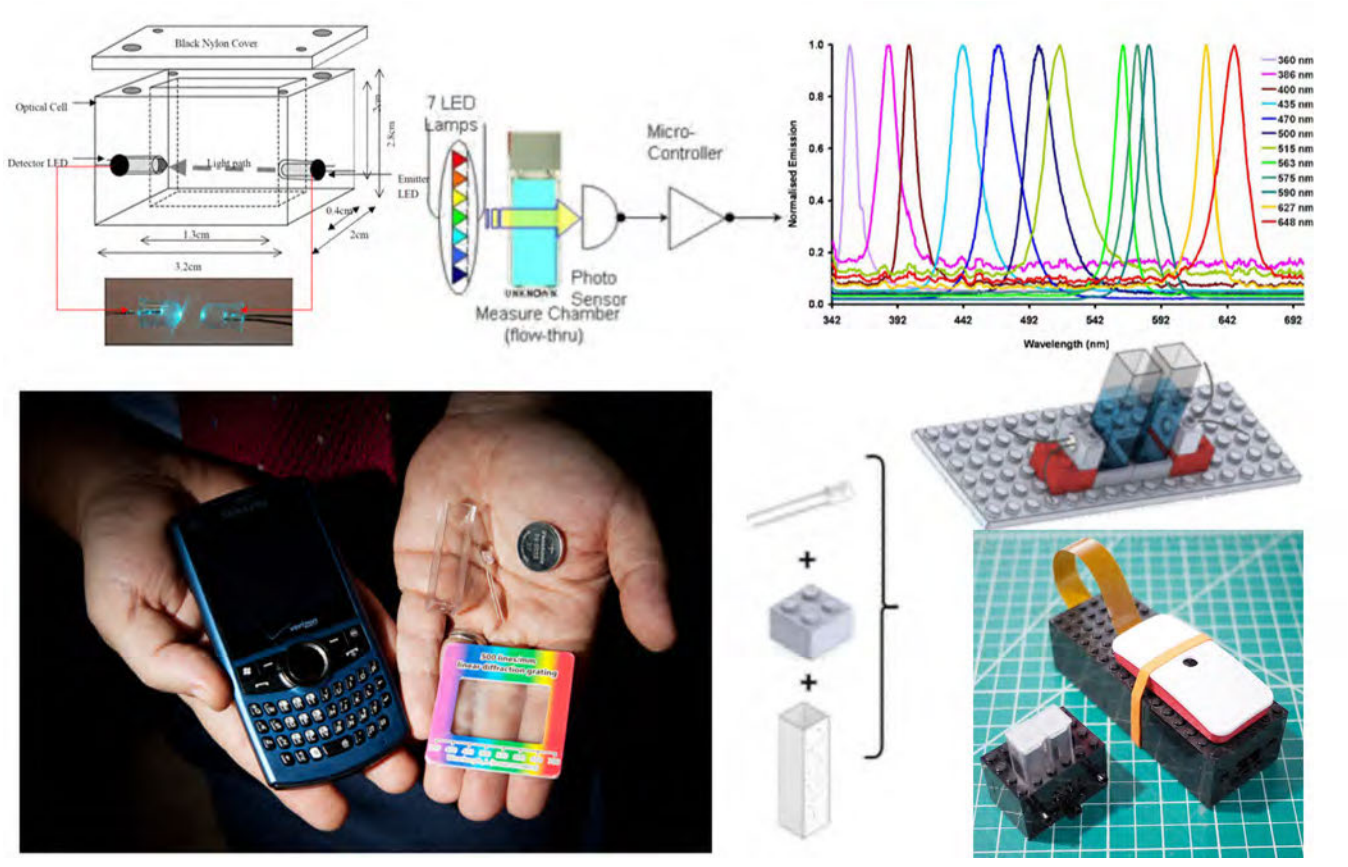


Figure 8: DIY spectrophotometers are very common now on the Internet and are being built by middle and high school students. The simple colorimeters can be built using specific wavelength LEDs or a grating made from any CD. The detector can be a common cellphone camera or specific cameras purchased for the Raspberry PI or Arduino. Illustrated is the popular LEGO spectrophotometer kit.

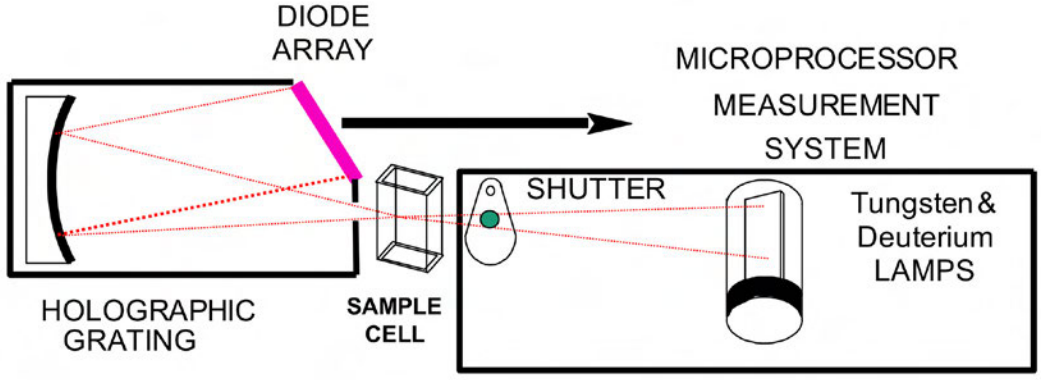


Figure 9: Schematic of how the new technology of a diode-array spectrophotometer works. (Source: HP brochure)

IR and UV-Vis spectrophotometers were all designed with a white tungsten light, a fine-ruled grating and a single photo-detector. In 1980, Hewlett-Packard developed a totally new IR-UV-VIS spectrophotometer with no moving parts. They used a fixed holographic grating and fine 2000-pixel diode array detector (DAS). This allowed a spectral scan in less than one millisecond. This fast scan allowed programmable wavelength concentration calculations, baseline suppression on reaction-kinetics to be performed. The diagram of the DAS is shown in Figure 9.

Figure 10: Photos of the first three generations of diode-array spectrophotometers from Hewlett-Packard (now Agilent).

The first-generation DAS, the Hewlett-Packard 8450A, had five sample cells, a beam director and software to automate data collection and analysis. The second-generation 8452A was 38% less expensive and used a color display. The third generation, the Agilent 8453E, is only 68% of the original DAS cost but has 25% larger wavelength sensitivity. These three units are seen in Figure 10. The Agilent DAS is an ideal piece of instrumentation to have in your PCB chemical laboratory. It allows easy experimentation of wavelengths, concentration calibration and automation of chemical analysis.

