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September 2015

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Cars: A Driving Force in the Electronics Industry

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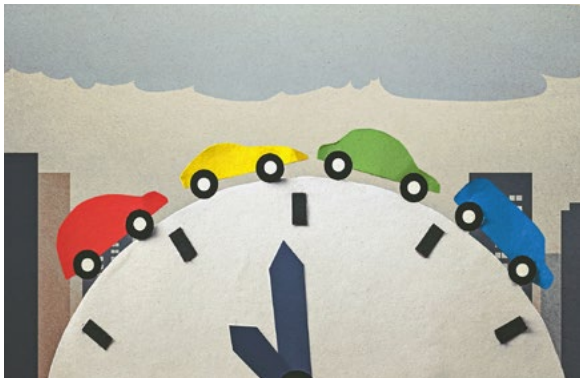
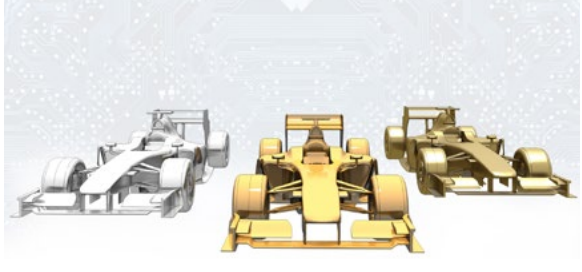
September Featured Content

CARS: A DRIVING FORCE IN THE ELECTRONICS INDUSTRY

As you've probably noticed, automotive electronics has increased exponentially. This month, our feature contributors get under the hood and examine the proliferation of electronics in cars, what it's like to be a supplier of PCBs destined for the automotive market, and where this market is headed.

FEATURE COLUMNS





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SEPTEMBER 2015
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DK @ 10 GHz	3.45	3.00	3.45	2.80 - 3.45
Df @ 10 GHz	0.0030	0.0017	0.0031	0.0028 - 0.0036
CTE Z-axis (50 to 260°C)	2.90%	2.90%	2.80%	2.90%
T-260 & T-288	>60	>60	>60	>60
Halogen free	Yes	No	No	No
VLP-2 (2 micron Rz copper)	Standard	Standard	Available	Available
Stable Dk and Df over the temperature range	-55°C to +125°C	-40°C to +140°C	-55°C to +125°C	-55°C to +125°C
Optimized Global constructions for Pb-Free Assembly	Yes	Yes	Yes	Yes
Compatible with other Isola products for hybrid designs	Yes	Yes	Yes	For use in double-sided applications
Low PIM < -155 dBc	Yes	Yes	Yes	Yes

NOTE: Dk Df is at one resin %. The data, while believed to be accurate and based on analytical methods considered to be reliable, is for information purposes only. Any sales of these products will be governed by the terms and conditions of the agreement under which they are sold.

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PATTY'S PERSPECTIVE

Cars, Cars, Cars!

by Patty Goldman
I-CONNECT007

By a show of hands, who has seen the 2006 Disney/Pixar-animated film Cars? My guess is that most of you have, especially if you have kids. Do you recall thinking, "Yes, this could really happen!" If not, did you think of the film as science fiction, or maybe just fantasy?

Well, guess what, it isn't so far-fetched any more, aside from the cute car faces and actual talking. And probably some of the more outlandish stunts or getting mad and racing each other is also a stretch. But, oh my goodness—automobiles communicating with each other and driving themselves? I believe we're there.

Unless you have been on another planet or far, far away, you could not have missed the almost daily news items on self-driving cars, new electronic gadgets for cars, new safety features…and almost as many items about recalls, including this one in a recent Sunday edition of the Pittsburgh Tribune: Carmakers scramble to keep hackers from becoming hijackers. And how about this one: Detroit Meets Silicon Valley, which talks about Americans' two passions—cars and technology—cooperating and competing. In fact, the jump title (in the newspaper version) was, "Geeks, gear heads share fate."

There's not just slightly more electronics in automobiles—the electronics are increasing exponentially. And all those exciting new features have as their basic building block (ta da!) printed circuit boards, components and assemblies. And if you haven't figured it out yet, that's the subject of all three of our I-Connect007 magazines this month: Cars—a Driving Force in Electronics.

We've got quite a line-up right here in The PCB Magazine. First up, Jason Marsh of Insulectro gives a thorough overview of the automo-

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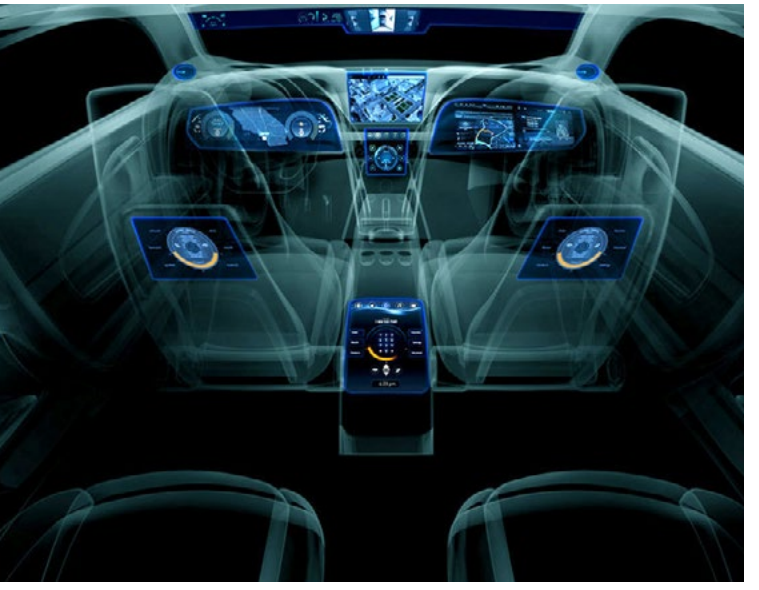
CARS, CARS, CARS! *continues*



tive electronics market today, where it's heading tomorrow, and what it all means to companies wanting to participate.

We asked Dan Feinberg to pay a visit to NVIDIA and he came back with an article that is chock-full of all the latest innovations, both real and still on the (virtual) drawing board. Plus, he got answers to a set of very interesting questions. Definitely an exciting read.

Steve Williams, of The Right Approach Consulting LLC, jumped right in to tell us more about what to expect in our car of the future, pointing out applications for PCBs along the way. While self-driving cars are the big attention getters, there is much coming in the near future that will make your next vehicle (your computer on wheels) oh-so-user-friendly. And it seems everyone is alert to the concerns of hacking a car's multiple computer systems. May the "good guys" technology always stay in the lead.

But wait a minute. Maybe being a supplier to the automotive industry isn't all it's cracked up to be. We have a cautionary tale from Yash Sutariya (Saturn Flex Systems)—proceed with care!

Along an entirely different line, let me introduce you to our newest columnist, Davian Larente, engineering manager at Marquardt Switches—you guessed it—a supplier to the automotive industry. Davian shows how lessons learned about supplier management and relationships can apply to any industry or market segment. This is a great tie-in with last month's issue on supply chain management.

Getting a little more nuts and bolts technical, we next come to an interview with Jonathon Doan of Nordsen MARCH on using plasma treatment as a cleaning method to ensure the kind of reliability now required in the automotive segment.

One of our newer, regular columnists, Tara Dunn, of Omni PCB, follows with a great analysis of the final surface finishes used on PCBs and flex circuits for automotive and other market sectors.

In an interview conducted by our China editor, Edy Yu, Shengyi's executive director Jack Dong tells us about the changing requirements and standards for copper-clad laminate for the automotive industry, and the impact this has had on his company.

And last, but absolutely not least, we have our well-known and (dare I say) beloved columnist Karl Dietz, who has taught us all so much over the years, about photoresist and imaging and all the associated processes. This month he gets into some interesting detail on the structure and composition of photoresist.

On a more personal note, with regard to the automotive industry, here's my advice: Maybe don't buy a new car right now. Wait two or three years! I believe I will wait a good while. I'm sort of liking the idea of a chauffeur—virtual that is.

Next month, we'll be talking about the many ways to reduce cycle time, within individual processes and throughout your company. If you haven't already, subscribe here to make sure you don't miss a thing. **PCB**

Patricia Goldman is a 30+ year veteran of the PCB industry, with experience in a variety of areas, including R&D of imaging technologies, wet process engineering, and sales and marketing of PWB chemistry. She has worked actively with IPC since 1981 and served as TAEC chairman, and is also the co-author of numerous technical papers. To contact Goldman, click here.

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Detroit vs. Silicon Valley: What's Driving the Proliferation of Automotive Electronics?

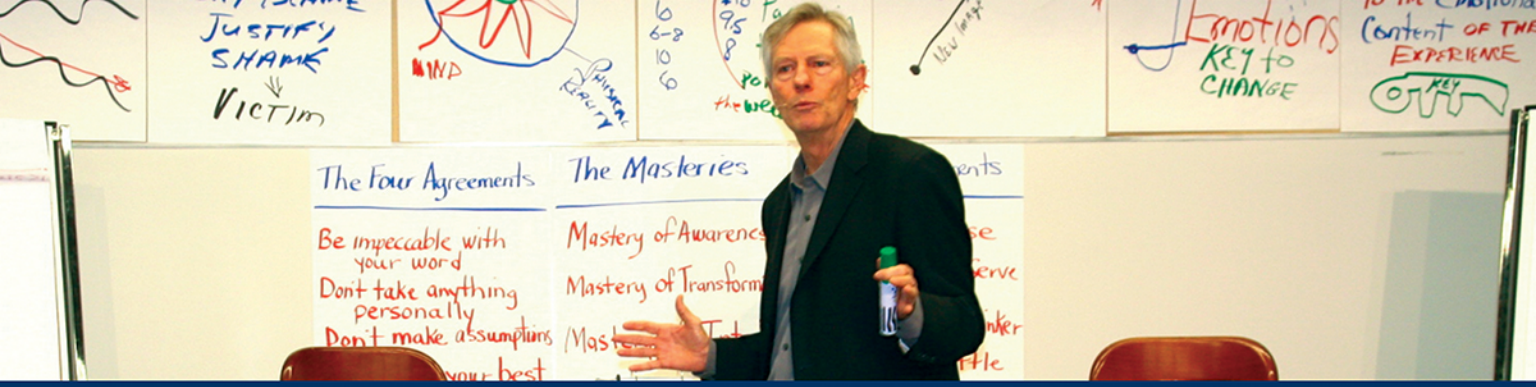
by Jason Marsh
INSULECTRO

For the past several decades, modern cars have not changed much. They have four wheels, an engine, a radio (possibly even an 8-track) and seatbelts. Over time, however, cars' electronics parts have evolved faster than any other part of a car with enhancements like power windows, power mirrors, seat heaters and GPS navigation. For the first time in history, the cost of the electronics in the car has surpassed the cost of the raw steel (steel historically represents about 22% of the manufacturing cost). The combination of growing auto demand, coupled with increasing electronic content means significant dollars. IMS Research estimates that the global market for automotive electronics will reach $240 billion by 2020 (Figure 1).

So, what is driving such a rapid proliferation of electronics in automobiles? One report indicates that in the 1970s, luxury car electronics were roughly 5% of the cost of the vehicle's BOM. This climbed to 15% in 2005, and today, including the hybrids and full electric vehicles, this total can be greater than 35%. How important are these new electronics? According to IEEE Spectrum, a late-model S Class Mercedes contains over 100 million lines of code across 70–100 microprocessors for everything from stereo to emissions to airbags, while a Boeing Dreamliner, for comparison, requires about 6.5 million lines of code to operate.

So where is all this growth happening, and what does it mean to PCB designers and fabricators? In the broadest sense there are three general categories that are rapidly evolving (Figure 2).

1. Functional electronics: Critical to the operation of the vehicle, it includes: ABS; automatic transmission control; starters; fuel injec-



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DETROIT VS. SILICON VALLEY *continues*

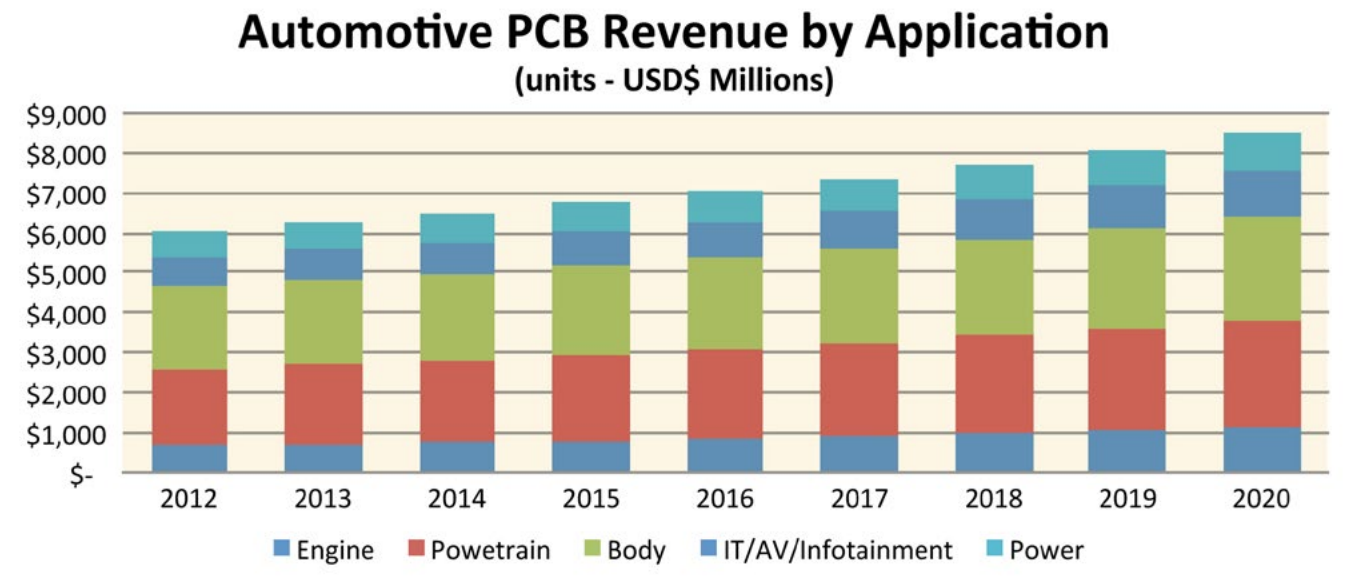

Figure 1: Automotive PCB revenue.

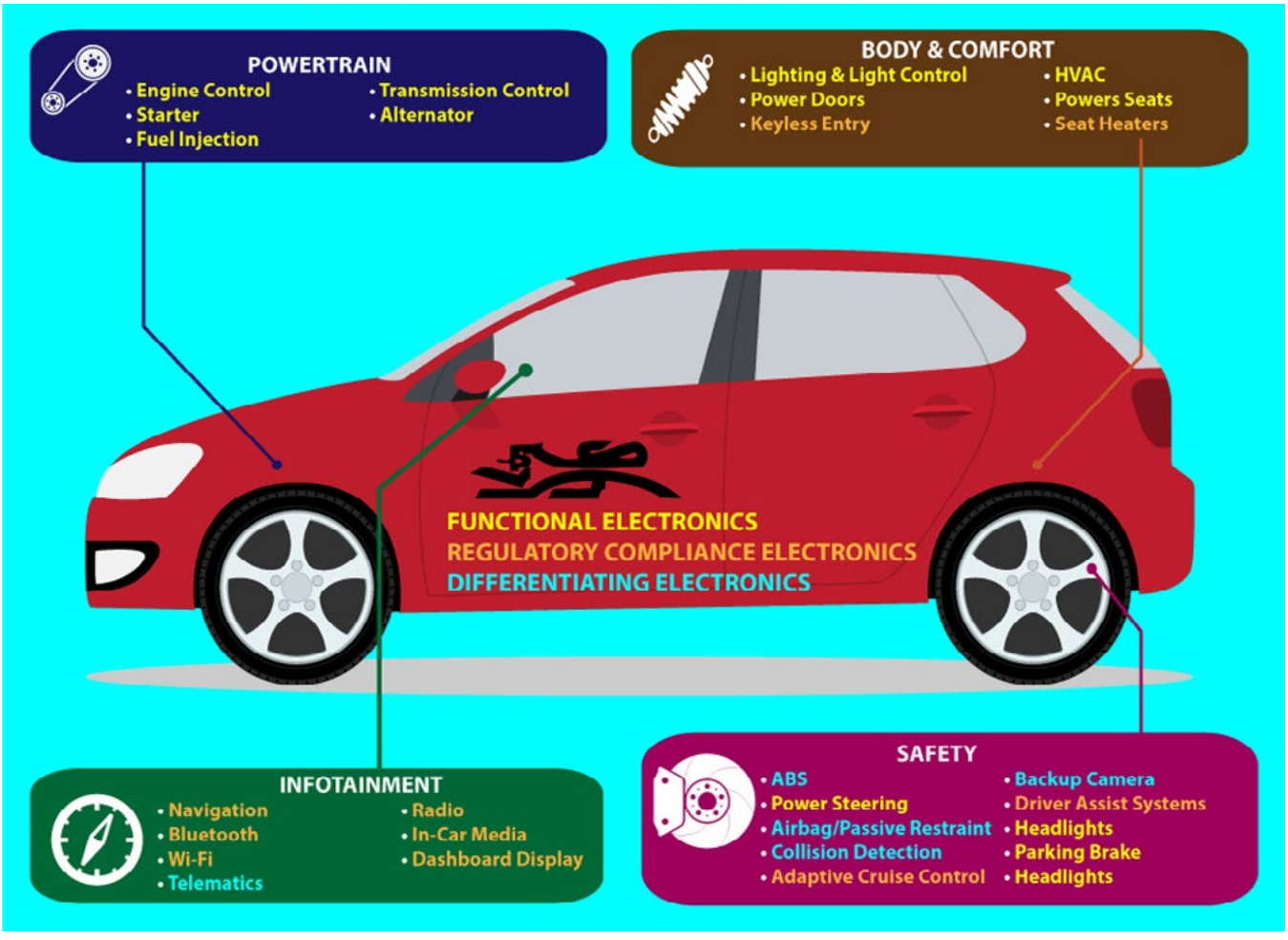

Figure 2: Location of key electronic systems and groupings.

tion; headlights; and electromechanical parking brakes.

2. Regulatory compliance electronics: Regulated into the vehicle by NHTSA or DOT mandate, it includes airbags: emission controls, backup cameras, and collision detection radar.

3. Differentiating electronics: These are unique, consumer-oriented technologies that are designed to convince consumers to purchase the car, including infotainment, adaptive cruise control, Wi-Fi connectivity, and ADAS (advanced driver assistance systems).

Diving deeper, there are key opportunities that could bring near-term growth to the PCB industry. "One of the key growth segments happening now is collision detection radar," explains Dave Barrell of Isola. Operated primarily at 77–79GHz, collision detection radar has already been adopted by the European Commission. By November 1, 2015, all new vehicles in Europe will require advanced emergency braking systems of which 79GHz radar is a critical component.

What makes this so interesting is that automotive radar is really poised to be the backbone of vehicle automation sensor technology, since many of the other proximity detection systems including, lidar, cameras, and even infrared (IR) will lose sensitivity in low visibility conditions. Radar is immune to many of these issues, and when paired with cameras or lidar, creates a very reliable system.

Companies like Rogers Corp. have long focused on these opportunities with PTFE dielectric materials and have strong market share in this arena. New materials from companies like Isola with glass-reinforced alternatives are rapidly gaining popularity as a way to meet cost and yield demands in the auto sector (Figure 3).