Some of the automatic analyses performed at HP's Sunnyvale PCB shop were:

- Saccharin additives
- Ni component 67 additive
- Nickel concentration
- Impurities
- Boric acid
- Chloride

One Agilent DAS allowed the replacement of manual titrations and an expensive atomic absorption spectrophotometer (AA) for analysis of tin, nickel, gold, copper, palladium, microetches, and catalysts. Table 4 shows some of the analysis of PCB chemistries using the Agilent DAS, as compared to manual titration or atomic absorption.

DAS spectra scans of three components of a nickel plating bath and palladium in catalyst and the differences for different concentrations of nickel and palladium can be seen in the new I-Connect007 e-book, *"Automation and Advanced Procedures in PCB Fabrication"* available for free download in April 2018.

Ampere-Hour

Ampere-hour sensors accumulate the total DC current used for time employed. This device can automatically replenish a chemical based on the current-time setpoint. The integral pump runs for a set number of seconds (2.3 ml per sec.) if energized. It can be cali-

Chemistry	Species	UV/VIS (g/l)	Titration (g/l)	AA (g/l)
Tin plating	Sn	34.19 31.00 34.72 33.59 32.19	34.81 31.06 35.34 33.20 32.13	
Alkaline etchant	Cu	136.4 +/-0.7 137.2 +/-0.4 131.4 +/-0.9		135.9 +/-1.9 137.9 +/-1.3 133.4 +/-1.1
Acid copper plating	Cu	7.71 +/-0.01 9.83 +/-0.01 7.77 +/-0.02		7.70 +/-0.1 9.82 +/-0.3 7.85 +/-0.3
Microetch	Cu	29.53 +/-0.02 31.46 +/-0.07 16.93 +/-0.08		29.37 +/-0.1 31.17 +/-0.11 15.61 +/-0.37
Cupric chloride etches	Cu	153.2 +/-0.2 137.1 +/-0.4		153.8 +/-1.1 140.0 +/-0.5
Palladium catalyst	Pd	4.12 +/-0.003		4.0 +/-0.25

Table 4: Application of the Agilent DAS for PCB chemical analysis compared to the older techniques of titration and atomic absorption spectrophotometer[2,3]. (Source: Printed Circuit Plating Bath Process Control-Part II, *Metal Finishing Magazine*, March 1985.)

brated for any size power supply using a 50 mv shunt. A unit can be built for less than $5 or purchased.

Electro-Analytical Techniques (Voltammetric)

To perform a typical plating bath analysis, a small volume of sample solution (10 – 100 microliters) is added to a test cell containing 10 milliliters of a supporting electrolyte solution and three specialized test electrodes. Instrumentation controls the electrical potential of the working electrode, with respect to that of the reference electrode. If, because of the applied potential, components of the test solution are reduced or oxidized, a current will be measured between the working electrode and counter-electrode. When the appropriate method is applied, different bath components are oxidized or reduced, and the current response is proportional to the concentration of the substance being oxidized or reduced. The concentration of a given component is determined by comparing the sample response to that of one or more standard solutions of known concentration. Multi-component analysis is performed by scanning the applied potential while recording the current responses of the sample. Voltammetric methods employing a continuously renewed mercury drop are formally classified as polarography.

Employing scanning or pulse potentials in voltammetry can determine copper and formaldehyde in electroless copper, the gold(I) and gold(III) in gold baths, nickel and cobalt levels in hard gold deposits, tin, lead, sulfonic acid, and proprietary additives in solder plating baths. The four common techniques of electroanalytical methods are:

1. Voltammogram (square wave voltammetry): measures current as a function of potential.
2. Polarography: voltammetry at the dropping mercury electrode.
3. Differential Pulse Polarography (DPP): forces species in solution to lose or gain electrons, i.e., oxide or reducer; measured versus a reference electrode. DPP determines concentration of species by measuring limiting current. Limiting current determined by concentration in solution.
4. Cyclic stripping voltammetry (CVS): A series of forward and reverse voltage

2018 Programs

April 10 — Boston, MA, USA

IPC Day

Complimentary event, network and learn more about IPC

April 10–11 — Boston, MA, USA

IPC Technical Education

Day One: IPC Technical Education — PCB Fabrication Basics: Process and Specification

Day Two: IPC Technical Education — Advanced Troubleshooting

April 16–17 — Ingolstadt, Germany

IPC Europe Technical Education

in English

April 18–19 — Ingolstadt, Germany

IPC Europe Technical Education

in German

April 24 — San Jose, CA, USA

IPC Day

Complimentary event, network and learn more about IPC

April 24–25 — San Jose, CA, USA

IPC Technical Education

Day One: IPC Technical Education — SMT Design for Manufacturing: Principles and Practice, Problems and Promises in a Lead Free World

Day Two: IPC Technical Education — BGA & BTC Design and Manufacturing Challenges with Emphasis on Reflow Profiling, Backward Compatibility and Head on Pillow

May 2 — San Diego, CA, USA

IPC Technical Education — PCB Layout — Place and Route

In conjunction with Del Mar Electronics and Manufacturing Show

May 8 — Milwaukee, WI, USA

IPC Technical Education

Morning: Real World Challenges and how IPC-HDBK-630: (Guidelines for Design, Manufacture, Inspection and Testing of Electronic Enclosures) has Helped

Afternoon: IPC/WHMA-A-620 CABLE & HARNESS DOCUMENTS: The Evolution of IPC's Cable and Harness Documents – A Brief History

In conjunction with Electrical Wire Processing Technology Expo

May 15–17 — Linthicum (Baltimore), MD, USA

IPC High Reliability Forum

May 21–23 — Washington, DC, USA

IMPACT Washington, D.C.

An executive-level, members-only event

June 4–5 — Nuremberg, Germany

Automotive Electronics Reliability Forum

June 5–6 — Glasgow, UK

IPC PERM International Meeting No. 36

June 7 — Frankfurt, Germany

Automotive Executives Roundtable

September 13 — Des Plaines, IL, USA

IPC E-Textiles 2018

October 13–19 — Rosemont, IL, USA

IPC Fall Standards Development Committee Meetings

co-located with SMTA International

November 13–15 — Schaumburg (Chicago), IL, USA

IPC/SMTA High-Reliability Cleaning and Conformal Coating Conference

WISDOM WEDNESDAY WEBINARS — Exclusive for Members

March 14	April 25	June 13	July 25	September 12	October 24	December 12
March 28	May 9	June 27	August 8	September 26	November 14	
April 11	May 23	July 11	August 22	October 10	November 28	

For more information, **visit www.IPC.org/events**

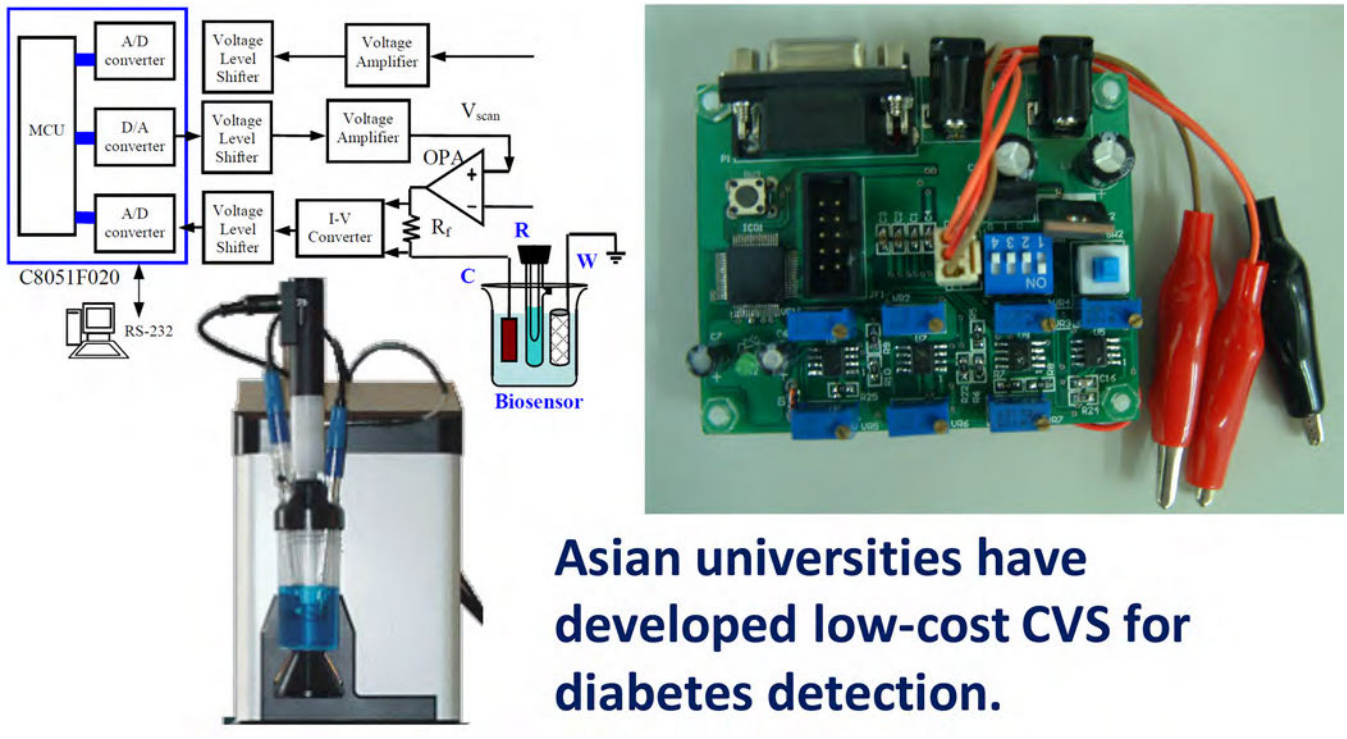


Figure 11: A DIY CVS analyzer based on the design of several Asian universities' publications on low-cost instruments to detect diabetes.

scans are applied that alternately plate and strip a layer of the major metal. The electrical charge required to strip the plate is a measure of deposition efficiency which, under some conditions, can be correlated to additive concentration. Employing scanning or pulse potentials in voltammetry can determine copper and formaldehyde in electroless copper, the gold (I), gold (III) in gold baths, nickel and cobalt levels in hard gold deposits, tin, lead, sulfonic acid and proprietary additives in copper plating baths.

The fourth most common analytical technique for PCB processes is the CVS analysis of copper plating additives. Here is an automated laboratory unit for analysis of multiple plating baths. This technique, developed in the early 1970s by Tench and Ogden at General Dynamics, was crucial in developing high-speed and via filling copper plating. The drawback on commercially available CVS instruments is their cost, typically $20,000 to $30,000. The CVS unit in Figure 11 was built for less than $250 using plans published by Taiwan universities as a part of a government program to have a low-cost analytical unit to detect diabetes in the general population. They were looking for the same molecules that are used as additives for copper plating baths.

Which Chemical Parameters Can Be Analyzed?

Tables 5 through 9 describe chemical parameters that have been analyzed by sensors or instruments and can be integrated into automated units. Table 5 shows the eight parameters for electroless copper and MSAP copper plus four parameters for the electroless line.

There are 32 chemical parameters that can be analyzed by sensors for different types of electroplating in electronics, connectors and relays (Table 6).

There are seven parameters for copper etching (Table 7) and five parameters for the photoresist developer (Table 8).

Three parameters for smear removal can be analyzed, plus three parameters for acid/clean-

Chemical Solution	Parameters that can be Analyzed
Electroless copper	Copper sulfate or copper chloride Sodium hydroxide Specific Gravity Formaldehyde Stabilizer Ductility promoter (NaCN) Deposition rate controller
Full additive M/SAP electroless line	Specific gravity Activator/catalyst Acid pH Etch specific gravity Cleaner pH

Table 5: What can be analyzed for in the electroless copper, additive MSAP and the rest of the electroless line.

Chemical Solution	Parameters that can be Analyzed
Electroplating Copper	Copper sulfate or copper pyrophosphate Copper brightener Specific gravity Chlorine ion Organic leveling agent Sulfuric acid concentration Ammonia Organic contaminations
Electroplating Nickel	Nickel concentration Nickel brightener Nickel additives (saccharin) Halides (Cl^-, Fl) Sulfuric and sulfonic acid concentration Nickel impurities
Electroplating Tin	Tin concentration Tin brightener Tin additives (wetting agent)
Electroplating Tin-lead	Lead concentration Lead fluoroborate Tin-lead additives (wetting agent)
Electroplating Gold	Total gold and Au^{+++} concentrations Au^{+++} impurities pH and specific gravity (oxilates) Total cyanide Cobalt, nickel or arsenic hardeners
Electroplating Palladium	Palladium concentration pH
Electroplating Rhodium	Rhodium concentration pH
Electroplating Line	Cleaner pH Acid pH Etch specific gravity

Table 6: What can be analyzed for plating lines of Cu, Ni, Sn, Sn-Pb, Au, Pa, Rh plus their cleaning process.

er processes and four parameters for waste water treatment (Table 9).