Another growth area is the differentiating technology used in the cabin compartment. These include the in-dash display, HUD (heads-up display), and infotainment systems. A significant trend toward full tablet-style touchscreen capability for in-dash systems using dual 17" screens is happening, with Tesla leading the way. Factory-installed HUD systems are already available on some luxury cars and are projected to grow from 3.1M units in 2014 to 33.8M in 2024, according to ABI research.

The communication technologies that include GPS, Wi-Fi, vehicle-to-vehicle (V2V), and telematics are the areas that could see significant growth. Today, Chevrolet leads the Wi-Fi race with nearly all models offering built in Wi-Fi, capable of connecting up to seven devices via 4G LTE.

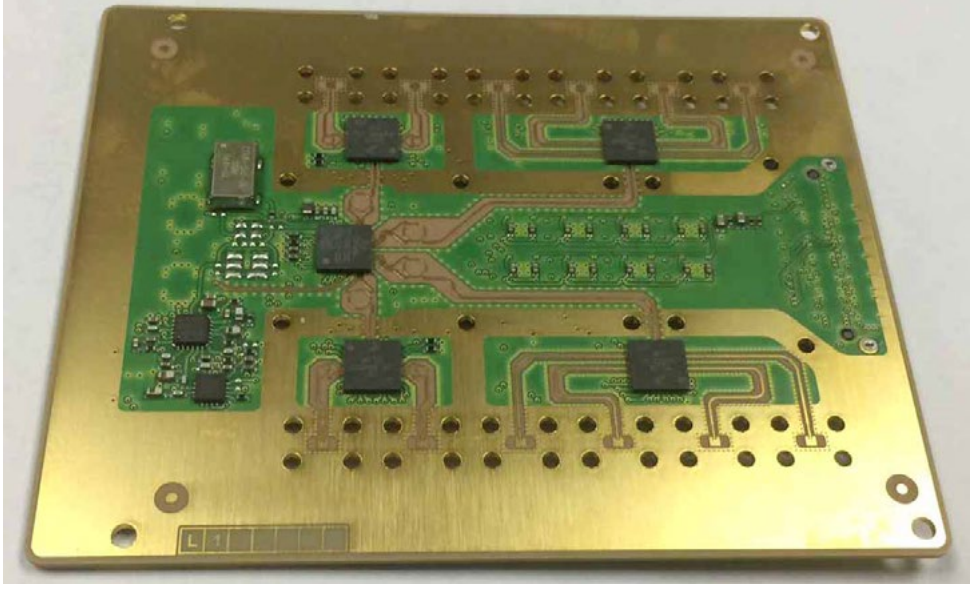

Figure 3: Freescale 79GHz radar demonstration unit using Isola's Astra material.

DETROIT VS. SILICON VALLEY *continues*

V2V and vehicle-to-infrastructure (V2X) communication are highly anticipated near-term innovation areas. One thing that is unique about this is that we are talking about a significant amount of data. We are looking at non-stationary systems pushing 10 Gb/s of data or more. Vehicle-to-vehicle communication is critical for self-driving vehicles, and NHTSA's Level 4 Vehicle Automation criteria, so we can expect this to gain traction as ADAS and the component technologies of driverless systems become more prevalent.

This extensive growth affects all aspects of the electronic supply chain. According to IC Insights, the growth for automotive ICs between 2013 and 2018 will lead the industry with a 10.8% CAAGR vs. 5.5% for the industry average, resulting in a total market size of $4.2 billion by 2018. Companies such as Freescale, Renesas, Avago and Infineon are positioned to capitalize on this extreme growth opportunity.

There is also significant innovation happening with printed conductors on both low-temperature and high-temperature substrates. Many of these can be seen in contact switch technologies for cabin lighting or climate control, as well as advanced projective capacitance touchscreen solutions for in-dash control, navigation and infotainment systems. There are even numerous printed electronics parts you don't see, from emissions sensors to mirror defrosters to seat heaters (Figure 4).

Whether the system uses additive conductors, new silicon technology or ceramic-based sensors, nearly all of these systems must incorporate a PCB to function. As a result, the automotive PCB industry is expected to grow to $8.5 billion by 2020, with companies like Mei-

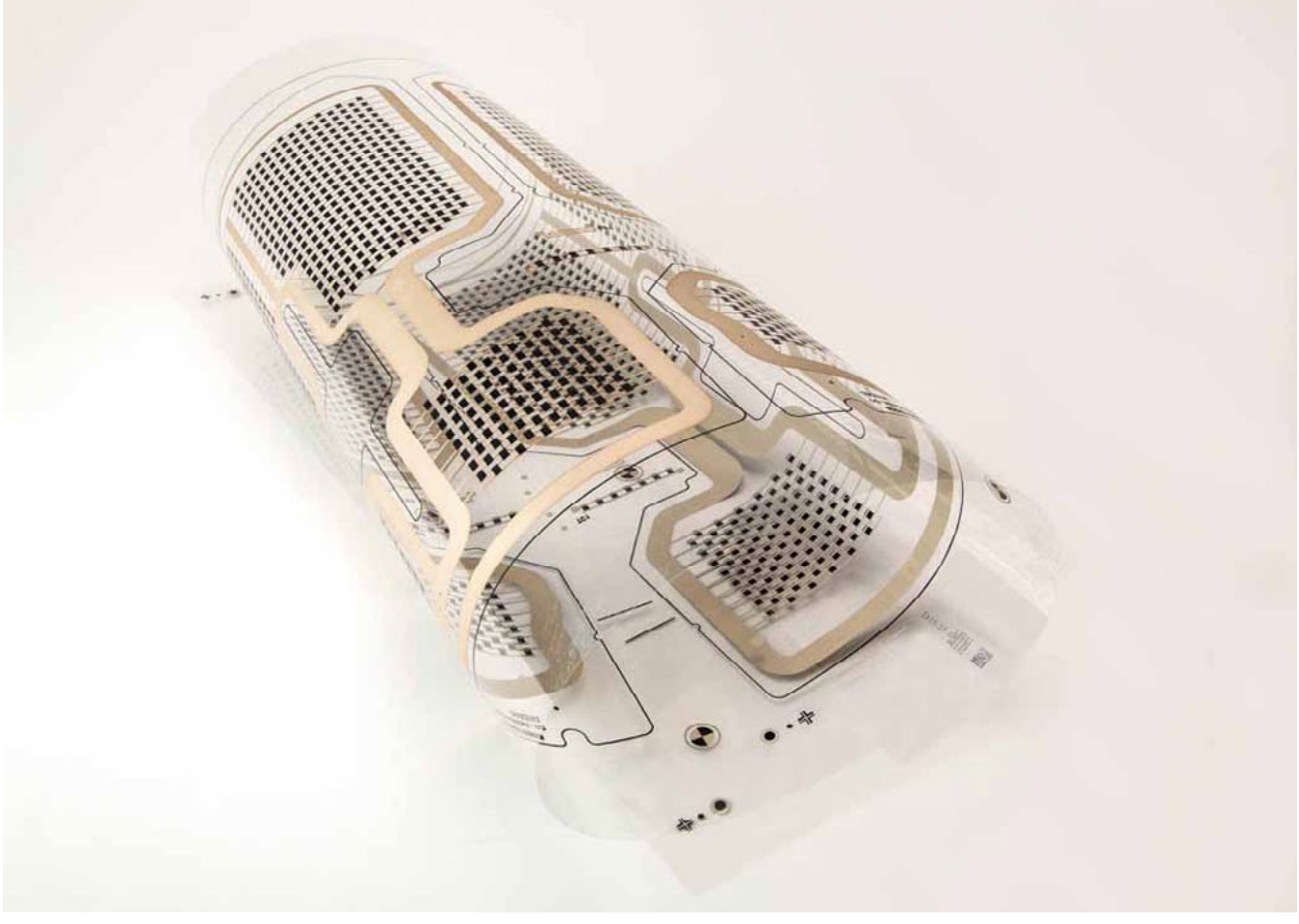

Figure 4: Flexible self-regulating seat heater element made with DuPont printed inks, courtesy of DuPont.

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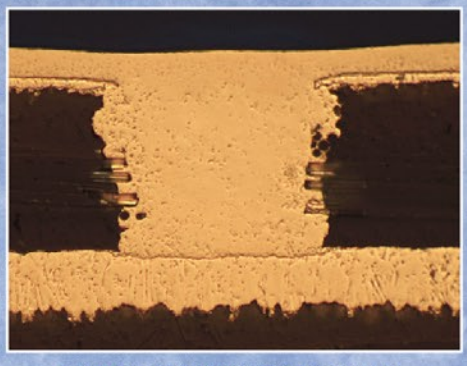

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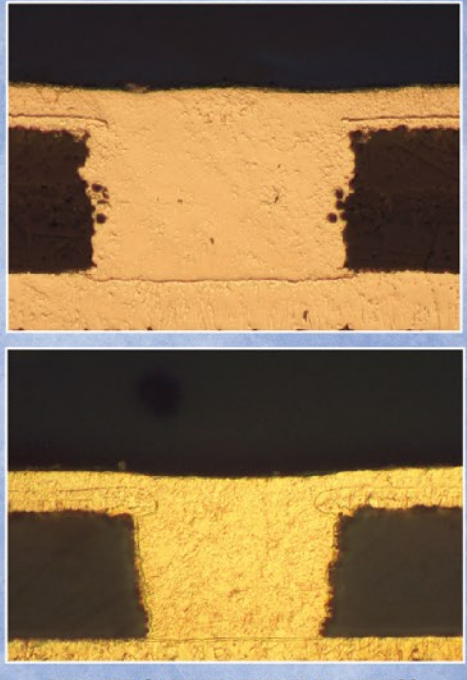

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ko, CMK, Chin-Poon and TTM (formerly ViaSystems) leading the volume overseas. In North America, players like American Standard, Saturn and Cirexx are carving out niche spaces with unique capabilities that allow them to make specialized boards for radar, LED illumination, sensors and control units.

According to Yash Sutariya of Saturn Flex Systems, "There are also opportunities for North American PCB fabricators to build prototypes, provide service parts or support emergency production demand."

Newer entrants such as Sanmina are tooling up to enter the space and "consider this an interesting growth area for the company," notes Leo LaCroix, VP of Global Supply Chain.

However, "Traditional automotive isn't the easiest market to get into," points out Anaya Vardya, president of American Standard Circuits. As a fabricator, you have several things to take under consideration. First, most suppliers will need a TS16949 certification for their facility. Finished assemblies may have to undergo accelerated life tests of up to 3000 hours with temperature ranges of -50–150°C. Next, you will learn that the products being produced today began their qualifications as many as six years ago at the beginning of the platform cycle. Tier 1 automotive suppliers will often prefer to make both prototypes and production in the same factory as it greatly reduces the qualification and paperwork challenges. And lastly, the volumes are often significant, but the industry expects annual cost reductions of 3–5% regardless of commodity indices.

One company who has built a strong portfolio of Automotive PCB sales is TTM. When asked about what was unique about TTM (formerly ViaSystems) that has allowed them to establish this position against strong domestic and overseas competition, John Sintic, VP of Sales–High Reliability and Automotive, explains that, "The key to TTM's success as a preferred automotive supplier is a long history of being a high reliability supplier… [W]e have decades of single digit PPM levels." Another critical success factor is capacity and scale. It is not uncommon for Tier 1 automotive manufacturers to expect their suppliers to be able to respond to 10% capacity surge demand on 48-hour notice. In TTM's case, they have multiple sites in North America and over a million square feet of manufacturing space in their automotive-focused facility in China that allows them to support this need.

Looking forward, there is a great deal of growth potential in areas that are not using PCBs today but where they would make sense from a weight or reliability perspective. According to Clemson University's International Center for Automotive Research, "Today's automotive designs have nearly 100 microprocessors and about five miles of wiring." These wiring harnesses are becoming so dense that manufacturers are running out of space in the columns and headliners and traditional routing channels. That is a lot of potential for flex and rigid-flex circuits and may prove to be one of the great growth areas.

> **Looking forward, there is a great deal of growth potential in areas that are not using PCBs today but where they would make sense from a weight or reliability perspective.**

DuPont, the industry leading manufacturer of materials for flexible circuits, continues to build on its portfolio of advanced materials to support the demand for reliable, lightweight flexible circuitry in automotive applications.

"DuPont™ Pyralux® flexible circuit materials are ideal for automotive designs, and we continue to expand our portfolio to meet the market's needs," said Mary Ellen Gustainis, business leader for Americas and Europe at DuPont Circuit and Packaging Materials. "We recently introduced Pyralux HT flexible circuit materials, for example, with the highest service temperature range of any flexible circuit offering, from -40°C up to 225°C." Materials advancements like these are poised to open the automotive market for significant adoption of flex materials.

The next chapter is V2V communication, which will be a cornerstone of ADAS. New antenna designs and lower loss materials will be required for these increasingly high data rates. These subsystems are a stepping-stone for driverless vehicles. Although Google cars, a frequent sight near Google's Mountain View, CA, headquarters are the most well-known, nearly every major auto manufacturer and Tier 1 supplier has a driverless vehicle project underway. Companies like Cadillac, Audi, Ford, Continental, Bosch, and Delphi lead the pursuit. London's Heathrow Airport even has its own POD parking spaces where a driverless vehicle transports you from the parking lot to your terminal. In May, Daimler's self-driving semi-truck was licensed to drive on roadways for testing, and in Australia, mining conglomerate Rio Tinto has self-driving trucks operating at three of its sites. Recently an Uber/Carnegie Mellon project for self-driving cars was spotted on the roads in Pittsburgh.

There is a great deal of development funding going into driverless car prototypes. However, the key to driverless transportation is getting all the systems in the vehicle communicating with each other and with other vehicles on the road. The payback for these efforts? A study conducted by Texas A&M estimates that 90% penetration of self-driving cars in America would double road capacity and cut delays by 60% on major freeways.

As a result of the confluence of these game-changing electronic features, there is a growing collaboration between Silicon Valley and Detroit. Companies like VW and Ford are putting R&D centers in Silicon Valley, and there are plentiful rumors about Apple hiring auto industry executives. Tesla is one of the few auto makers to make PCB design a core competency, and maintains a top level PCB design team in house. This suggests the industry is headed for some significant change and that the trend of electronics growth in automotive will continue.

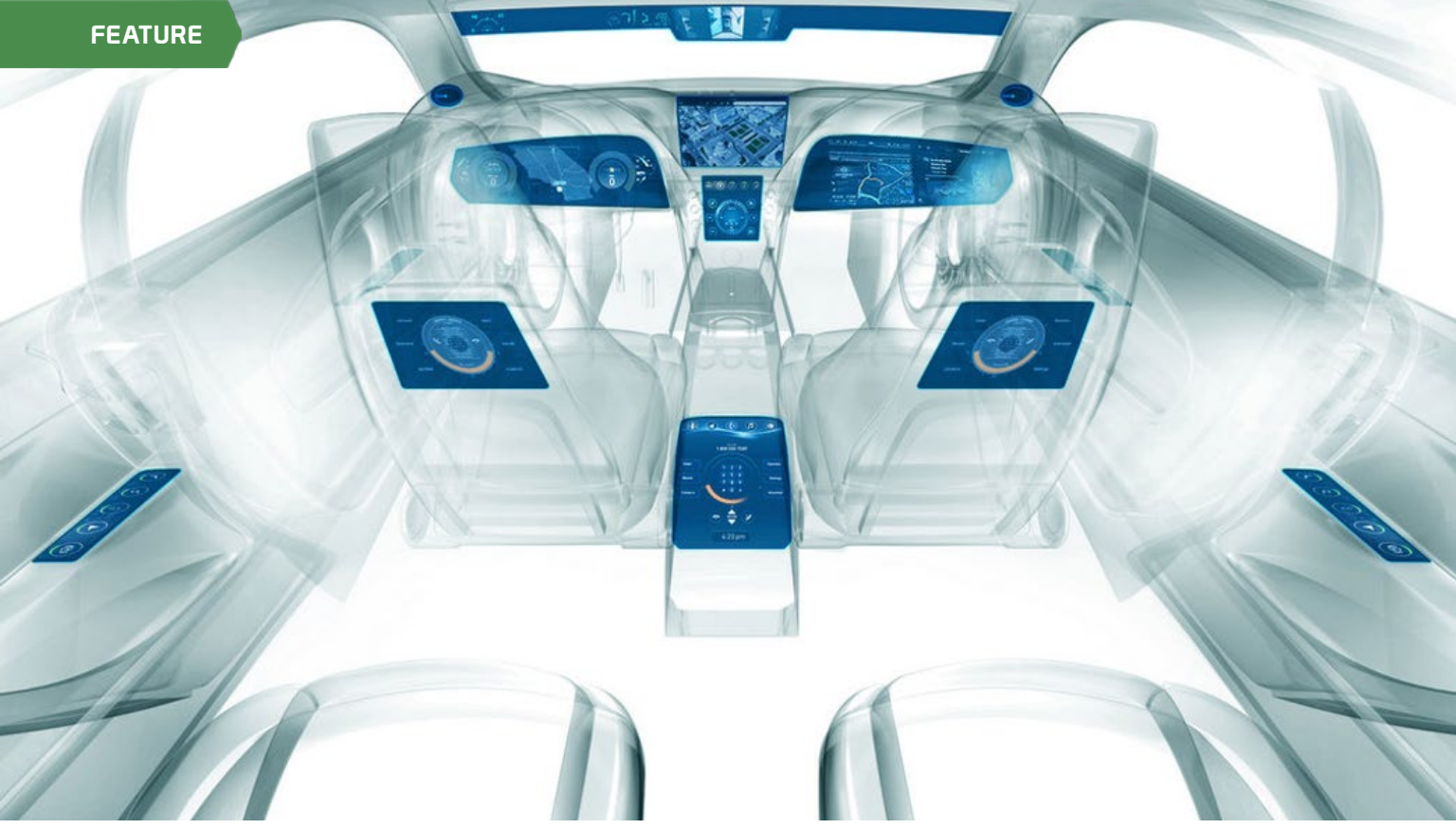
One area where Detroit and Silicon Valley will likely be at odds is the NHTSA requirement that "automakers must continue to support and supply OEM parts and therefore software for a minimum of 10 years after the model year launch," points out Stacy Duff, president of PAPCO automotive, a major distributor of OEM repair parts in the Silicon Valley Area. Although Ford has been tight-lipped on the reasons for its departure from Microsoft and its alliance with RIM's QNX platform for its Sync 3 Infotainment system, the industry speculates that they came to an impasse over the NHTSA requirements for supporting hardware and software for over a decade, something very uncommon in the consumer electronics industry.

Plus, this level of software and automation opens up major security concerns that will require immediate and aggressive solutions. The publicity surrounding the hacking of the Jeep Cherokee in July will drive the industry to get even more serious about cyber security. Egil Juliussen, senior analyst at IHS Automotive, points out that, "Five years ago, the auto industry did not consider cyber-security as a near term problem…this event shows that cyber-security protection is needed even sooner than previously planned."

So, no matter which area of automotive electronics we are looking at, it seems certain the relentless pace of growth will continue. Based on the number of players looking at self-driving vehicles, we can expect significant milestones in that quest in the near future. All of this automation will naturally create opportunity for reliability and cyber security experts, and all of it will use PCBs. So, if your shop is equipped to participate in this space, there may be some good business opportunity on the horizon.

If all of this sounds like a science fiction novel from the 1950s, just consider that the dominant form of human transportation for the past 3,000 years was the horse, and it has only taken 100 years for that to change forever. All of a sudden, it isn't so fantastic to imagine sitting in a driverless car and catching up on e-mails or watching the news during your commute. **PCB**

Jason Marsh is vice president of product management at Insulectro.



Automotive Technology: the Next Driving Force in Electronic Manufacturing

by Dan Feinberg
TECHNOLOGY EDITOR, I-CONNECT007

Many of us have lived through a series of electronic industry growth spurts: from radios to TV and then to high-definition home theater; from vinyl records to cassettes to DVDs; from simple four-function calculators to today's powerful PCs; from Pong and Atari games to today's X-Box, PlayStation and monster gaming computers. Each of these and other segments rely on advances in electronic technology design and manufacture and each of them spurs growth in the industry. One other such segment has also added to the scope of the industry and that segment is automotive electronics. We started with AM and then FM radios, then full stereo systems complete with tape, then disk, then SSD storage; we added speed control then GPS, and then mapping. The higher-end vehicles now have collision and obstruction warning, back-up cameras, driver fatigue warning, maintenance and component failure warning and some have self-parking that actually works—well. But in the automotive segment, as the man once said, "You ain't seen nothing yet."

First of all, the devices we have come to expect in luxury and high-end vehicles are now becoming available and even common in lower priced ones. That alone will significantly increase automotive electronic device manufacture volume. The next wave, however, will dwarf what we have experienced to date. Soon, we will be considering the self-driving, fully-connected and self-learning vehicle that is part of a network that teaches and learns from its peers. Controlling your own car in a traffic jam

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may soon become a thing of the past, and that is only the next step. The rapidly moving world of auto connectivity is moving more quickly than the typical four- to five-year development cycle of new cars. Because of this, carmakers cannot keep up with the overall development and progress regarding the capability and power of electronic components and systems. For years, automakers resisted this, but that's changing. Industry experts say their surveys indicate most consumers think that's OK, as they want their car to act as an extension of their phone for music, contacts, navigation, and more.

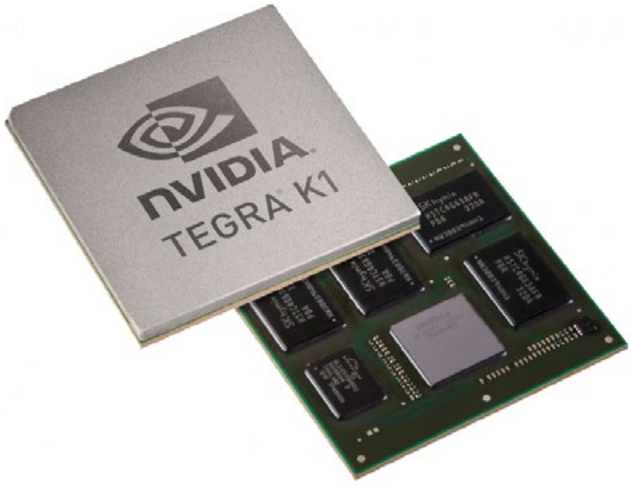
As the I-Connect007 group has increased its consumer electronics coverage over the last year, we have come to realize that our readers are very interested in many aspects of the end-user market. Cell phones, tablets and PCs of course and now also drones, sports cams, etc., but also the new and rapidly advancing fields of advanced automotive electronics (and not just GPS and Bluetooth cell phone connectivity) are topics that have garnered a great deal of interest; but what is coming in automotive electronics has the potential to eventually dwarf them all. The road will be long, however, due to the life cycle of a vehicle being significantly longer than a cell phone or tablet. And yet, one has to ask how long before it is no longer cool to replace your phone every few years, but keep it over a reasonable life cycle just as you do your car.

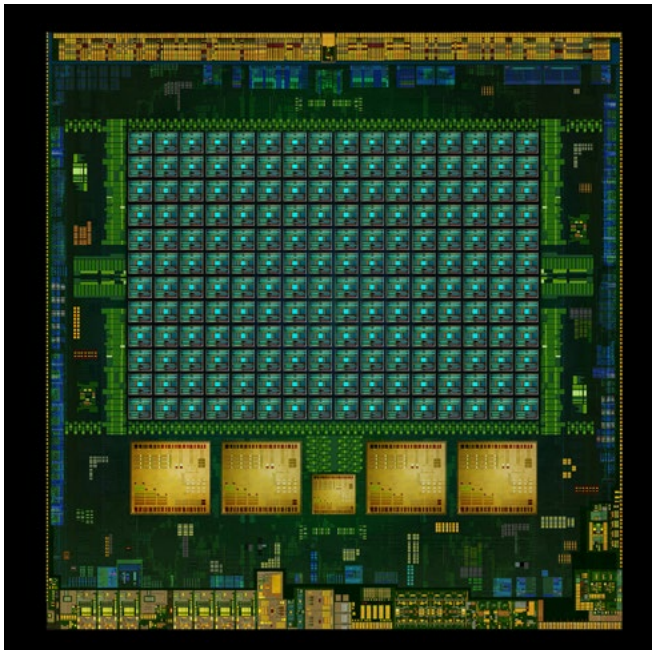
So who are some of the key players to watch? In this article, I'll focus on one well-known company who is a major player in designing hardware and software for the auto manufacturers: NVIDIA. Recently, I had the opportunity to visit the NVIDIA facility in Santa Clara, California, where I was treated to a detailed presentation and first-hand demonstration of their latest technology, and software, including the effect on targeted applications. I also had a chance to ask a number of questions of the NVIDIA team. While much of what I have learned is incorporated in this article, some of the questions, as well as the team's replies, deserve a standalone view, so I have included an excerpt of our Q&A session, which appears further below.

NVIDIA: Truly *Driving* Innovation

Anyone who has any interest in or need for modern computer graphics, be it for gaming, engineering design or even creating art using a computer, knows NVIDIA. Over the last decade they have arguably become the most innovative and therefore, in the opinion of most of us, the leading computer graphics hardware chip designer and supplier, globally. The vast majority of advances made in graphics processing units (GPU) available are, in fact, available because NVIDIA keeps pushing the performance and capability envelope. Things are changing, however, regarding the end markets. Computers and computer display graphics are becoming only one market segment that can be addressed by this company in what is becoming a much larger universe.

The same innovative spirit that made NVIDIA the leading GPU chip company has driven them to peruse advances in the technology required





to meet the challenges and needs of the 21st century's automotive market and not only the hardware needs, but also software to make maximum use of the rapidly advancing hardware.

I believe that the expansion into this market started with the first Tegra chip. Tegra is a full system on a single chip for mobile/portable devices; it integrates a GPU with a central processing unit (CPU) as well as the bridge and memory controller circuits. It's kind of a computer on a chip. Tegra is now well-established in the portable device market and the latest version is quite advanced from the original Tegra 1. If you consider what is needed to power a car of the near future, however, you need more than a chip; you basically need a kind of super computer in a cigar box. Hence, you need the NVIDIA Drive PX to power the systems in the self-driving auto of the near future. It is literally a mini supercomputer. Their description of it is:

"NVIDIA DRIVE™ PX self-driving Car Computer—the DRIVE PX platform is based on the NVIDIA® Tegra® X1 processor, enabling smarter, more sophisticated advanced driver assistance systems (ADAS) and paving the way for the *autonomous car.* Tegra X1 delivers an astonishing 1.3 gigapixels/second throughput—enough to handle 12 two-Megapixel cameras at frame rates up to 60 fps for some cameras. It is equipped with 10 GB of DRAM memory and combines surround Computer Vision (CV) technology, extensive deep learning training, and over-the-air updates to transform how cars see, think, and learn."

The X-1 Tegra has the power of a super computer from the year 2000; the latest unit they showed me has two of them, thus twice that power.

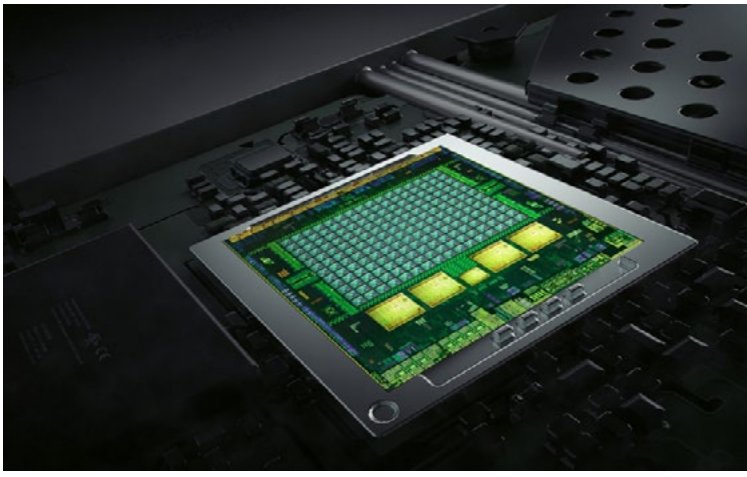
NVIDIA says it is now powering 8 million cars on the road and expects 30 million more cars in the near future to be powered by its Tegra platform, but more on that later.

Today's automotive electronics or automotive embedded systems are mostly distributed systems, and they can be classified (in no specific order) thusly:

1. Active safety
2. Transmission electronics
3. Chassis electronics
4. Driver assistance
5. Engine electronics
6. Passenger comfort
7. Entertainment systems

Some of these have been around for a while, but you can soon add to the list systems to manage autonomous vehicles—and that is not even the far future, but right around the next curve on the freeway. It's much closer than we may have imagined.

Let's think about the autonomous or self-driving vehicle of the near future. What are some justifications?



Fuel savings due to more efficient driving, safer commutes due to the elimination of most human error, freed-up time behind the wheel—these are just some reasons to embrace autonomous vehicles.

Lawmakers from California, Texas and Virginia and now Nevada are wooing the autonomous-car industry, because of increased jobs and tax revenue. I have read that they are "financing research centers, building fake suburbs for testing the cars and, perhaps most important, going light on regulation, all in an effort to attract a rapidly growing industry." It is estimated that automakers will spend at least $20 billion on development over the next five years, according to an analysis by Gartner. Every politician wants a piece of this pie. As Richard Biter of the Florida Department of Transportation explained, "The first thing is, don't do anything to discourage."

Google, known for its pioneering work in autonomous vehicles, states, "Imagine if everyone could get around easily and safely, regardless of their ability to drive. Aging or visually impaired loved ones wouldn't have to give up their independence. Time spent commuting could be time spent doing what you want to do. Deaths from traffic accidents—over 1.2 million worldwide every year—could be reduced dramatically, especially since 94% of accidents in the U.S. involve human error. Our self-driving cars are designed to navigate safely through city streets."

Yes, NVIDIA has entered the field of automotive electronics in a very big way. Their slogan "Driving Innovation" has taken on an entirely new dimension.

Following is the excerpt of the interview.

Dan Feinberg: ***How are you involved in the automotive industry and when did you start?***

NVIDIA: For more than 15 years, NVIDIA has played a role in automotive design and engineering. Areas we have been involved with include virtual crash test simulations, wind tunnel simulations, laying out the factory floor, marketing,* etc. The automotive business unit first started out bringing CPUs from PCs into the car but now the fully integrated Tegra unit is driving the screens, navigation, entertainment, sensors and soon even mirror replacement, using cameras and screens instead of mirrors. This has already started with back up cams, especially the ones that show your path of movement based on how you turn the wheel.

(* Note: We all thought that those spinning and wall-climbing cars were done by stunt drivers, that is not so. Innovative NVIDIA graphics design is being used to generate rendered cars such as the ones you see in TV ads. What you think are real cars spinning around could be NVIDIA-generated graphics.)

Feinberg: ***What sort of electronics, under the hood and in the interior, are involved with today's vehicles?***

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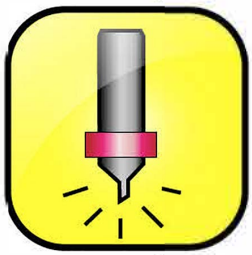

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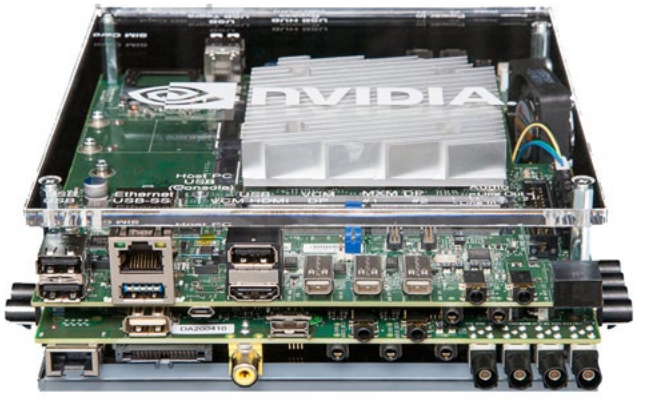


NVIDIA: Today it is mostly graphics and sensors, but think about the 8 million cars that now have NVIDIA devices and add the expectation of 25 million more cars using our devices in the next five years. We are working with the BMW group, Tesla, Audi and the Volkswagen group and Rolls Royce, also Honda has just announced. The 25 million expected is just based on Graphics; autonomous driving will add a great deal more NVIDIA content to those 25 million and increase the total. There are no drive PX using specific carmakers announced as yet, but we are working with them and announcement timing is up to the specific manufacturer.

Soon we will be able to enable vehicles that can take advantage of some lanes that may become useable for driverless cars only.

***Feinberg:** What do you see regarding the change/increase of electronic devices in automobiles over the next five years?*

NVIDIA: It is accelerating. Some cars now have 250 processors already, but some of them are very basic, such as managing the door locks or the memory seats, etc. But what we are doing is bringing supercomputing into the car, reducing the number of separate systems, reducing the costs while adding greatly to the capability. There are other established competitive companies but they are bringing faster and faster overall progress. For example, we now have twice as many software engineers than hardware engineers. We plan on building the systems as well as the applications to enable the car manufacturers to design tomorrow's systems.

***Feinberg:** How are electronics changing the driving experience besides the obvious inclusion of GPS, verbal texting and phone communications, etc?*

NVIDIA: The entire movement to autonomous vehicles will greatly change the driving experience starting sooner than many think.

***Feinberg:** What demands are car manufacturers placing on you? What are their key needs?*

NVIDIA: Cost/price is a factor and always a stated need, but the mindset is shifting. Car companies are starting to invest in the future. They are also starting to say that "once they ship the car they are not done with it." They believe they can continue to improve the car by sending out software updates. Tesla is leading the industry in using that model. It is expected that the industry will adopt that model more and more. Going into the dealer and getting a software update that renews the car and adds features and changes the interior appearance, and even the GUI, have become expectations. Nevada is now building "automotive grade" devices. Even the computer modules in newer cars will be upgradable as new hardware is designed and produced.

***Feinberg:** From your perspective what does the car 5 to 10 years out look like?*

NVIDIA: In five to ten years, there will be radically more computing horsepower in the car and many more sensors. Fully autonomous vehicles will be ready sooner than most think, but the questions are will the public and society be ready to accept it and will the regulations and laws be ready? There will be more than one autonomous mode. For example, Audi and NVIDIA will have their system to self-drive in traffic jams—keeping a safe distance, stay in lanes, etc. (This should be the first autonomous mode generally available.) This mode, the traffic jam pilot, will be available in 2017. From that the next step will be the ability to program in your destination and get on the highway and the car will drive the highway. This may be available in about three to four years. Remember, we already have auto Parallel Park that works well. There will be more and more additional driver assist

modes until we finally get to full autonomous mode in about ten years. Also coming is a good voice control system. Voice is a good control mode but the implementation so far has not been that good, as it takes a huge amount of computational power—but it is coming.

(For an example of what is coming, check out the Mercedes F-15.)

All the door panels are touch screens; you are fully surrounded by pixels. And, as we have stated, many updates and upgrades will be available via software updates instead of having to buy new hardware.

***Feinberg:** What requirements are you placing on your suppliers, especially those that you would like to see advances in?*

NVIDIA: From a technology perspective, we are demanding higher speed interfaces from our suppliers. Let's take sensors for example. On one end, we have state of the art imaging solutions with several million pixels per second coming in. On the other end, we have a world class super computer class TEGRA SOC that is capable of processing all these pixels, and more. The interfaces that connect these two ends together, however, is currently the bottleneck.

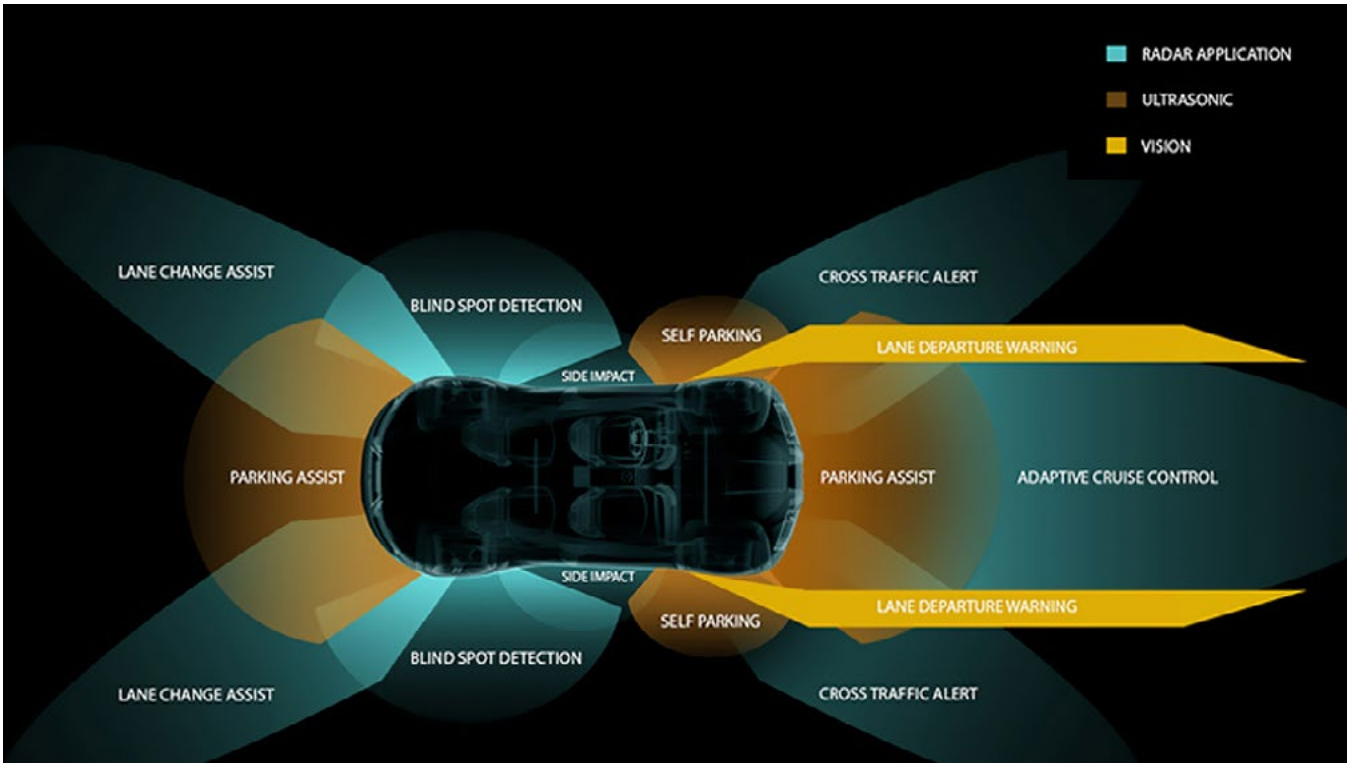
From a supply chain point of view, longevity is key and we continue to ask our suppliers for longer life cycle components. The car companies take 2–3 years to test and qualify a car to be ready to place it on the market. The last thing they want to hear is that one of the 30,000+ parts in a car has a DRAM, for example, that is being retired and moved to a new silicon node or a different package.