Implementing a Controller

The big advantage of continuous analysis, especially for copper plating additives, is that a consistent lower-level concentration can be

Chemical Solution	Parameters that can be Analyzed
Copper etching	Copper concentration Ammonium Hydroxide Specific gravity pH Sulfuric acid Hydrogen peroxide concentration Fe/Cu ratio

Table 7: What can be analyzed for copper etching.

Chemical Solution	Parameters that can be Analyzed
Photoresist developer	Carbonate concentration pH Specific Gravity
Photoresist stripper	Hydroxide concentration Specific gravity

Table 8: What can be analyzed for photoresist developer and strippers.

Chemical Solution	Parameters that can be Analyzed
Smear removal	Sulfuric acid concentration Permanganate concentration Hypochlorite concentration
Oxide/Cleaner lines	Cleaner specific gravity
Waste water treatment	Rinse water conductivity Water hardness (total solids) Total dissolved solids Turbidity Boiler/chiller water corrosion Metal in drain rinses

Table 9: What can be analyzed for smear removal, oxides and waste water/incoming water treatment.

maintained without exceeding the low-level limit. This could be a 30% lower usage of chemical than allowed by periodic laboratory analysis by conventional CVS instruments, as seen in Figure 12.

A basic automatic solution controller consists of four parts (Figure 13):

- A sample collection delivery and preparation system.

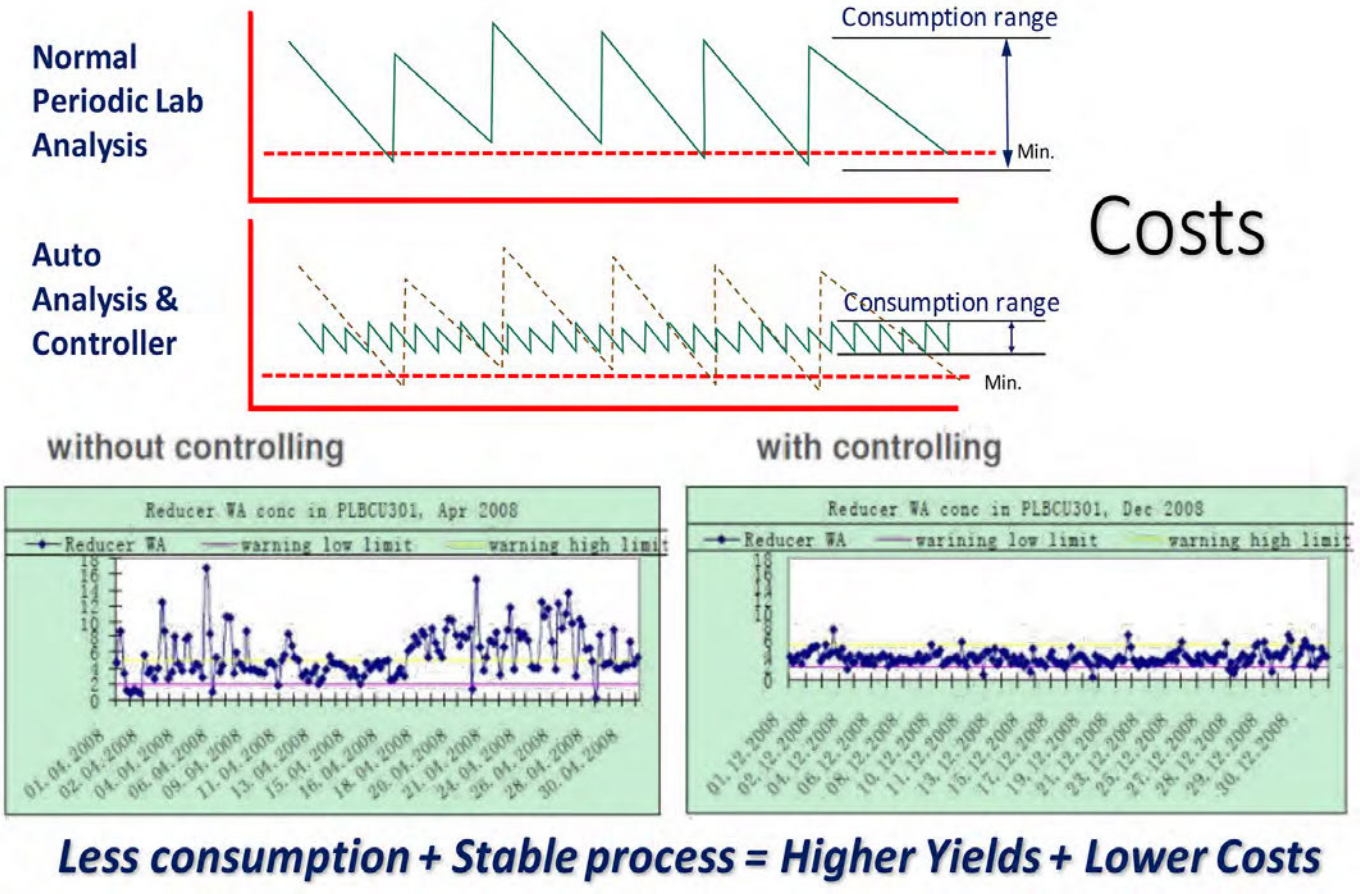


Figure 12: Illustration of the cost benefit of using a continuous controller. It reduces the total chemical requirements and keeps it from reaching dangerous minimum concentrations. Also displayed are actual readings of a copper reducer concentration with and without a controller.

- A sensor or transducer sensitive to the concentration of a chemical species.
- An analyzer/controller to convert the electrical signal to engineering units and provide outputs to feedback systems.
- A replenishment system that refortifies the solution of the chemical species analyzed.

Commercial systems are available for control of photoresist developers and strippers based on pH. Some commercial systems use simple panel counting as the control technique. Two examples of commercially available automatic controllers are a copper microetch controllers—one using colorimetric analysis for copper, the other a specific gravity (displacer) sensor. Standard electroless copper (and MSAP) controllers use three standard sensors: colorimetric for copper, pH for hydroxide concentration after the add of hydrochloric acid, and pH for formaldehyde after the addition of sodium sulfite, as shown in Figure 13.