***Feinberg:** What advice would you give a manufacturer who is or wants to do business with you?*

NVIDIA: That's easy; we require robustness, zero defects and high quality. They must support our goal of delivering the absolute best user experience.

***Feinberg:** How will cars interact with each other and with their environment (e.g., road signs, obstacles, etc.)?*

NVIDIA: Road signs will become interactive, they will be able to communicate with the car and the driver in various languages—just select the one you want to use. The infrastructure will



be expensive, however. Right now advanced cars can sense and warn, but soon they will interact. Some cities and locations will not have this capability for quite some time, if ever.

***Feinberg:** Just as with any connected device, there is the possibility of hacking. How seriously do you take this threat?*

NVIDIA: We take safety and security extremely seriously. We have been working with our customers from day one to deliver reliable, secure systems. For example, we create a sand box which separates an app-related or connected car content from any other safety-critical systems.

During our conversation, NVIDA also stated that besides the auto manufacturers that they have announced they are working with, in fact, they are working with all of the Detroit three and others, but it is up to the auto manufacturers to make announcements when they are ready. Soon we will be seeing NV-branded products, not just the chips, as car makers are now buying the entire platform from NVIDIA.

One topic we did not discuss, but that I know NVIDIA is working on, is parking. Industry watcher Gartner states that almost a third of motorists want parking info in their cars. Probably more will want it as it becomes available. Now that navigation, weather, and traffic information are commonplace, drivers are looking for help with where to park the car. Expect it to become more widely available as the infrastructure catches up, and even the opportunity to pay from the car so you can easily find available parking, pay and move on.

I would like to thank the entire NVIDIA team for spending so much time with us, presenting, and demonstrating, and for patiently answering all of our questions. Thanks to Brian Del Rizzo for introducing us to the automotive team; Fazel Adabi, PR manager, Automotive; and to Danny Shapiro, senior director, Automotive. **PCB**

Dan Feinberg is the owner and president of FeinLine Associates, Inc. In addition, Dan is a Technology Editor for I-Connect007.

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The Evolution of Automotive Electronics

Many of us can painfully remember our early cars that had manual door locks, windows we had to crank up and down, and doors that we actually had to put the key in the lock to open. The rise of electronic content in automobiles has been relatively steep. The 1977 Oldsmobile Toronado had a very simple computer unit that was used for spark plug timing, and the following year the Cadillac Seville offered an optional trip computer running a Motorola chip. This transformation is further supported when looking at cost; according to the publication IEEE Spectrum, as a percentage of vehicle costs, electronics climbed to 15% in 2005 from 5% in the late 1970s—and would be approaching 25% today. Figure 1 highlights some major milestones in automotive electronics innovation.

Today, even basic vehicles have at least 30 microprocessor-controlled devices, known as electronic control units (ECU), and a high-end luxury car like a BMW 7-series model can have up to 150 ECUs and five miles of wiring. These ECUs are the vehicle's electronic brains and control dozens of functions, including managing the efficiency of the car, the steering and the surround view system to avoid collisions; the Wi-Fi system that provides information on attractions, gas stations, traffic, etc.; and the electronic stability/traction control to maintain proper steering, and sensors that deploy airbags during a collision. Then there are the audio/video center stack that provides entertainment and navigation, dashboards with heads-up display (HUD), and, of course, electric windows with intelligence features. Software and multiple PCBs drive each of these ECUs that function both independently and as part of an overall vehicle electronic network.

Automobile Electronics Milestones			
1911	Electronic Starter	1985	CD Players
1925	Cigarette Lighter	1994	On-board Diagnostics
1930	AM Car Radio	1995	Navigation Systems
1952	FM Car Radio	1997	GPS
1965	8 Tracks	2000	Hybrid Cars
1970	Cassette Decks	2002	DVD Players
1973	Catalytic Converter	2003	Satellite Radio
1982	Electronic Fuel Injection	2000-2015	Smart Cars
1984	Air Bags		

Figure 1: Automobile electronics milestones.

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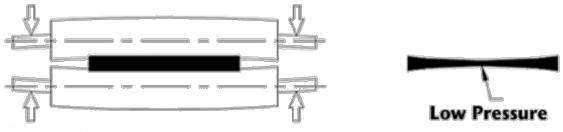

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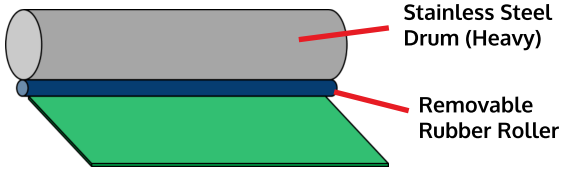

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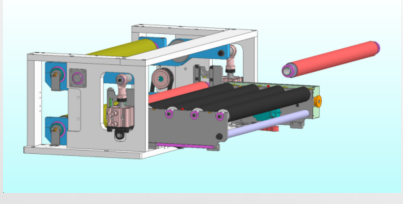

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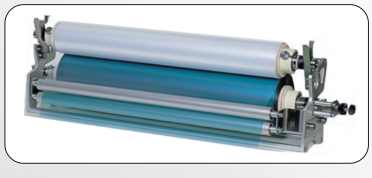

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- Electronic computer unit (ECU)/car computers
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- Emergency assist
- Engine coolant level (ECL) monitors
- Engine timing systems
- Global positioning systems (GPS)
- Interior LED lighting systems
- LCD displays
- LED Brake Lights
- Navigation equipment
- Power distribution junction box
- Power relays
- Radar & radio systems
- Remote diagnostic systems
- Security systems
- Transmission controls
- Running lights
- Rear LED lights

Are Cars Too Complex?

I received a recall notice the other day for my 2014 truck, but it wasn't for anything mechanical; it was for the entertainment system. The recall said a chip upgrade was needed to prevent hackers from stealing personal information through the entertainment system and any smartphones connected through it. This was amazing to me, so I did some research and found that not only can someone hack into the system, but with the right equipment they can control the vehicle remotely. How scary is that? Then I found this recent story about a car whose system was hacked while it was being driven down the road.

Future Applications

Now that cars are more mechanically sound than ever before, the vehicle's infotainment system will become the next major system to continue to advance. With today's tech-savvy consumer there are three things that "smart" systems must be: easy to use, fast, and familiar. In fact, many automakers are mimicking smartphone interfaces into their next-generation infotainment systems to be sure to hit these three attributes. Ford's 2016 Sync 3 version will feature a more responsive "capacitive" touchscreen that users can swipe and pinch to zoom, just like a smartphone screen. The smartphone-inspired interface features large touch targets, with high contrast, which make it better for automotive use.

On the luxury side of things, Audi debuted the interior for the next-generation Q7, which borrows the virtual cockpit from the 2016 Audi TT. That environment includes a 12-inch TFT display that doubles as the gauge array and infotainment system. For the Q7, Audi adds a touchpad with pinch-to-zoom control and "haptic" feedback (meaning you get a tactile response, such as a vibration, when you touch the pad). It also features improved voice control that will respond to such natural-voice commands as, "Where can I fill up?" or "Where is the nearest restaurant?"

Apple CarPlay and Android Auto are solutions that Apple and Google use to integrate their smartphones into the vehicle. Both systems focus on the key features that a person wants from a smartphone when driving: navigation data, messaging, music and phone. The systems take a different approach with how they display the data, but the goal is the same: reducing distraction by getting the driver to put down the phone and rely instead on voice functionality and the presentation of data on the vehicle's screen.

Hyundai, meanwhile, announced that its new Display Audio System ditches the CD player and satellite navigation system to keep costs down and allow more people to have access to Apple CarPlay and Android Auto. This means you won't have to buy the top-of-the-line vehicle to get the latest in smartphone integration.

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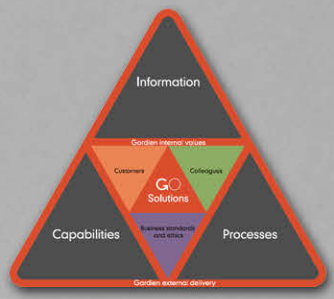


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COMPUTER ON WHEELS *continues*

Gesture is the New Touch

While touchscreens are still one of the best ways to access a number of features in a vehicle, screens take the driver's eyes off the road. Many in the industry believe that gesture control is a solution to that problem. BMW's next-generation iDrive interface has sensors mounted in the headliner that detect movements near the infotainment system and respond to specific commands. Want to raise the volume? Twirl a finger clockwise. Need to answer a call? Point at the screen to accept. Need directions home? Point two fingers at the screen. The Volkswagen Golf R Touch concept eliminates all buttons inside the vehicle and instead relies on multiple touchscreens with haptic feedback.

Autonomous Automobiles

We were all sufficiently wowed a few years ago when automakers introduced a few self-parking cars. Well, the bar has been raised when earlier this year Audi's A7 Piloted Driving Concept car made a road trip from Palo Alto, California, to the Las Vegas Convention Center. The car drove on its own for more than 550 miles and could initiate lane changes and passing maneuvers. There was, of course, a human in the driver seat, ready to take the wheel at a moment's notice. Audi has seamlessly integrated the autonomous-driving technology into the vehicle so there is no radar array or cameras protruding from the grill or roof.

Think of the electronic computing power such a feat takes and the enormous amount of data and calculations that would quickly overwhelm a traditional vehicle's computer. So Audi turned to Nvidia, a computer GPU chip manufacturer. Nvidia created the Tegra X1 superchip, which allows a car to teach itself with a training algorithm that identifies different types of ve-

Figure 2: Audi's self-piloted car.

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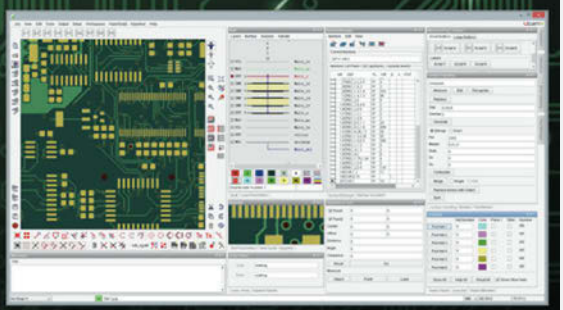

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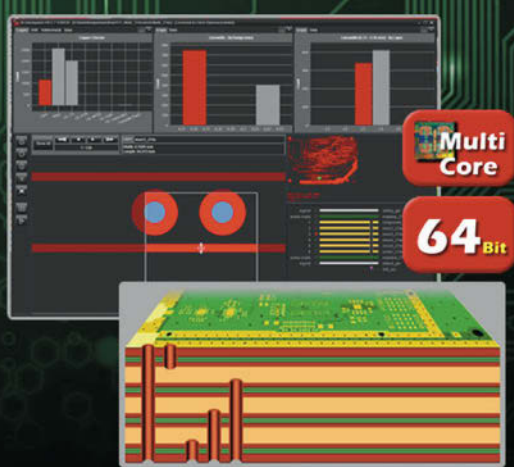

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COMPUTER ON WHEELS *continues*

Figure 3: Mercedes' F 015 Luxury in Motion concept vehicle.

hicles on the road, such as an SUV, truck, or police car. It also can spot a pedestrian, even if he is partially blocked from view by a parked car. The Tegra X1 is about the size of a thumbnail, but packs the computing power of a room-sized supercomputer from 10 years ago, said Dave Anderson, Nvidia's senior manager of automotive integration.

Mercedes-Benz offered a glimpse even farther into the future. The carmaker says it imagined the F 015 Luxury in Motion concept from the ground up to serve as transport of the future. Passengers can rotate the bucket seats to face each other to socialize while the car automatically takes them to their destination. Inside the vehicle, the door panels have touchscreens, which respond to gestures and enable the passengers to make video calls, browse the Web or keep up on social media. The LED lighting outside the vehicle gives pedestrians visual cues to signal that it sees them and indicates whether it is driving autonomously (blue) or being driven by a person (white).

Conclusion

Today's average automobile has about 100 microprocessors controlling all aspects of vehicle operation, and this number is expected to double in the next five years. Looking at the above future trends from automakers, it is clear that the "computer on wheels" concept will continue to explode as innovation drives the next generation of the automobile.

And our boards drive this innovation! **PCB**

Steve Williams is the president of The Right Approach Consulting LLC and the former strategic sourcing manager for Plexus Corp. He is the author of four books, including *Quality 101 Handbook* and *Survival Is Not Mandatory: 10 Things Every CEO Should Know about Lean.* To read past columns, or to contact Williams, click here.

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Becoming an Automotive Supplier—Proceed with Caution

by Yash Sutariya
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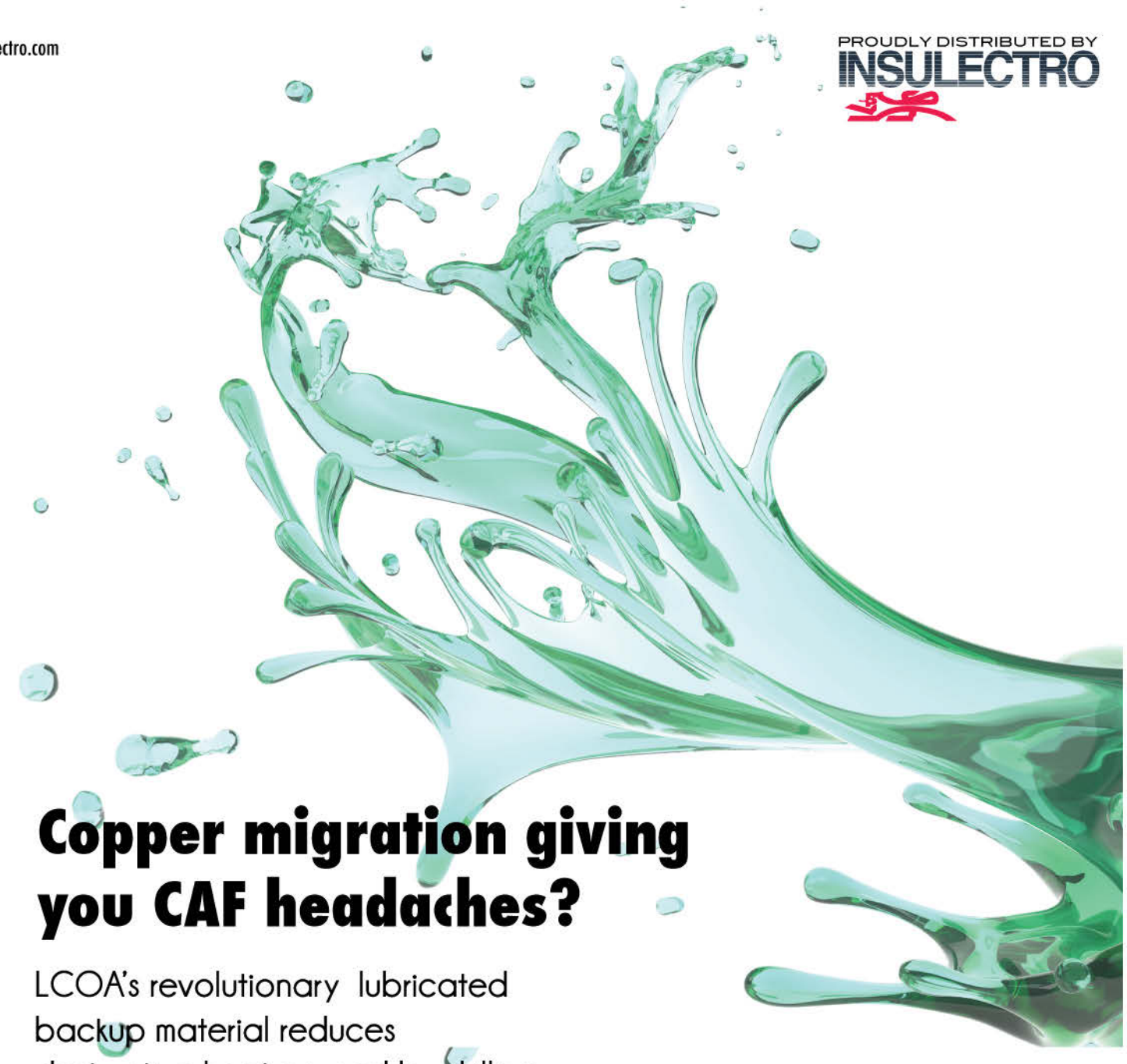
In past articles about PCBs for the automotive industry, we've discussed topics such as applications and quality systems requirements for becoming an automotive PCB supplier. Possibly further fueling a growing desire in our industry towards participating in this sector have been further technology advancements in automobiles, as well as a tear in Tesla's stock price and headlines.

Sales dollars in the automotive industry are traditionally very sexy, top-line numbers, but a nice bottom line has often been an evasive target, as evidenced by the slew of automotive supplier bankruptcies in the past 10–15 years. Fortunately, the past five years have shown a tremendous recovery in the industry, leaving most participants with positive income and much stronger balance sheets. This is yet another carrot to becoming an automotive supplier.

Before you make that plunge to becoming an automotive supplier, we need to talk about liabilities. In our industry, the liabilities for shipping bad boards are generally limited to a range of a) replacing or b) crediting out the bare boards to pay for the assembly (parts and labor) that was affected. Historically, this has been the case for automotive applications, as well. It's been my feeling that since the OEMs have beaten down pricing so badly over the past 20 years, they generally bore most of the costs of warranty claims.

That's been changing in the past 3–6 years, as OEMs are under tremendous pressure to keep growing their bottom lines. Warranty reimbursement claims have been one method of achieving improved fiscal performance. Car manufacturers have pushed liabilities to their Tier 1 suppliers who have in turn pushed it on down the line. So if you supply a bad circuit board or assembly, you may have to pay for the installed part. Not only that, you may have to pay for the new part to be installed—and we all know how expensive dealer labor is.

My story goes back a few years, but it is, if anything, even more relevant today with the increasing number of recalls by automakers.



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BECOMING AN AUTOMOTIVE SUPPLIER—PROCEED WITH CAUTION *continues*

Due to the increased cost pressure from OEMs, most PCBs for autos are sourced from China, either direct or via a domestic PCB manufacturer. This is most likely to be the case if you choose to become an automotive PCB supplier. Even though you worked hard to achieve TS16949 certification, you will most likely have to purchase boards from overseas and then resell them to your automotive customer.

We had a similar arrangement years ago when we were awarded a program for back-up cameras. During launch, boards started failing at functional test—which is about the worst time it can happen since this was an entirely new program that was under a microscope. Despite our concerns, the decision was made by our customer, a Tier 1 supplier, to ship product that passed test while we performed root cause analysis with the overseas supplier. So what about halting a production line when bad parts are known to exist? Yes, that can be done, but the costs there are astronomical. When an automotive production line is shut down, you are charged for the cost of each vehicle that cannot be produced, which can run $1–2 million *per hour*. I can see why they pushed forward.

> **During launch, boards started failing at functional test–which is about the worst time it can happen since this was an entirely new program that was under a microscope.**

We ended up finding rough hole-wall issues that contributed to failed vias in these parts. Not only did we have to pay for the assemblies, our customer charged us administrative time to recover the efforts by their personnel. Needless to say, our profit was more than eaten up by the total bill of about $120,000. This was 2008. The thought was, "At least it's over—let's move on and hopefully make up the losses over the life of the program."

Unfortunately, some of the assemblies that made it to the field (that is, into cars), had issues too. Only the condition wasn't as bad as those that failed during functional test, which is actually worse. These vias were actually causing latent failures, blowing after spending time in hot and cold conditioning. We actually weren't made aware of any issues until 2011—right after the warranty period ended. We received an e-mail from the Tier 1 supplier with a bill for $1.2 million! Basically, the OEM's thought process was that since we did have this issue at launch, any issues that came to the dealers with the back-up camera must have been due to the same root cause. Dealers were authorized to replace faulty cameras with new units, and just toss the faulty units without any need for root cause analysis. Essentially, no evidence was presented that the boards were bad, but the bill was presented all the same.

The biggest kick in the walnuts was that, based on the number of units affected by warranty repairs, the total selling price of the associated bare boards was roughly only $1,750! And here we are being presented with a seven-figure bill for brokered boards that may have generated a couple hundred bucks in gross margin.

Naturally, there was much wrangling back and forth—shouldn't the Tier 1 pay some of the cost, since the bad assemblies slipped through, which was clearly their fault? We settled for about half the amount, well over $600K. I don't know of too many PCB manufacturers who would say this was chump change and I am sure there are any number who would quickly be put out of business. We survived it, but our business model has since changed from 90% automotive to less than 15%—and those are for prototypes or low-risk, small-run business.

This is my tale of woe, but this is not being written so I can cry on a shoulder or two. We learned some hard lessons and want to pass on a few of the things learned to others.

Still interested in supplying PCBs to the automotive industry? First, understand that it is a very price-sensitive industry. Lowest cost is everything. The volume is definitely going overseas (read China or another low-cost Asian area) where the labor costs and even some ma-

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The True Figures

terial costs are much lower. But beware price differences between offshore manufacturers. A cheaper price doesn't necessarily mean a more efficient operation—not any more. Efficiencies and yields in our industry are already very high at most shops, since the methodologies have remained quite the same for the past couple decades at least. However, being a true automotive supplier means that there needs to be strict quality systems being applied to both the manufacturing facility as well as the supply base (laminates, soldermask, final finishes, etc.). Unfortunately, many shortcuts can be taken in PCB manufacturing to get costs down, including in the raw materials area, as well as in inspection, cleaning, equipment repair and maintenance, and so forth.

As such, the number one priority should be to find a very good and capable partner/supplier of PCBs. Then learn all about their costing. How did they get to their low pricing? Is it through cheaper material sources, cutting out process steps, skipping inspections or cleaning, or…what?

Secondly, it is absolutely imperative that you audit your prospective overseas PCB supplier in person. ISO certification is basically meaningless, and TS16949 certification can be purchased without actually doing the required work (so I am told from reliable sources). Everyone says they can build for the automotive market; make sure they actually do, not just say they do. That is the true test of how effectively TS16949 is being used.

Referring back to one of my past articles, Built Board Tough (The PCB Magazine, July 2012), there are three critical production areas that require extra attention during an audit. These are lamination, drilling, and plating. These areas must be gone over with a fine-toothed comb, so to speak. Following are some pointers for each area—but this is not an all-inclusive list.

Materials

What laminate is actually being used to make the boards? Ask for a datasheet while quoting. Then, during your audit, take a look at the laminate storage area. Is the material they called out actually in there? (And by the way, how are they storing their pre-preg?)

Run some solder float tests. Figure 1 (a and b) shows two FR-4 laminates put through solder

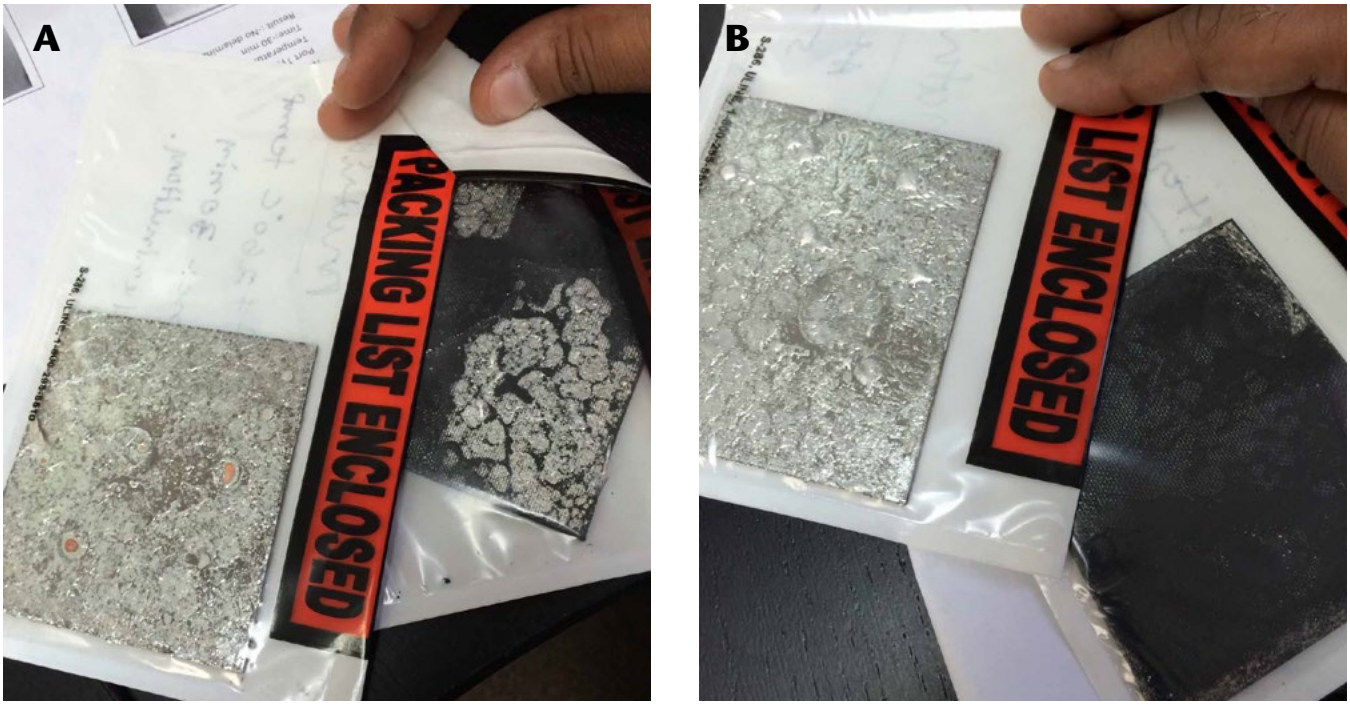

Figure 1: (a) Solder floats of two materials, 260°C for 30 minutes; and (b) 280°C for five minutes.

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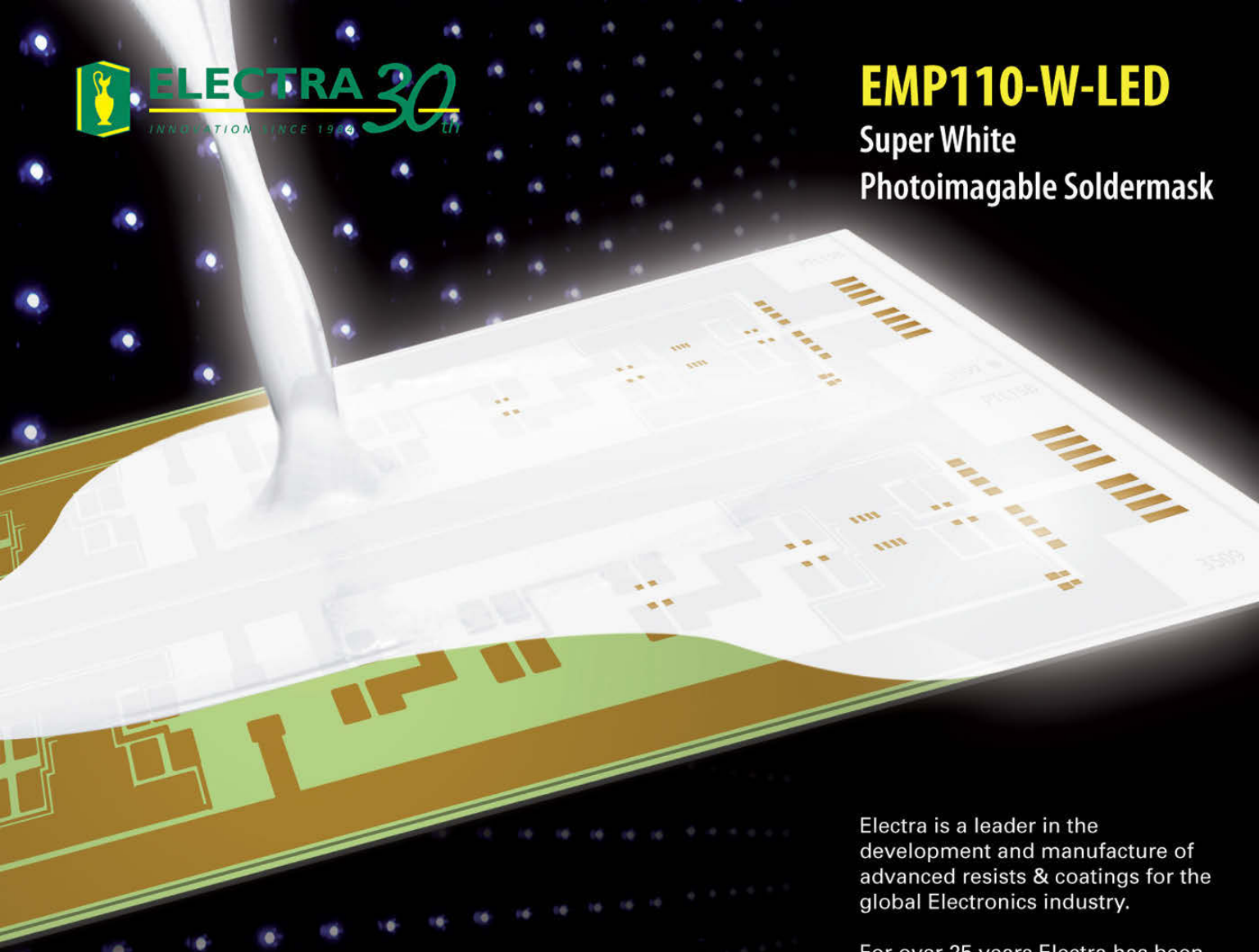

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float tests; one material has been basically incinerated—obviously not the laminate you want used with your PCBs. There are many laminate manufacturers in Asia. How well known, reliable, well-tested, etc. is the one being used? It is best to conduct such tests yourself or have them done by a reliable test lab. While you're at it, a few tests on the pre-preg would also be a good idea.

Multilayer Lamination

From what I've seen, most small- to medium-sized PCB fabricators in China don't actually run their own multilayer presses. Rather, they contract this out to a mass laminator. Every time I've asked what type of audits they do on those suppliers, I just end up getting copies of certs. That's not very reassuring since mass laminators don't just press the panels. They actually take responsibility for the entire innerlayer production process, including:

- Materials selection
- Image
- Develop, etch, and strip
- AOI
- Oxide
- Multilayer lamination

These are all critical steps. Questions you can ask would include:

1. How often are thermocouples run with the panels to validate press recipes?
2. How do operators validate that min/max line widths are being met?
3. How often does the PCB fabricator visit the mass laminator for spot audits?
4. What types of validation are being performed by the PCB fabricator on the mass laminator's products? (e.g., delta Tg/Td testing to validate cure; registration tests to confirm scale factors; layer-to-layer registration, etc.)

Drilling

Most China PCB shops re-point their drill bits in-house, and they usually have a manual operation set up to do this. The setup would include bit grinding/re-point stations and then at least one inspection station for every two re-point stations. This is an area where I bust almost every board house.

During one visit I had, the management folks were walking with us. I made a comment that I would bet they barely ever reject drill bits after inspecting, and they all proudly concurred. It

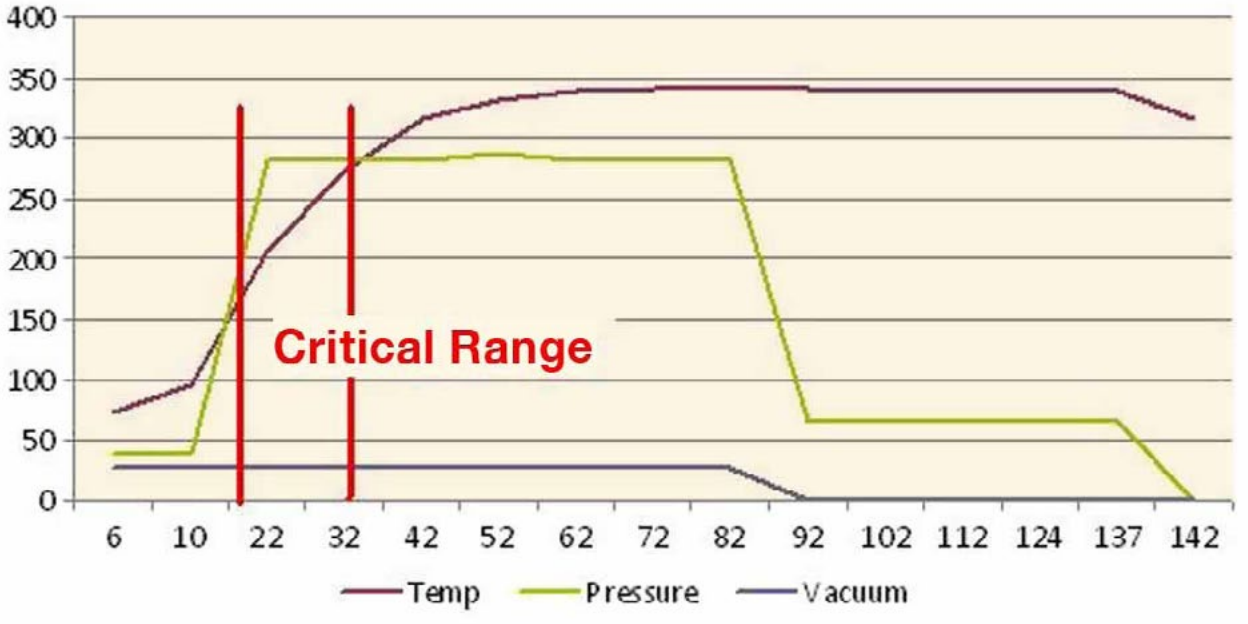

Figure 2: Sample press cycle.

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was validated by showing me a nearly empty reject bin. I said, "That's great—now show me a box of recently re-pointed and passed drill bits," and out came the box. I sat down at the re-point inspection microscope and started inspecting the bits myself. By the third one I had it—huge gouges on the cutting edge! I showed it to management and immediately their glare turned towards the poor operator I just helped bust.

I stepped in right there. I explained that the scope was too low of a magnification to properly inspect each bit—especially when the diameters they were running are down to 8 mils. I asked them how exactly does one accurately re-point a 10- or 12-mil drill bit when it is barely visible, and then inspect it, all at a relatively high rate of speed (time is money)? There are multiple facets on the typical drill bit that should be looked at. The lesson here is to look for an automated re-pointing and inspection operation, or out-sourcing to one. Do not settle for less if your designs have smaller vias (< 12 mils). Otherwise you are playing a not-so-fun game of roulette.

Next, inspect the drilling area for optimal settings for the material being processed. How are they assigning feed and speed tables to the machines? I have yet to see file server software being used in China, such as that from FASTechnologies. This means that the operator is responsible for entering in feeds and speeds based on the type of material—super scary. On more than one occasion I've picked up a traveler and asked them to show me the machine settings, only to find out they don't match the F&S tables for the given material. Other times, the machine settings require something to be calculated or converted from their standard F&S tables, but there's no calculator to be found in the department. They really expect operators to do this sort of math in their head—or are they just assigning round numbers that are close? All of these are opportunities for failure, but I've yet to be presented with a bad cross section…very sneaky. Table I shows some of the failures caused by poor drilling and the effects.

Figure 3: Video of an automatic re-pointing machine.

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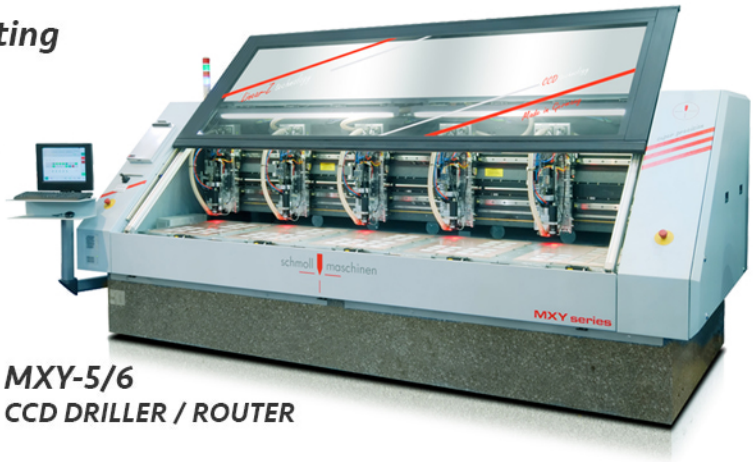

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Plating

Referring again to the article I previously referenced, you can check the list of critical items for plating against their actual hardware (dual rectification, agitation, vibration, computer controls, etc.) and you will find that most shops in China actually meet the criteria. However, if you see a bunch of manual hand lines, run. Table II outlines some basics for the copper plating line.

Failure Mode	Effect
Rough hole wall	Rough plating/blown vias
Nailheading of innerlayers	Broken innerlayer interconnects after thermal exposure
Impacted drill debris	Hole-wall pull-away
Excess smear across interconnects	Long-term reliability of via connection decreased
Pink ring/delamination	Interconnect separations

Table I: Failure Modes of Incorrect Parameters.

While you're in the department, ask for a plating thickness meter that measures plating inside the holes, then measure the corners and middle of a few panels. Hopefully you will find variation of 20% or less, which is a sign that not only do they have the right hardware, but they are maintaining the line properly.

A good line maintenance program for high reliability copper plating would include:

- Minimum annual full carbon treatment
- Minimum half year anode maintenance (dumping out of anodes, tossing small anodes, and installing clean filter bags)
- Variation testing
- Rectifier calibrations

If you start asking these questions and get blank stares, put on your gym shoes and take off, as those guys are ripe for an issue. Most commonly, you will find that they run their anodes until they turn to powder because it's seen as a waste of money to throw out anodes just because they are down to 1/2" diameter. However, anodes that are this small don't plate out

Action	Effect
Plate panels one high in the plating rack	Reduced variation via smaller anode area
28" Anode-to-anode distance	This is the optimal distance to ensure that the production panel area is adequately covered by anode area, without being so far as to reduce the effectiveness of the anodes
Water-submerged cathodes	Eliminates possibility of reduced contact due to oxidation of mating metal areas
Chemical-submerged anode bars	Eliminates possibility of reduced contact due to oxidation of mating metal areas
Mechanical agitation	Promotes chemistry flow through holes
Vibration	Helps to remove air from microvias and blind microvias
Dual-sided rectification	Delivers optimal amperage to each side of the production panel
Advanced rectification	Newer DC and reverse pulse rectifiers have more consistent energy flow
Reduced amps per sq. ft. (11–15 for DC plating)	Plating at reduced ASF for longer cycle time reduces plating variation

Table II: Key Parameters for Plating Quality.

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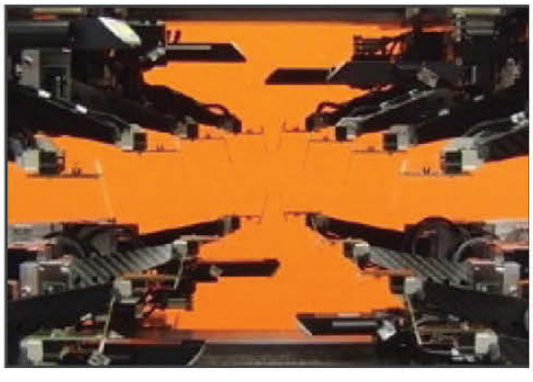

Test area:	610 mm x 620 mm (24.0” x 24.4”)
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Smallest pad / pitch :	35 µm (1.4 mil) / 80 µm (3.2mil)
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at the same rate as larger, newer anodes, which leaves spots that will have lower plating thickness.