Any PCB process can be automatically controlled with the application of a DIY sensor based on: 1) Specific gravity; 2) Colorimeter; 3) pH, ORP or ion-specific probes; 4) CVS sensor and available basic stamp-propeller or Arduino or Raspberry Pi microprocessor units, as seen in Figure 14.

Figure 15 shows a schematic of the high-speed research plating cell for MSAP copper via fill and the automatic chemical control unit. Six basic sensors can be utilized: Specific gravity; specific ion; pH/ORP; CVS; colorimetry and conductivity.

Conclusion

Chemical control of critical process solutions can be as simple as an indicator light attached to a specific gravity sensor or a continuous ana-

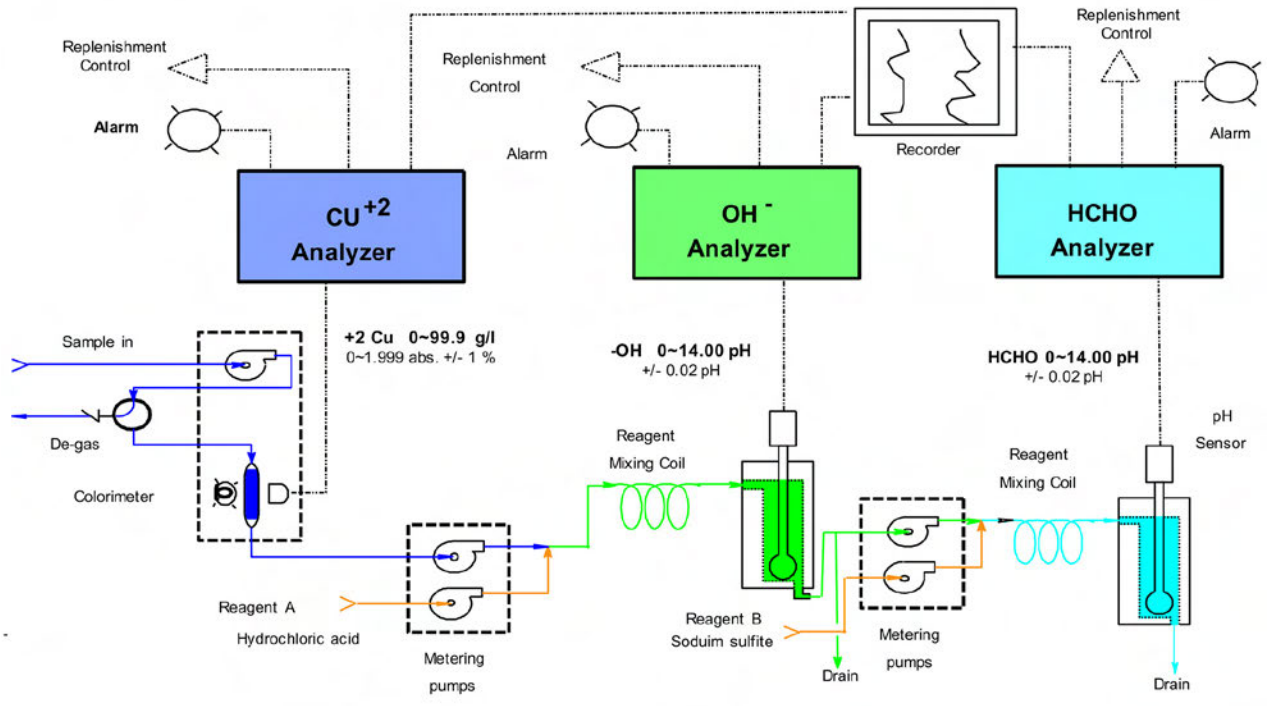


Figure 13: A basic automatic solution controller; in this example, an electroless copper controller for copper, hydroxide and formaldehyde concentrations.

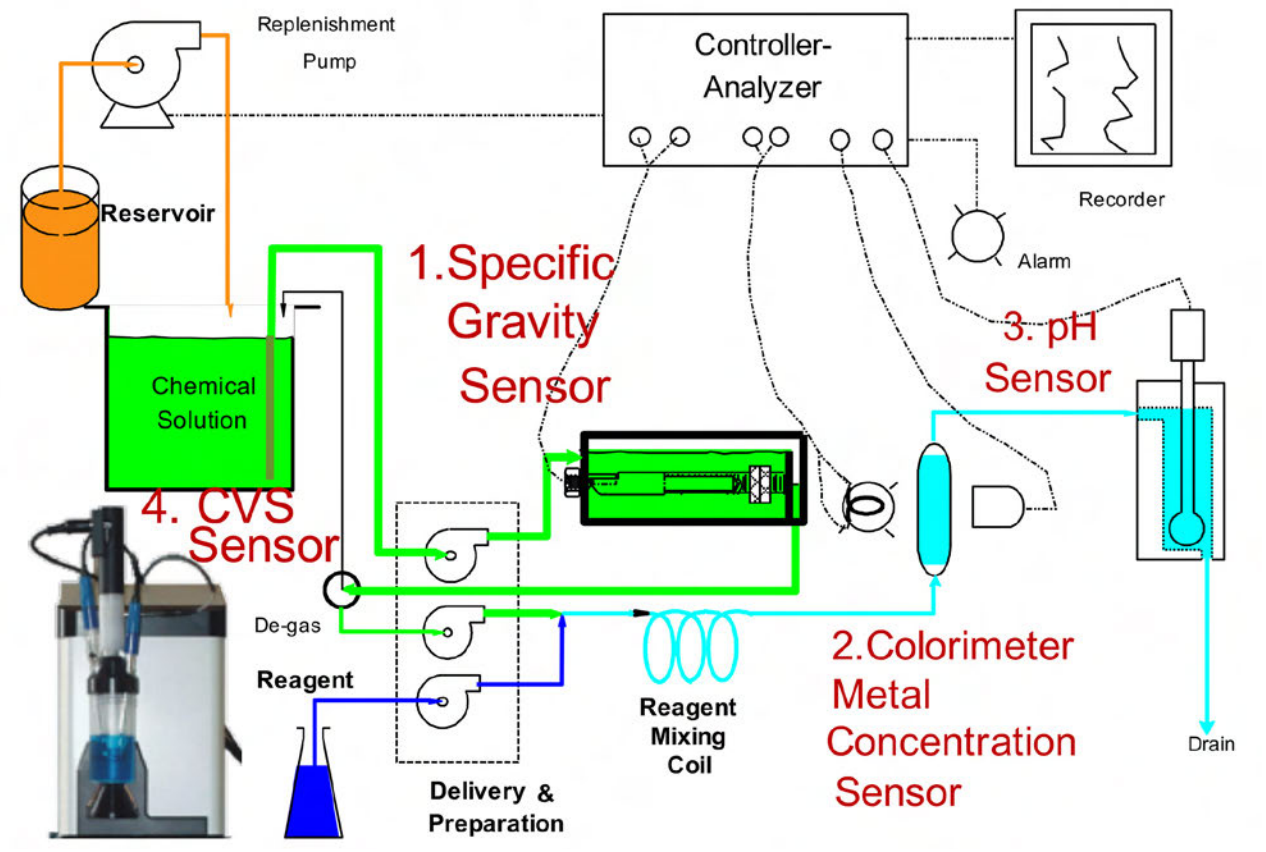


Figure 14: Schematic of an advanced chemical analyzer/controller using the four basic sensors: 1) Specific gravity; 2) Colorimeter for metal concentration; 3) pH/ORP sensor; and 4) CVS sensor.

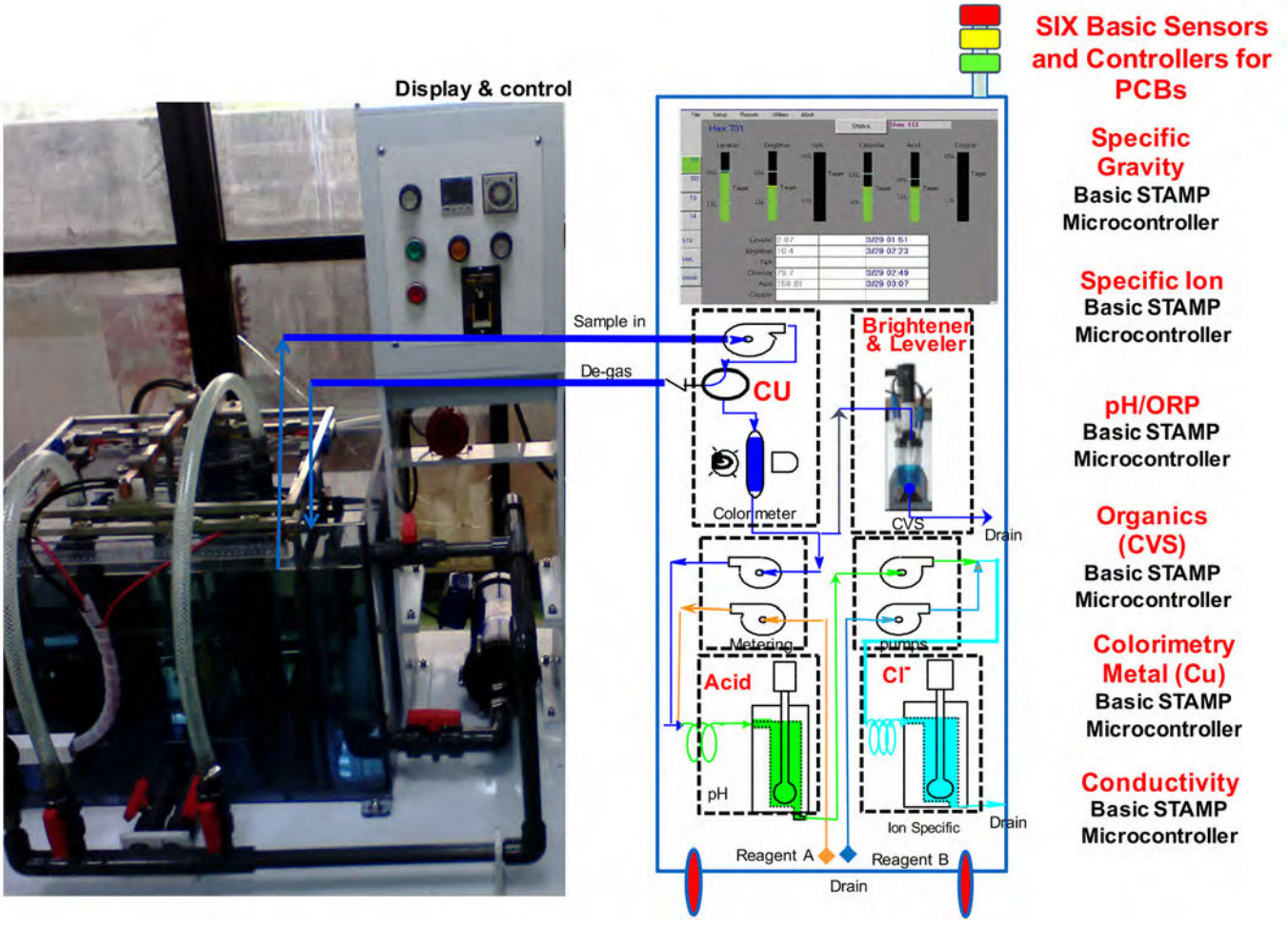
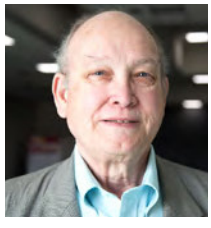


Figure 15: A high-speed, R&D copper-fill plating bath and schematic of the plating controller using the six basic sensors.

lyzer for a plating bath with addition of brighteners and levelers. The technology is simple and easy to implement. Most maintenance organizations can accomplish the construction and installation with process engineering supervision. The payback is enormous, as this can reduce defects, improve productivity, increase reliability and lower costs. Give it a try and write up your successes. **PCB007**

References

1. Assembling the Public Lab LEGO Spectrometer.
2. "Chemical Feedback Process Control," Pittsburgh Analytical Conference, paper no. 24, March 1983.
3. "Printed Circuit Plating Bath Process Control-Part II," *Metal Finishing Magazine,* March 1985.



Happy Holden is a contributing technical editor with I-Connect007. To read past columns or to contact Holden, click here.

iNEMI MEPTEC THE NEXT GENERATION SMTA Surface Mount Technology Association

Medical Electronics Symposium 2018

May 16 & 17

University of Texas at Dallas • Dallas, TX

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

TECHNICAL COMMITTEE

General Chair:
Chuck Richardson, iNEMI

Technical Chairs:
Don Banks, Abbott
Peter Tortorici, Ph.D., Medtronic Microelectronics Center

Dock Brown, DfR Solutions
Dale Lee, Plexus Corp.
Glenn Robertson, Processes Science Incorporated
Nicholas Leonardi, TechDirect Consulting
Gary Tanel, Libra Industries

REGISTRATION SPECIAL
Four Registrations for the Price of Three!