Conclusion

At the end of the day, being an automotive PCB supplier can really help to fatten your top line. But it's important not to open yourself up to not only losing everything in your bottom line, or potentially your entire company, if the issue is large enough. Ensuring PCB reliablility is not an easy task, especially when your supplier is halfway around the world. This brings a huge importance to really making sure your suppliers are producing the quality that you need (not want) for you to be an automotive supplier. **PCB**

Yash Sutariya holds management positions at Saturn Electronics Corporation and Saturn Flex Systems Inc. To contact the author, click here.

PA STEM Students Learn about 3D Printer Technology by Building One

The best way to learn about 3D printer technology is to build a printer. That's the idea behind 3D Printer Summer Workshops conducted in Pittsburgh, Harrisburg and Allentown for students in the Pennsylvania Cyber Charter School STEM program. This is the third summer for the week-long 3D printer build workshops.

Joel Cilli runs the online school's STEM program and leads the workshops. He has created and posted a series of how-to videos to guide not only workshop participants, but anyone who undertakes to build Printrbot Play 3D printers from a kit.

"I made all the assembly videos at home over the summer and shared them via youtube," Cilli said. "My instructions are now linked on the manufacturer's website so that anyone in the world can follow along with the same build instructions we use in the workshop. I video recorded how to do the steps because still pictures just aren't clear enough," he said. During the workshops, "The videos play at the front of the room and the students follow the steps. We walk around to each person's desk to check their work and offer assistance."

Cilli said the Printrbot Play is an all-metal-body 3D printer that was released this summer.

Workshop students pay a discounted equipment fee of $200 for the kit and take it home with them – it's theirs.

"The 3D printer workshop is exclusive to students pursuing the STEM graduation certificate, so you have to join the larger STEM program to be invited," Cilli said. "The program exposes students to hands-on STEM opportunities where they meet peers from around the state with an interest in science and engineering."

Workshops were held at PA Cyber regional workshops in Allentown, Harrisburg and Wexford, near Pittsburgh. Staffer Karen Cummings assisted with the Harrisburg and Allentown workshops.

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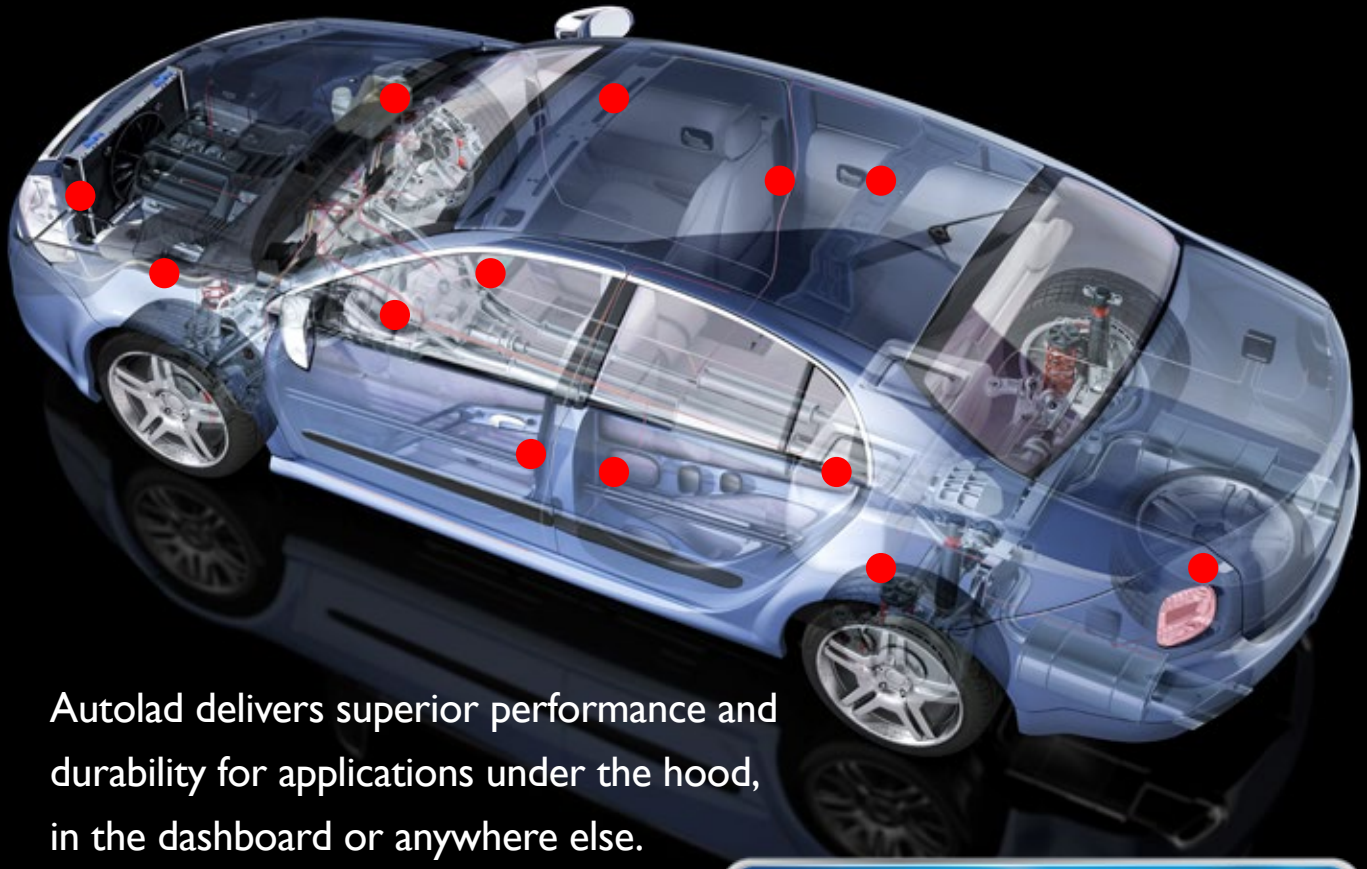

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Electronics Industry News
Market Highlights

Smart Home Devices and Systems to Top 7 Million Support Requests in 2015

A new report from Parks Associates finds that smart home devices will prompt over 7 million support requests this year, with adoption at 16% of U.S. broadband households and nearly 40% planning to buy a smart home product in the next 12 months. By 2019, the number of support requests will reach nearly 11 million.

A Small, Modular, Efficient Fusion Plant

It's an old joke that many fusion scientists have grown tired of hearing: Practical nuclear fusion power plants are just 30 years away — and always will be. But now, finally, the joke may no longer be true.

Connected Car Market Services to Reach $40B by 2020

New market research titled Connected Car Ecosystem: 2015-2030 - Opportunities, Challenges, Strategies & Forecasts presents market size forecasts for connected car services from 2015 through to 2030.

Consumers in Germany, UK Outline Technology Preferences for New Vehicles

As the rate of smartphone use in vehicles continues to grow rapidly in nearly every major market globally, vehicle manufacturers and suppliers are rushing to integrate and incorporate design and connectivity elements into new vehicles to address the market demand and desire among consumers.

Smart Robots Market to Hit $7.85B by 2020

According to a new market research report "Smart Robots Market by Component (Software, Hardware), Application (Collaborative Industrial Robots, Personal Service Robots, Professional Service Robots), by Geography (North America, Europe, APAC, RoW) - Analysis & Forecast to 2020", published by MarketsandMarkets, the total Smart Robots Market is expected to reach USD 7.85 Billion by 2020, at an estimated CAGR of 19.22% between 2015 and 2020.

N.A. PCB Business Rebounded in June; Shipments Up 4%

IPC announced the June findings from its monthly North American PCB Statistical Program. Sales and orders were up and the book-to-bill ratio strengthened to 1.06. Total N.A. PCB shipments increased 4.0% in June 2015 from June 2014, improving year-to-date shipment growth to -0.%. Compared to the previous month, PCB shipments were up 18.7%.

Automobile Sector Drives Global Smart Sensors Market

The Global Smart Sensors Market is expected to reach US$9.22 billion in 2018, growing at a CAGR of 11.53% from the period 2014-2020. The growth of the market is fueled by increasing adoption in automobile sector. It has been emerged as one of the top contributor in the overall market size due to increase in the number of vehicles by emerging economies.

Worldwide Smartphone Market Posts 11.6% YoY Growth in Q2

According to the latest preliminary release from the International Data Corporation (IDC) Worldwide Quarterly Mobile Phone Tracker, vendors shipped a total of 337.2 million smartphones worldwide in the second quarter of 2015 (2Q15), up 11.6% from the 302.1 million units in 2Q14. The 2Q15 shipment volume represents the second highest quarterly total on record. Following an above average first quarter (1Q15), smartphone shipments were still able to remain slightly above the previous quarter thanks to robust growth in many emerging markets.

U.S. Department of Labor Proposes New Wage and Overtime Regulations

On June 30, the Department of Labor (DOL) proposed new wage and overtime regulations under the Fair Labor Standards Act (FLSA) and is seeking comments by September 4, 2015. DOL proposes to raise the salary threshold for an employee to be exempt from minimum wage and overtime pay to be equal to the 40th percentile of earnings for all full-time salaried workers in the U.S.

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SWITCHING GEARS

How to Handle Short Development Cycles

by Davian Larente
MARQUARDT SWITCHES AUTOMOTIVE GROUP

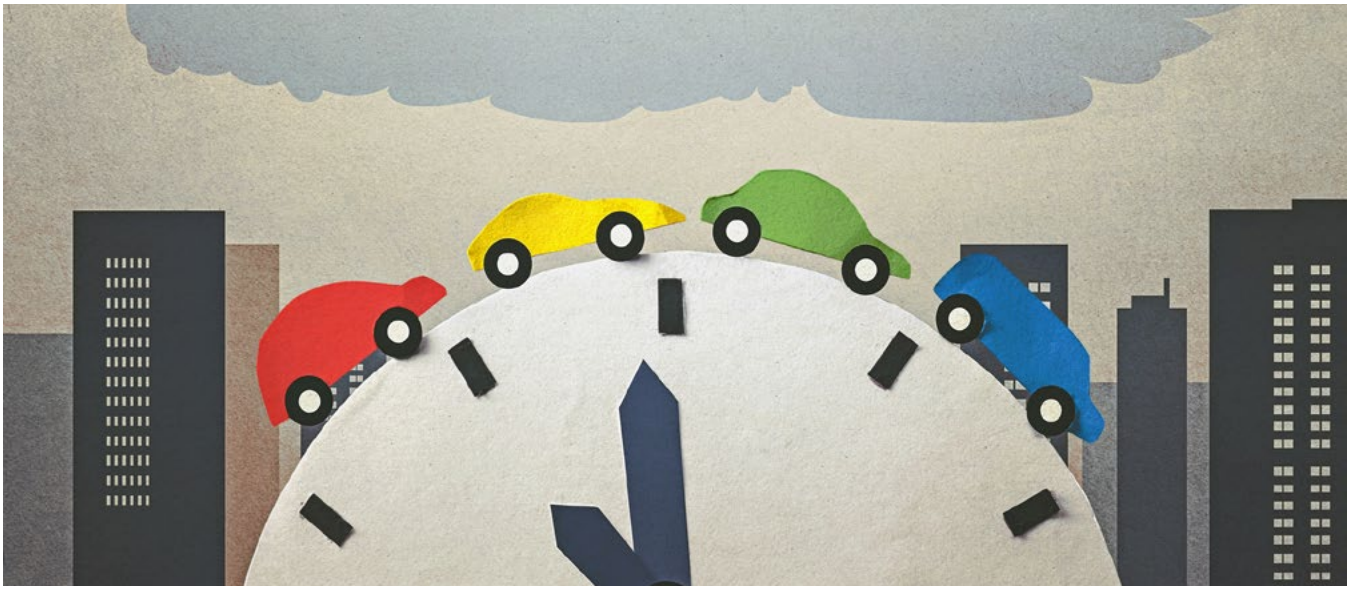
I have always wanted to write and share my experiences with others, and now I have been fortunate enough to have a friend introduce me to this opportunity. I hope that it will help you be successful. Without all the great people I have worked with, I would not be in a career that I enjoy every day. My first few columns will focus on the challenges of short development cycles in the automotive industry. In this first column, I will introduce three concepts: developing relationships, delegating, and stopping mistakes, which can all help you survive the issues in short development cycles. Future columns will expand in detail on these three concepts and illustrate how to specifically realize the improvements.

Automotive is a segment that any market can learn from. In past years, we had a saying: "You can have cheap, on-time or high quality; pick two." Going back five years, this was the response to short development cycles. In looking at the last two years, however, we have the reality of the short development cycle. Mix this with the recent recalls and safety issues, and it is now an unwritten requirement to deliver low cost, high quality and on time. It is not uncommon to go from idea to series production in only 14 months.

As a senior engineering manager responsible for electrical, software and mechanical engineering, I have run into many topics that created challenges for my team. In the end, the solutions for the many challenges were relatively simple and carried over to all other projects. Interestingly, the most effective solutions did not have any technical relation to the challenge—it was simply a change in process or culture. My focus is keeping it simple. The most elegant solutions to problems are often the simplest ones.

Concept 1: Develop Relationships

As companies grow, with more resources being added, the supplier relationship is often forgotten. Mix in turnover in an organization and soon, the relationship your company has no longer includes people—just transactions. As your company grows, never forget who helped



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you get there. Keep track of what makes a good supplier and ensure your organization is aware of this. When turnover occurs, take the time to introduce new resources to your suppliers so that they understand how they helped you grow. Make clear you expect them to continue to build on the relationship. All too often, competitively bidding erodes relationships. After all, it is the environment that we live in. As a company, you must involve your suppliers in the challenges you have as well as the risk you are trying to avoid. There is a positive way to competitively bid so that everyone wins. Good suppliers will adapt to changing environments with you. Do not make the mistake of taking the lowest price and forget that you need to invest in building the relationship.

Additionally, make sure you understand what role each supplier plays in your project. If we look to PCBs, your production supplier is not the critical supplier. At this stage you are sourcing something developed to a company that specializes in this. In design, your critical supplier is your prototype supplier. A good prototype supplier is essentially a team member. They help you to produce a solid design by working directly with your engineering resources. They can help you design in a way that avoids problems in production.

Concept 2: Delegate, Delegate, Delegate

Before we go further, write down the word "delegate" a fourth time and hang this paper at your desk—it is that important. Engineers, by nature, want to be involved in every aspect of their design. It is built into an engineer's DNA to want to do everything himself. However, short development cycles do not allow this. Take, for example, the person who starts a business on his own. To grow, he must step out of what he loves to do and delegate tasks that allow him to focus on bigger topics—like growing the business. Engineers have the same situation: To develop more advanced products, they must delegate and focus on a higher level. Engineering schools do not teach this critical way of thinking. For the most part this is a new idea in engineering and still carries the stigma of "my job is going away."

Note: Delegation is really a paradox. For example, I delegate what I am effective at, but in turn, I use the experience to create new things to be effective at. This idea can be explored by looking at the concept of globalization. The book The World is Flat by Thomas L. Friedman provides a good history lesson on how engineering evolved to what it is today.

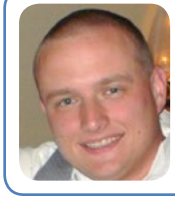
Concept 3: Stop Learning from Mistakes

Mistakes are how we learn, or so goes the cliché. In automotive, however, OEMs expect suppliers to not make mistakes. After all, they took the time to architect the system and source a piece of that business. There is an expectation that you can deliver. The typical 14-month development cycle seen on many components of the automobile does not allow you time to learn. Mistakes can be disastrous to a successful launch and potentially cost you the next opportunity.

To avoid mistakes, strategies must be developed. Do not assume that your engineering team can do it independently, project to project. As with any strategy, it can only be successful with the right people. Companies have to evaluate the team continuously and identify who can coach, who can provide lessons learned and who can be trained. There are many more things to look for, but to say it simply, you must be evaluating your people and developing a strategy to utilize those people in order to avoid mistakes.

In the news recently there was a story about an OEM recalling vehicles. In some cases, the issue resulted in loss of life. As vehicles become more complex, the opportunity for system failure increases. Engineers have a higher level of accountability than ever before.

By focusing on developing relationships, delegation and avoidance of mistakes, you can make your next project a success and improve the current one. Be open-minded and analyze your situation without bias. Simple changes that are implemented as culture will ensure your success in the environment we operate in today. **PCB**



Davian Larente is a senior engineering manager with the Automotive Products Group at Marquardt Switches Inc.

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PCB007 Supplier/New Product Highlights

PhiChem Appoints Gene Weiner Chairman of Advisory Board

PhiChem Corporation, parent company of PhiChem America, Inc., announced the appointment of Gene Weiner, President of Weiner International Associates as Chairman of its Advisory Board, effective immediately. PhiChem Corporation is one of the world's leading suppliers of UV curable optical fiber coating materials.

Cadence Posts Q2 Revenue Jump, Launches Stock Repurchase Program

Cadence reported second quarter 2015 revenue of $416 million, compared to revenue of $379 million reported for the same period in 2014. On a GAAP basis, Cadence recognized net income of $58 million, or $0.19 per share on a diluted basis, in the second quarter of 2015, compared to net income of $23 million, or $0.08 per share on a diluted basis, for the same period in 2014.

Taiyo Announces New Director & COO at Taiyo America, Inc. Facility in Nevada

Taiyo America, Inc. announced that the company has promoted Tadahiko Hanada to Director & COO, effective July 1, 2015. Mr. Hanada earned a B.S. degree in physics from Kyoto University in Japan and started his career as a researcher of fiber optic devices at NEC Corporation in 1991.

U.S. Circuit Installs Second Maskless Direct Digital Imaging Machine

U.S. Circuit, a printed circuit board manufacturer based in Escondido, California, has installed a second Maskless direct digital imaging machine. The MLI-5800 is the newest and most advanced digital direct imaging machine from Maskless Technology and utilized their UV LED light source.

IEC Enters Sales and Service Partnership with Tritek

IEC is pleased to announce the addition of Tritek Circuit Products (Tritek) as Sales Agents to IEC's North American customers. Tritek will provide sales and service to customers in the Southern California and Texas markets. Tritek Circuit Products is a full service distributor to the PCB fabrication industry and provides a full complement of products and services.

Plasma Etch, Inc. Releases New Technical Details About the World's First Plasma Etching System Requiring Mo CF4 Gas

Plasma Etch Inc, a leader in plasma innovation, has released new details about the workings of the Magna plasma etching system. The Magna series utilizes the newest technologies available, eliminating the need for CF4 gas, a harmful contributor to ozone layer depletion. CF4 gas is presently used by PCB manufacturers using plasma etching systems across the globe.

Fast Interconnect Introduces Test Engineering Services

Full turn-key provider Fast Interconnect recently announced the expansion of its services to include test engineering services. Increased test coverage and reduced test times are the key qualification tools for enabling the best production yield.

Polar Instruments: Si and Speedstack Projects Now Shipping

Polar Instruments is delighted to announce that Projects option is now available in Speedstack PCB, Speedstack Si, Si8000m and Si9000e layer stackup, impedance & insertion loss design tools. Projects allows groups of structures to be saved and recalled in Si8000m and Si9000e and entire stackups of structures to be pasted from Speedstack into Si8000m and Si9000e with just a few clicks of the mouse.

Liam lynch appointed as Sales & Customer Service Manager for Ventec UK

Ventec Europe is pleased to announce the appointment of Liam Lynch as Sales & Customer Service Manager for Ventec UK. Well-known and highly respected in the UK printed circuit community, Liam brings with him a wealth of industry experience.

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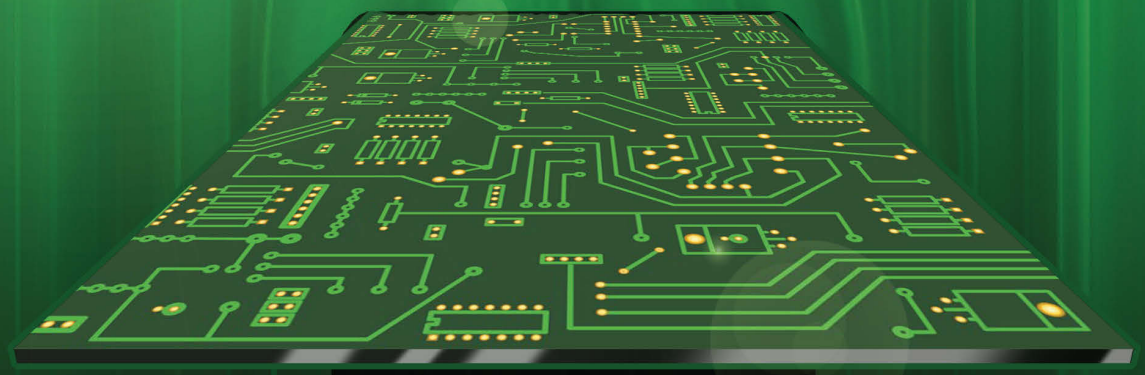

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Carmakers Now Embracing Plasma Treatment

Plasma treatment is an essential step in ensuring the cleanliness of a board to improve wettability and adhesion. Now, the growing complexity of automotive electronics is leading more carmakers to consider using plasma treatment to ensure greater reliability. Nordson MARCH's Jonathan Doan shares the benefits of the process along with some new information regarding the MES3 requirement with Publisher Barry Matties.

***Barry Matties:** Please start with an overview of Nordson MARCH, Jonathan.*

Jonathan Doan: Nordson MARCH makes plasma equipment primarily for the back end in terms of semiconductor applications and PCB manufacturing, medical applications, some automotive and mil/aero. Really, anything that requires plasma treatment for packaging or fabrication.

***Matties:** How do you fit into the automotive sector?*

Doan: What we're seeing with the automotive customers is an increase in automation requirements for processing their parts. We're seeing more of our equipment being used to plasma treat their parts in terms of improving the reliability.

***Matties:** How does plasma treating improve the reliability?*

Doan: What we offer is the ability to thoroughly clean the surface. A lot of times, when you do any type of cleaning of the surface, even if you use a chemical, for example, there's still some residue. It's microscopic, but that microscopic layer interferes with adhesion or any type of bond. What plasma treatment does is remove that microscopic layer. You get a very clean, smooth surface that helps with adhesion. At the same time, what we can also do is change the surface energy. That could improve properties previously incompatible to be more cooperative with each other.

That's really where the plasma treatment, in terms of usage, comes into play. You hear stories about electronics in automotives failing early, and that's where we're seeing a lot of customers, especially as some of the big providers of automotive electronics are seeing more

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CARMAKERS NOW EMBRACING PLASMA TREATMENT *continues*

of their components being used inside cars, with sensors, etc. We're seeing more of them go to plasma treatment. This is not only from a batch standpoint—where they were using our machines before—but now they're using an automated machine because they have the new MES3 requirement for automation and tracking to guarantee that if there are any problems from the consumer side later, they can backtrack and figure out exactly which lot and which device went through which process.

***Matties:** To see who's liable.*

Doan: That's right. It's all about liability in the end. That's one of the things they're pushing on us right now. One of the big guys out of Europe just recently sent us an MES3 spec saying, "If you can, we want five machines that meet this criteria," in terms of automation, but also recipe control, lot tracking, and all of that.

***Matties:** So with the head-in-pillow issue, that's obviously a big defect. Is this one of the steps someone would utilize to mitigate that?*

Doan: Yes, it's definitely one of the steps you would use to mitigate that, because for head-in-pillow it's a physical way for them to do the bond. If you have any type of layer in between when you have the physical contact, it will cause poor adhesion. By removing any of that unwanted material, you improve the bond.

***Matties:** Why wouldn't someone just do this as a matter of best practice to begin with? Is the machine very costly?*

Doan: The machine isn't very costly, but I think it's more in terms of looking at it from a longevity aspect. I think we've gotten so used to certain products having a certain lifetime and exchange rate that we don't really build them as reliably. A very good example—although I know it's outside of the automotive world—is from the old days, when we had VCRs. Originally, everything was hand soldered, everything was treated, and the reliability was very good. Then we went to an automated world where we're making them very cheaply, but the VCR, instead of lasting

Jonathan Doan, Nordson MARCH.

10 years, was lasting one to two years. It's a disposable thing now.

Now, with cars, the perception in the past was we would swap out a car every four to five years. That's where the mindset came in that we're only going to build a component to handle four or five years. As you see now, people are keeping cars up to 15 years or longer. They need the electronics lasting at least as long.

That's where companies are changing their mindset now. They can't build the way they used to. It's not really a cost factor, it's more of a mentality or shift in how they see where they need to manufacture. You have to look at a car as a commercial good. It's no longer a consumer-grade good; it has to be on the same level as, say, a military-based commercial good that's going to last some time. That's more or less how the end-user perceives it, too. When you're paying a certain amount of money, you want that feel of quality and durability, with minimal time taking it to the shop. That's where the change is coming in. The cost isn't really there. We have automotive customers that, for a long period of time, we didn't see plasma orders from. Suddenly, now we're seeing orders. It's really the shift in their mindset.

***Matties:** Is it something that the OEMs—the car producers themselves—are requiring in their specs?*

Doan: I think so, but I think it's also driven, as you were mentioning earlier, from a legality aspect. You're seeing huge lawsuits, especially with the airbag recall, for example. Even the manufacturer of the airbag doesn't really know the root cause. There's no tracking and such. If you look before that with Toyota and the gas pedal incident, there was not enough tracking to understand exactly where the failure occurred. What they want to do now is also being reinforced from the legal side that says, "If we're going to look at trying to find out the core of the problem, then we need to have better tracking from our component suppliers." I think the component suppliers are saying, "Okay, if we're making these electronics, we might as well be proactive and prepare ourselves. If it falls on us and we're the ones that have to figure out if we're the cause, it's better if we have all the capabilities and we manufacture for minimal failure."

***Matties:** Right, so it's to cover your ass and improve your quality. That's the mentality that we're seeing.*

Doan: Yes. It's not just on the automotive segment, either. I think it's most electronics.

***Matties:** Anything in the high-reliability area where there's catastrophic failure or consequence to catastrophic failure, like ignition switches or airbags, or jets falling out of the sky.*

Doan: I think that's the key. Now, all of the various safety boards in the world, as soon as there's any minimal issue, try to mitigate any dangers to the consumer or the person. A good example is Boeing with the battery issue and the minor smoke. They took it out of service completely because they don't want to put people at risk. It's a catastrophic thing that you don't want to have. It goes back to them having to look at the battery manufacturer. How did they build it? What kind of coatings did they use? Those are the types of things that, as a manufacturer, you have to look at how to better control your quality. Sometimes it's really the minute contaminants in between that you're not removing that cause the problems. That's where having some way to microscopically clean materials helps. I'm not against wet. I believe firmly in the use of wet chemicals, because wet chemicals are good for bulk removal. If you have something extremely thick and you need to clean it off, it's great, but it's not going to clean down to the microscopic level. Even the bulk chemical leaves residue. That's the downside.

***Matties:** Have you done any analysis with and without plasma on A and B products?*

Doan: Yes, we have done that. A good example is the packaging of a sensor. Usually, the typical packaging of a sensor is molded on. Using the example of a car, you have stages where the car is parked and it's relatively cool, then suddenly the temperature can easily escalate to

over 120°C. We've taken molded sensors and put them through a thermal cycle. What we noticed is, with plasma, after 5,000 thermal cycles, we didn't see any delamination or any failures within the mold. On the non-treated plasma samples, after 5,000, you already see the edges starting to delaminate. You see weaknesses in those areas. Let's imagine if you had 10,000 cycles—or even 50,000 cycles, depending upon how often your car goes from low temp to high—those sensors can easily fall apart and fail. If you have a failed sensor, you can have a problem with the car. These are the types of things that we look at.

***Matties:** So you have empirical data that justifies the expense or the process step. What's the cycle time in the plasma?*

Doan: Cycle time is fairly quick, depending upon what the customer is treating. That's the good part. If they're trying to do bulk removal, it may be longer. It can be as much as say, five minutes, or it could be as little as 10–20 seconds.

A lot of the treatments, in the case that you're talking about, with the head-in-pillow example, it's a 10-second process for most people to use plasma to treat. You send your part in for 10 seconds, you clear off the oxide and any contaminants, and then the part's ready to be treated.

> On the non-treated plasma samples, after 5,000, you already see the edges starting to delaminate. You see weaknesses in those areas. Let's imagine if you had 10,000 cycles–or even 50,000 cycles, depending upon how often your car goes from low temp to high–those sensors can easily fall apart and fail. If you have a failed sensor, you can have a problem with the car.

***Matties:** Because you have to start with a clean board, have a great stencil, bring in the right amount of paste, and so on. The idea is to eliminate every variable at each step, and that's what you guys are all about.*

Doan: Yes, that's our goal.

***Matties:** Anything that we didn't talk about that we should be sharing, or that someone should know about plasma?*

Doan: What we're doing now, beyond just doing surface cleaning and activation, is we're also using plasma to coat. This is from a finished product reliability standpoint. Let's say you have a finished board or a finished circuit. What we can do, instead of just using a traditional conformal coating—which is fairly thick—is use a plasma coating that's very thin, and then you can package this easily. It offers a nice resistance to humidity and water and such. It's minimal, it's not as thick as your traditional conformal coating, but at the same time it offers good enough protection for your package device.

***Matties:** Is this good enough for high-reliability automotive, or is it shelf life?*

Doan: It's more for shelf life. In automotive, I think you would still need a thicker coating. With this, it's thin and it's not scratch resistant—you can easily scratch it off. This is more to keep the shelf life and protect the circuit from any type of oxidation or any type of degradation. It's good for when you're manufacturing large parts and you're not shipping and packaging them instantly.

***Matties:** Because if we let them sit around, then contamination creeps back in.*

Doan: That's right, so that's what it's really there for.

***Matties:** Jonathan, it was nice talking to you today.*

Doan: It was good talking with you. **PCB**

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Final Surface Finishes for Automotive: No One-Size-Fits-All Solution

by Tara Dunn
OMNI PCB

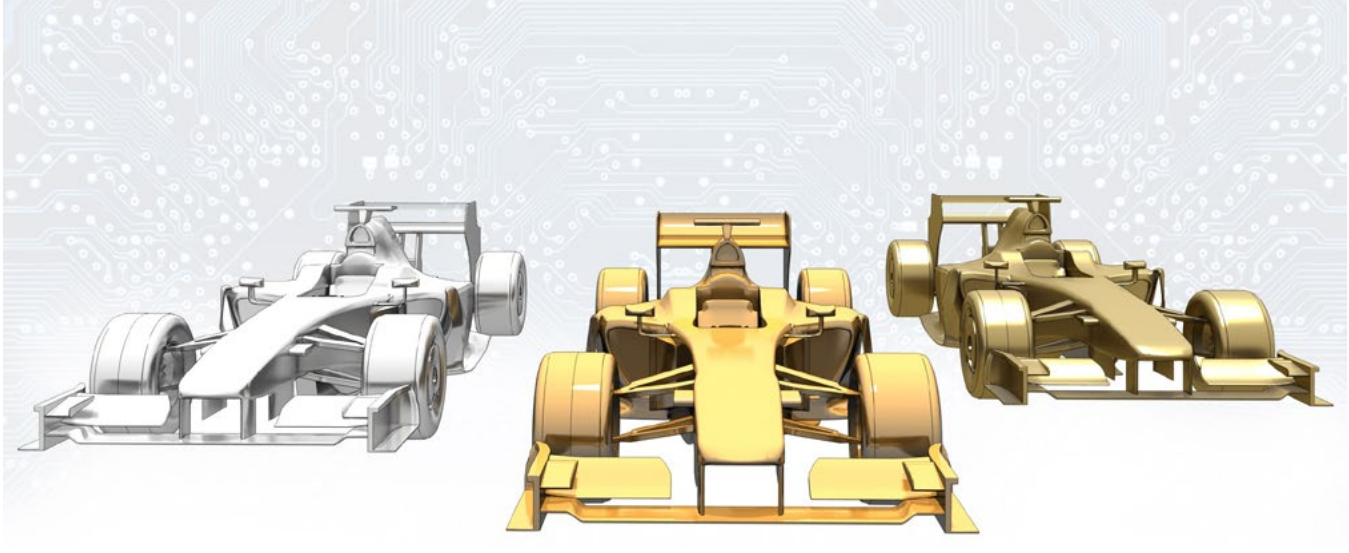
The predominant surface finishes being specified for automotive electronics—one of the fastest growing electronics market segments—are immersion silver, OSP, and immersion tin. Each is selected to meet critical application demands.

Remember the good ol' days when hot air solder leveling was the go-to surface finish for almost all applications? The decision about surface finish was an easy one. The primary function of the surface finish was to protect the copper from oxidation prior to assembly. Wow, have things changed! Today's expectations include: superior solderability, contact performance, wire bondability, corrosion and thermal resistance, extended end-use life, and of course, all at a low cost. Common surface finishes now include HASL, both leaded and lead-free, OSP, immersion tin, immersion silver, ENIG and ENEPIG. Unfortunately, there is no one-size-fits-all surface finish that fulfills all the requirements in the industry; the decision really depends on your specific application and design. With over 100 different PCBs in a typical vehicle and designs ranging from heavy copper, rigid boards to flexible circuits, automotive electronics clearly demonstrates the need to utilize multiple surface finish options.

Recently, Elizabeth Foradori and I sat down with OEM/Assembly Specialist Robyn Hanson of MacDermid Electronic Solutions to learn about the key considerations for final surface finish choice and the cautions of each from the OEM or assembly perspective. To listen to the discussion, click here. For a concise list of the pros and cons of each finish, click here. Following are some of the highlights.

Considerations for Surface Finish Choice: Does the application require lead or lead-free assembly? Will the end environment have extreme temperatures or humidity concerns? What shelf life is needed, and will it be months or years? Does the design have fine-pitch components? Is this an RF or high-frequency application? Will probeability be required for testing? Is thermal resistance or shock and drop resistance required?

Once these questions are answered, the surface finish options can be reviewed to find the best fit.



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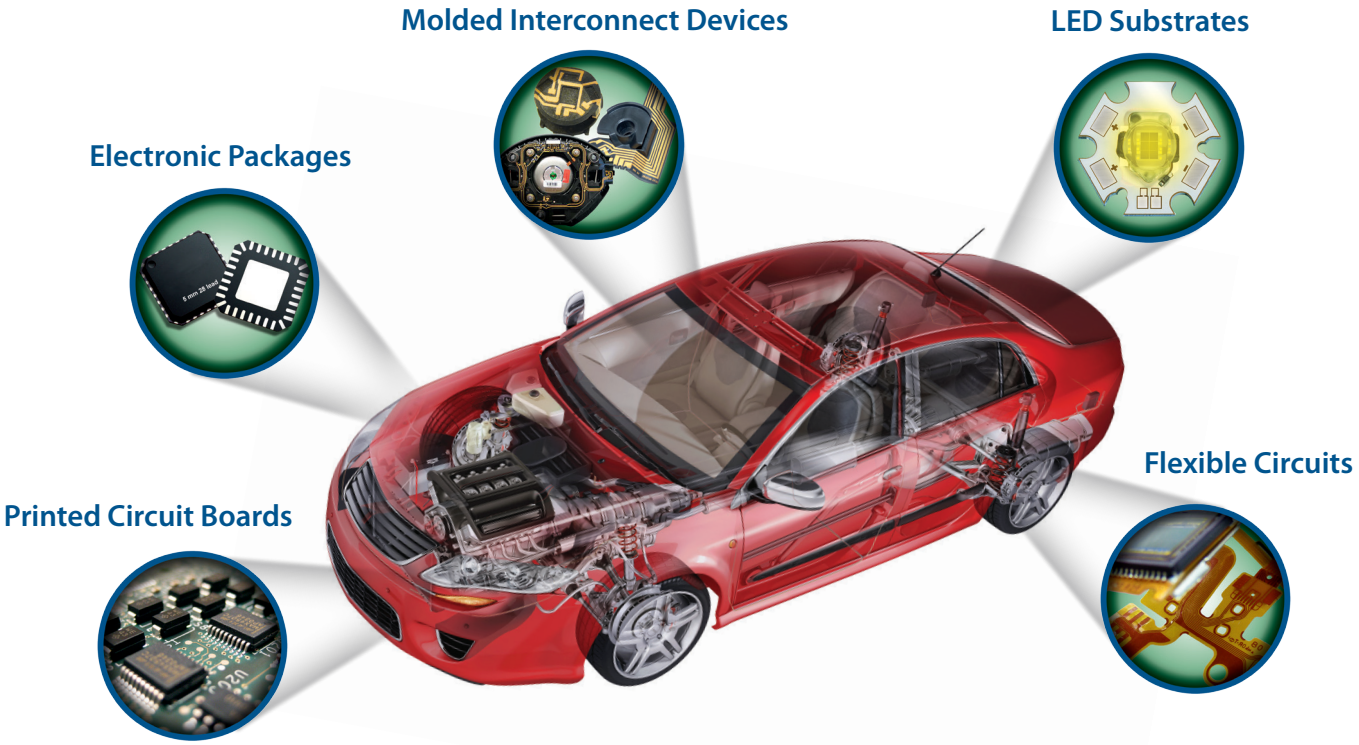

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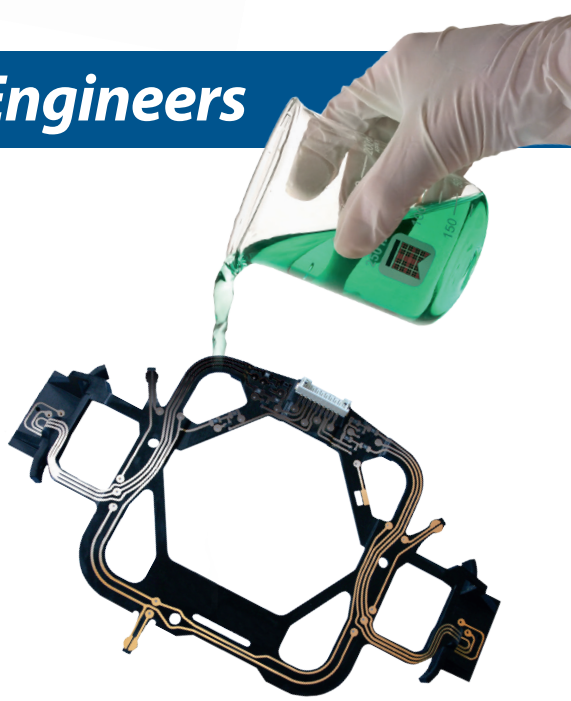

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Lenora Toscano
Director of OEM Applications Worldwide
lenora.toscano@macdermid.com

HASL—Hot Air Solder Leveling:

- The oldest surface finish
- Lead and lead-free versions are available
- Leaded HASL currently in limited use due to ROHS and WEEE initiatives
- Currently exempt: industrial vehicles, military, aerospace and defense, high performance electronics
- Leaded versions are harder to source
- Long shelf life
- Not suited for fine pitch

HASL is blown from the PCB surface to remove excess solder; this can create non-uniform coverage which makes component placement of tight pitch components difficult. The hot temperatures of lead-free HASL can cause warpage and soldermask embrittlement. The plated through-hole may be plugged or reduced.