KEYNOTE SPEAKERS

Sensorizing and Connecting Medical Devices
Cory Forbes, CTO
Nypro

Robotic Surgery: Where Are the Opportunities?
Kemp H. Kernstine, Sr., M.D., Ph.D.
Division of Thoracic Surgery
UT Southwestern Medical Center

Sensors for Medical Applications: Unlocking the Value
John Burnes, Medtronic Technical Fellow
Director of Implantable Core Teams
Cardiac Patient Monitoring and Diagnostics
Medtronic

Multiple Track Topics Include:

■ **TRACK 1:**
Designs, Components and Assembly for High-Density Medical Electronics Solutions

■ **TRACK 2:**
Next Generation Microelectronics for Changing Healthcare Markets

Sponsorship Opportunities and Exhibit Spaces Available

REGISTER TODAY AT SMTA.ORG/MEDICAL

Recent Highlights from PCB007

1 All About Flex: FAQs on UL Listings for Flexible Circuits ▶

The requirement for flexible circuitry recognition is driven by the end-product specification as flexible circuits themselves are not sold directly to the consumer. The applicable UL spec for flexible circuits is UL796.

2 EPTE Newsletter: Taiwan Snapshot–Things are Good! ▶

Taiwan continues to exceed expectations as the manufacturing hub for consumer electronics. Trends for the global electronics market can be forecasted by analyzing shipments of printed circuits from Taiwanese manufacturers.

3 Advanced Circuits Upgrades Free PCB Design Software ▶

Advanced Circuits has released version 4.0 of PCB Artist. The free design software offers many features and functionality found in paid PCB design packages without the price tag.

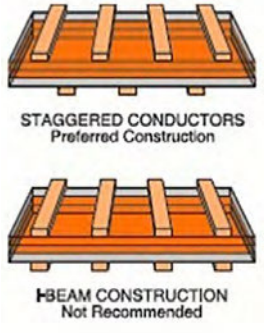
4 It's Only Common Sense: Who is the Customer? ▶

If you buy into the golden rule, "Do unto others as you would have them do unto you," then just about everyone you deal with is your customer, which means that you should treat them as such. Let's look at our business and talk about who our customer really is.

5 RTW IPC APEX EXPO: Candor Industries' History and Advanced Circuit Constructions ▶

Founder and president Yogen Patel shares Candor Industries' history and describes some of the non-standard approaches to PCB production the company uses to make advanced circuit constructions.

6 All About Flex: Avoiding Trace Fracturing in a Flexible Circuit ▶



Flexible circuits are used in applications requiring millions of flex cycles. But this does not suggest they never experience failures due to flex life. In fact, occurrences of performance issues as the result of fractured traces have been experienced in a variety of applications.

7 IPC Volunteers Honored for their Contributions at IPC APEX EXPO 2018 ▶

IPC—Association Connecting Electronics Industries—presented Committee Leadership, Distinguished Committee Service and Special Recognition Awards at IPC APEX EXPO 2018 at the San Diego Convention Center. The awards were presented to individuals who made significant contributions to IPC and the industry by lending their time and expertise through IPC committee service.

8 SCL PCB Solutions Group to Centralize PCB Manufacturing ▶

SCL PCB Solutions Group announced that it will centralize the United Kingdom PCB manufacturing facilities, namely Spirit Circuits and Lyncolec.

9 RTW IPC APEX EXPO: Prototron Moves Offshore ▶

Prototron's Dave Ryder and Russ Adams discuss the company's recent decision to begin manufacturing high-volume jobs overseas. They also discuss some of the partner shops' capabilities, including flex and rigid-flex, which are driven by customer demand.

10 AT&S Wins Business Oscar 2018 in Innovation ▶

The USA-BIZ AWARD, the so-called Business Oscar of the Austrian Trade Commission in Los Angeles of the Austrian Federal Economic Chamber (WKO), puts the media spotlight on outstanding achievements of Austrian companies in the highly competitive U.S. market.

For the Latest PCB News and Information, Visit: PCB007.com

Career Opportunities

Pssst! Are You Looking for Someone?

Place your notice in our Help Wanted section.

For just $500, your 200 word, full-column—or, for $250, your 100 word, half-column—ad will appear in the Help Wanted section of all three of our monthly magazines, reaching circuit board designers, fabricators, assemblers, OEMs and suppliers.

Potential candidates can click on your ad and submit a résumé directly to the email address you've provided. If you wish to continue beyond the first month, the price is the same per month. No contract required. We even include your logo in the ad, which is great branding!

To get your ad into the next issue, contact:
Barb Hockaday at barb@iconnect007.com or +1.916.608.0660 (-7 GMT)

I-Connect007
GOOD FOR THE INDUSTRY

smt007 pcb007 pcb design007

SALESPERSON WANTED · MAINLAND SOUTH CHINA

Work where you live!

The I-Connect007 China team is seeking an experienced salesperson to generate and manage a revenue stream for our Chinese publications.

Key Responsibilities include:

- Sell advertising contracts for monthly magazine
- Develop and cultivate new business
- Keep timely and accurate records
- Generate and follow up on all leads
- Manage contract renewals
- Account management: work with local and international team to provide customer support
- Phone and email communications with prospects
- Occasional travel

Qualifications

Successful candidates should possess a university degree or equivalent, experience with managing and cultivating leads, projecting, tracking and reporting revenue. We are looking for positive, high-energy candidates who work well in a self-managed, team-based, virtual environment.

Compensation

This is a base salary-plus-commission position. Compensation commensurate with experience.

Requirements

- Must be located in China Mainland, South China area preferred
- Good command of Chinese language, proficient with English speaking and writing
- Able to follow established systems and learn quickly
- Able to maintain professional external and internal relationships reflecting the company's core values
- 2-5 years' sales experience
- Experience with Microsoft Office products
- Must be highly motivated and target-driven with a proven track record for meeting quotas
- Good prioritizing, time management and organizational skills
- Create and deliver proposals tailored to each prospect's needs
- Experience in the electronics industry desirable

QUALIFIED CANDIDATES: CLICK HERE TO APPLY

I-Connect007
GOOD FOR THE INDUSTRY

pcb007中国 线上杂志 CHINA MAGAZINE

pcb007中国 每周通讯 WEEKLY NEWSLETTER

WWW.ICONNECT007CHINA.COM

Career Opportunities

MacDermid Enthone
ELECTRONICS SOLUTIONS

Account Manager, Northeast

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

The position of Account Manager will be responsible for selling MacDermid Enthone's chemical products. The position requires a proactive self-starter who can work closely and independently with customers and sales management to ensure that customer expectations and company interests are served while helping to promote MacDermid Enthone's exclusive line of products.

- Develop a business plan and sales strategy that ensures attainment of company sales and profit goals
- Prepare action plans for sales leads and prospects
- Initiate and coordinate action plans to penetrate new customers and markets
- Create and conduct proposal presentations and RFQ responses
- Possess the ability to calm a situation with customers, initiate a step-by-step plan, and involve other technical help quickly to find resolution

Hiring Profile

- Bachelor's Degree or 5-7 years' job-related experience
- Strong understanding of chemistry and chemical interaction within PCB manufacturing
- Verifiable sales success in large complex sales situations
- Desire to work in a performance driven environment
- Excellent oral and written communication skills
- Decision making skills and the ability to multitask

apply now

KYZEN
Where Science and Care Converge.

KYZEN Regional Manager – Midwest Region

General Summary: KYZEN is seeking a Regional Manager to join our sales team in the Midwest. This position is ideally suited for an individual that is self-motivated, hard-working and has a "whatever it takes," positive attitude, especially with customers. Being mechanically inclined is a plus. KYZEN will provide on-going, in-the-field training to help you succeed.

CORE FUNCTIONS:

- Collaborates with the Americas Manager in establishing and recommending the realistic sales goals for territory
- Manages the assigned geographic sales area to maximize sales revenues and meet corporate objectives
- Develops sales strategies to improve market share in all product lines (Electronics and Industrial)
- Ensures consistent, profitable growth in sales revenues through planning, deployment and management of distributors and sales reps as well as continued direct support for customers and prospects processes

REPORTING:

- Reports directly to Americas Manager

QUALIFICATIONS:

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

apply now

Career Opportunities

Mentor®
A Siemens Business

PCB Manufacturing, Marketing Engineer

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

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

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

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

Location flexible: Israel, UK or US

apply now

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

Front-End CAM Operators

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

The candidate should also possess:

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

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

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

apply now

Career Opportunities

MacDermid Enthone
ELECTRONICS SOLUTIONS

Technical Service Rep, Northeast

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

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

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

Hiring Profile

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

apply now

saki
The Future in Focus

Field Application Engineer

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

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

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

apply now

Career Opportunities

ventec
INTERNATIONAL GROUP
騰輝電子

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

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

Skills and abilities required:

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

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

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

apply now

CHEMCUT
BOUNDLESS INNOVATION | UNBEATABLE PRECISION

Field Service Technician

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

Job responsibilities include:

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

Requirements:

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

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

apply now

Career Opportunities

BLACKFOX
Premier Training & Certification

IPC Master Instructor

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

For more information, click below.

apply now

ventec
INTERNATIONAL GROUP
騰輝電子

Technical Sales Engineer

Positions available in the Chicago area and California

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

Skills and abilities required:

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

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

Please forward your resume to:

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

apply now

Career Opportunities

ARLON

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

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

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

more details

IPS INTEGRATED PROCESS SYSTEMS INCORPORATED

PCB Equipment Sales

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

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

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

more details

Events Calendar

2018FLEX Japan ▶
April 19–20, 2018
Tokyo, Japan

KPCA Show 2018 ▶
April 24–26, 2018
Kintex, South Korea

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

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

IMPACT Washington, D.C. 2018 ▶
May 21–23, 2018
Washington, D.C., USA

2018 EIPC's 50 Years Anniversary Conference ▶
May 31–June 1, 2018
Bonn, Germany

JPCA show 2018 ▶
June 6–8, 2018
Tokyo, Japan

IPC E-Textiles 2018 Workshop ▶
September 13, 2018
Des Plaines, IL, USA

electronica India productronica India ▶
September 26–28, 2018
Bengaluru, India

electronicAsia 2018 ▶
October 13–16, 2018
Hong Kong

SMTA International ▶
October 16–17, 2018
Rosemont, Illinois, USA

TPCA Show 2018 ▶
October 24–26, 2018
Taipei, Taiwan

Additional Event Calendars

PUBLISHER: **BARRY MATTIES**
barry@iconnect007.com

SALES MANAGER: **ANGELA ALEXANDER**
(408) 489-8389; angela@iconnect007.com

MARKETING SERVICES: **TOBEY MARSICOVETERE**
(916) 266-9160; tobey@iconnect007.com

EDITORIAL:
MANAGING EDITOR: **PATRICIA GOLDMAN**
(724) 299-8633; patty@iconnect007.com

TECHNICAL EDITOR: **PETE STARKEY**
+44 (0) 1455 293333; pete@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: **DAN FEINBERG**
baer@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: **HAPPY HOLDEN**
(616) 741-9213; happy@iconnect007.com

MAGAZINE PRODUCTION CREW:
PRODUCTION MANAGER: **SHELLY STEIN**
shelly@iconnect007.com

MAGAZINE LAYOUT: **RON MEOGROSSI**

AD DESIGN: **SHELLY STEIN, MIKE RADOGNA , TOBEY MARSICOVETERE**

INNOVATIVE TECHNOLOGY: **BRYSON MATTIES**

COVER: **SHELLY STEIN**

COVER IMAGE: **© CHOMBOSAN, ADOBE STOCK**

PCB007 MAGAZINE

PCB007 MAGAZINE®
is published by BR Publishing, Inc.,
942 Windemere Dr. NW, Salem, OR 97304

April 2018, Volume 8, Number 4
PCB007 MAGAZINE is published monthly,
by BR Publishing, Inc.

ADVERTISER INDEX

Coming Soon to PCB007 Magazine:

MAY: 5G
What is it and how will it affect your business?

JUNE: Wet Processing
The latest on wet processes for PCBs.

I-Connect007

GOOD FOR THE INDUSTRY

FREE SUBSCRIPTION

myiconnect007.com

mediakit.iconnect007.com

EDITORIAL CONTACT

Patty Goldman

patty@iconnect007.com

+1 724.299.8633 GMT-4

SALES CONTACT

Barb Hockaday

barb@iconnect007.com

+1 916 365-1727 GMT-7

www.iconnect007.com