OSP—Organic Solderability Preservative:

- Highest volume surface finish, worldwide
- Applications range from low-end to high-frequency server boards, also used in selective finishing
- Latest versions are copper selective and more thermally resistant for high-temperature, no-lead applications
- Applied through chemical absorption on the copper surface; no metal-to-metal displacement
- Inexpensive surface finish
- Limited shelf life

OSP does have implications at the assembly level. Older versions of this finish are not thermally resistant and couldn't resist more than one reflow. The coating hardens with reflow exposure and becomes more difficult to solder. Material transfers onto the probe tip (during electrical test) can result in false readings and will require more frequent probe maintenance or a special probe style. Higher OSP thicknesses are detrimental to solder paste flow and hole fill.

Immersion Tin:

- Applications are predominately automotive, U.S. military and aerospace
- Excellent for press-fit applications (i.e., large back panels)
- All contain anti-whiskering additives, but tin whisker elimination is not guaranteed
- Low cost, flat and suited for fine pitch
- Aggressive on soldermask

Cautions at the assembly level include the fact that pure tin thickness is lost to the copper intermetallic with time and temperature. Loss of pure tin will degrade solder performance. The first reflow exposure will dramatically reduce the pure tin thickness and deposit stress could result in tin whiskers. This is a naturally occurring characteristic of tin in direct contact with copper.

Immersion Silver:

- Greatest conductivity of all the surface finishes; well suited for high-frequency applications
- Applications range from low end to high-reliability product
- Topcoats have been formulated to overcome tarnish and corrosion issues in aggressive environments
- Flat, suited for fine pitch with excellent solderability
- Easily scratched, sliding connector limitations

The predominant issue seen at the OEM level is micro-voiding. Small voids occurring at the intermetallic layer of the solder joint could cause solder joint fracture. This defect manifests itself preferentially on solder mask defined pads which are more difficult to develop properly.

ENIG—Electroless Nickel Immersion Gold:

- Highest revenue surface finish
- Applications associated with high reliability
- Used often in the flex market
- Aluminum wire-bondable
- No degradation between reflow cycles, can be held mid-assembly for extended times
- New deposit thickness specifications for gold are under review to address the high cost of gold and hyper corrosion/black pad issues with extended dwell times for the gold

This chemistry requires tight process control. Proper plating conditions and control over the entire process are critical to performance. Proper chemical add-backs and numerous chemical analyses are required during start up and plating. Layer thickness is also critical. Low nickel thickness will result in poor corrosion and thermal resistance in end use. Low gold thickness will result in less resistance to thermal conditioning during assembly and high gold thickness can promote nickel corrosion or black pad. Too much or not enough metal area in the plating bath will affect plating performance.

ENEPIG—Electroless Nickel Electroless Palladium Immersion Gold:

- Gold and aluminum wire bonding
- Applications include medical and U.S. military
- Excellent solderability
- Mitigation of black pad
- Gaining interest and acceptance in the market

The primary caution at the assembly level is palladium thickness. Palladium that is too thick reduces the solderability performance. This will be slower to wet and have potentially palladium-rich areas in the solder joint. Palladium does not readily solubilize into the solder joint like silver or gold.

Surface Finish Breakdown by Market Sector:

- Automotive: Silver, OSP, immersion tin
- Data/Telecom: silver, OSP, ENIG
- High-end consumer: ENIG, silver, OSP
- Low-end consumer: HASL, OSP
- Aerospace, defense and high-performance electronics: HASL, immersion tin, ENIG, ENEPIG
- Medical: ENIG, ENEPIG, silver

Regardless of whether your application is automotive, medical or military, there are many factors to consider when selecting a final surface finish. Cost, lead or lead-free requirements, end environment, shelf life, fine-pitch components, RF applications, probe-ability, thermal resistance and shock and drop resistance, to name a few. There is not a one-size-fits-all finish. Understanding the advantages and disadvantages of each surface finish allows the designer to select the finish that best fits each particular application. **PCB**

Tara Dunn is the president of Omni PCB. She works with PCB designers and purchasing organizations to find the best fit solution based on volume, technology and lead-time requirements. Click here to reach Tara.

New Graphene-based Catalysts for the Energy Industry

Researchers at the Universitat Jaume I in Spain have developed materials based on graphene that can catalyse reactions for the conversion and storage of energy. The technology patented by the UJI combines graphene and organometallic compounds in a single material without altering the most interesting properties of graphene, such as its electrical conductivity.

The technology, developed by the Group of Organometallic Chemistry and Homogeneous Catalysis (QOMCAT) of the UJI, is of great interest to the energy industry and is part of the so-called "hydrogen economy." An alternative energetic model in which energy is stored as hydrogen. In this regard, the materials patented by the UJI allow catalysing reactions for obtaining hydrogen from alcohols and may also serve as storage systems of this gas.

The patented materials can be used both in the development of catalysts as well as storage batteries or other energy types.

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Highlights

RED Epic Dragon Camera Captures Riveting Images on Space Station

In October 2014 NASA delivered high-definition, 3-D footage of astronauts living and working on the International Space Station to the Internet, posting video of astronauts exploring water tension in microgravity. The same engineers have now delivered a new camera capable of recording images with six times more detail than either of the previous cameras.

NASA's Space Launch System Design 'Right on Track' for Journey to Mars

You know the feeling of pride and achievement when you've worked really hard on a term paper, and finally turn it in? That's how the critical design review team for NASA's Space Launch System is feeling this week as the program completed its review.

Agricultural Drones and Flexible Circuits

According to MIT Technology Review[1], one of the Top 10 breakthrough technologies last year was the agricultural drone. I focused on drones in one of my recent columns, Flexible Circuits and UAV Applications, which briefly mentioned agriculture as one of the uses for drones.

Could 'Windbots Someday Explore the Skies of Jupiter?

Among designers of robotic probes to explore the planets, there is certainly no shortage of clever ideas. There are concepts for robots that are propelled by waves in the sea. There are ideas for tumbleweed bots driven by wind, rolling across Antarctica or Mars. Recently a team of engineers at NASA's Jet Propulsion Laboratory wondered if a probe could be buoyant in the clouds of Earth or a distant gas giant planet, like Jupiter.

Airbus Defence and Space and Lockheed Martin to Upgrade German Navy P-3C Orion Fleet

Airbus Defence and Space together with its team partner Lockheed Martin Overseas Services Corporation (LMOSC) are to undertake a Mid-Life Upgrade (MLU)—re-winging—of the German Navy fleet of P-3C Orion maritime patrol and anti-submarine warfare aircraft.

Gary Ferrari Shares His Thoughts on PCB Design and More

Recently, I had a chance to talk with Gary Ferrari, the director of technical support at Firan Technology Group Corporation (FTG). Our conversation ranged from CID training to the need for reaching high school students as a way of introducing more young people to career opportunities in our industry. We also covered strategies for helping customers design and build better product, and keeping designers provided with the most critical part of their supply chain—information.

Latent Short Circuit Failure in High-Rel PCBs Due To Cleanliness of PCB Processes and Base Materials

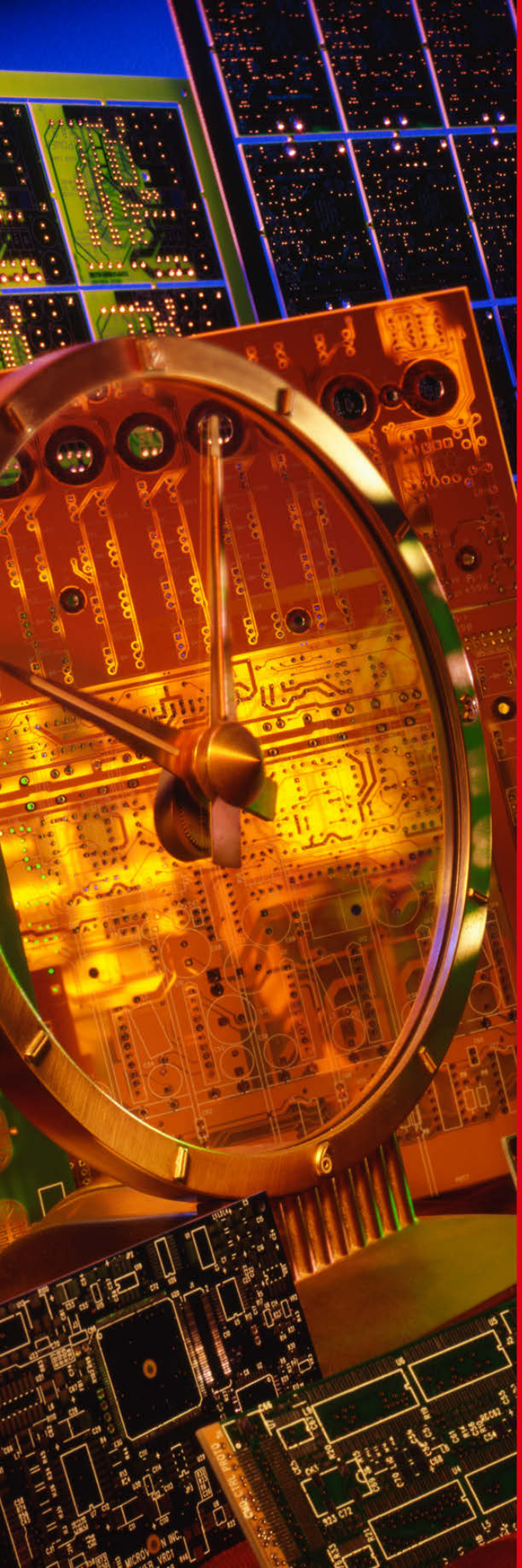
Latent short circuit failures have been observed during testing of PCBs for power distribution of spacecraft of the European Space Agency. Root cause analysis indicates that foreign fibers may have contaminated the PCB laminate. These fibers can provide a pathway for electromigration if they bridge the clearance between nets of different potential in the presence of humidity attracted by the hygroscopic laminate resin.

Boeing Salt Lake Team Trades Hand Tools for Robots

To help meet Commercial Airplanes increased production rates, Boeing Salt Lake employees are transforming the way they build and paint 787-9 horizontal stabilizers.

Future Army Nanosatellites to Empower Soldiers

One Army project is making the future of satellite communications more responsive to Soldiers' needs. The U.S. Army Space and Missile Defense Command/Army Forces Strategic Command's Nanosatellite Program, or SNaP, will be a small satellite communications, or SATCOM, constellation. This will allow communication across great distances using existing UHF tactical radios.



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The Impact of Automotive Trends on China's PCB Supply Chain

Since 2008, the automotive industry in China has been the largest in the world, as measured by automobile unit production[1]. Since 2009, annual production of automobiles in China exceeds that of the European Union and of the United States and Japan combined—and it keeps booming. China also leads with the localization rate of parts and components: 20 years ago, when cars were built in China, 95% of the parts were imported; now about 15% or parts are imported, with 85% made in China. Recently, I-Connect007 Editor Edy Yu spoke with Jack Dong, executive director at Shengyi Technology Co. Ltd., about PCBs in the automotive industry.

***Edy Yu:** How big is the current automobile market, locally and globally?*

Jack Dong: The automobile market is a continuously increasing market. Especially with the smart car concept, the automobile will become a new moving terminal. It will bring higher technology requirements than the smartphone. Currently, the global automobile market demand is 12 billion dollars and the Chinese market occupies around 35%. The whole global market is still increasing by 6–9% annually.

***Yu:** What are the challenges for the PCB fabricator in this market?*

Dong: The biggest challenge is how to seize the future automobile technology development trend and how to integrate the whole automotive supply chain. Then we can integrate the product design, raw material supply, manufacturing, and guaranteed quality.

We will establish a new technology corporative alliance for industries and products among the relevant downstream enterprises simultaneously. Intelligent automobile is the trend in the future automobile industry. However, 4G and 5G technology standards must be set in the communication industry. In addition, since many Internet companies and non-traditional automobile manufacturers are attempting to enter into the intelligent automobile industry, the relevant product and industry standards are disordered and inconsistent. All these defects result in the threat against the safety of automobile and cost of R&D and manufacturing.

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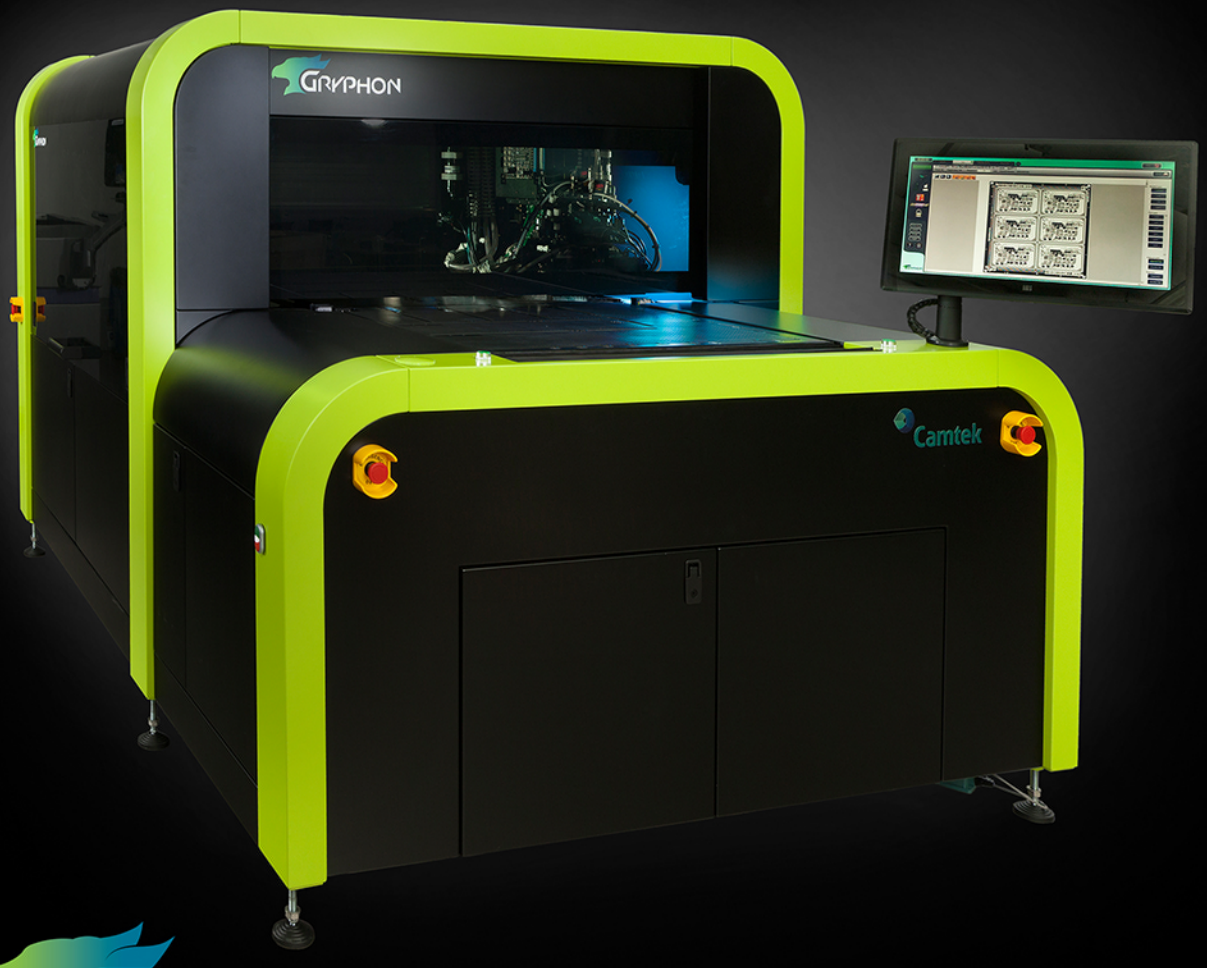

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See Beyond

Jack Dong, executive director, Shengyi Technology Co. Ltd.

Resource integration is very important for the traditional enterprises producing automobile electronic products. Nowadays, many enterprises attempt to enter into the automobile electronic products manufacturing industry. That said, they lack the knowledge of the relevant future needs for technology and products. In this regard, it is very dangerous to blindly invest and expand in this industry.

Thriving in a Global Auto Market

In the Industry 4.0 era, the global automotive electronics industry is experiencing rapid growth. As cars utilize increasingly more electronic systems, the "connected car" has become an industry hot topic in recent years.

As a result of the growth in automotive electronics and through years of persistent effort, Shengyi's automotive segment has now become a niche market of significant value. Moreover, high-reliability copper clad laminate (CCL), which is used in automotive electronics, is becoming one of the highlights of Shengyi's business.

The market for anti-CAF laminate, heavy copper laminate and radar board laminate favored by the automotive segment has been surging recently. Shengyi has abundant experience in anti-CAF, heavy copper and high-frequency applications. Recently, after S1000 lead-free compatible FR-4 became widely used in automotive electronics, Shengyi launched its second-generation high-reliability product—Autolad series for automotive electronic control units and radar board laminate for automotive 77G radar board.

Within the last few months, as Autolad became a hot topic at the Shanghai CPCA show, many well-known automotive customers like Bosch, Continental, TRW, and LEAR, among others, visited Shengyi to discuss potential partnerships. Most notably was Daimler-Benz, who visited the Shengyi Songshan Lake site with other car makers. They learned Shengyi's automotive customers were all impressed by the company's production process control, excellent on-site management and exclusive national R&D center ability.

Shengyi will continue to seek alliances with a variety of global automobile manufacturers and with the goal of becoming a leader in the automotive electronics market.

Can you imagine CAM to etch in 5 minutes? Meet Lunaris, the first fully digital inner layer printer based on inkjet technology.

Inner layer production methods haven't changed much in over forty years. The basic process has remained the same: use lots of interdependent equipment and chemistry to completely cover a panel with photo resist. Then, use some more interdependent equipment and chemistry to remove most of it!

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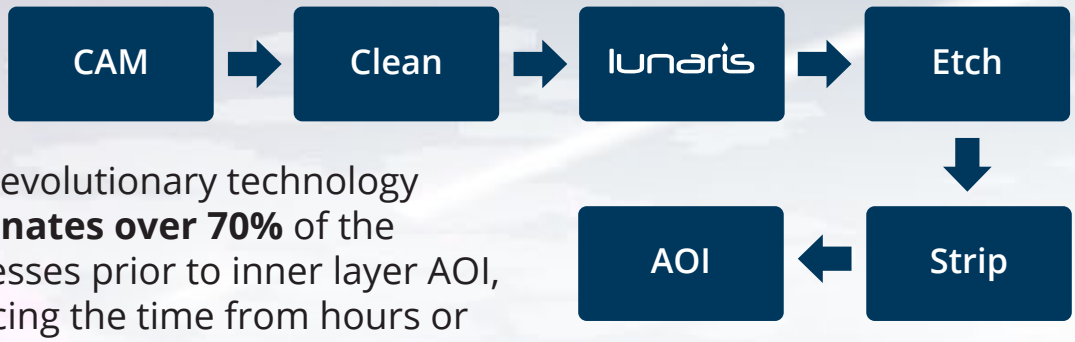

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Yu: What are the requirements for materials?

Dong: Different changes and developments in function. Laminate will be extended from anti-CAF and lower CTE products to HDI, heavy copper and RF/high-frequency raw material. At the same time, it requires much stricter manufacturing control in order to guarantee the automotive safety and high reliability.

In the future, automotive electronics materials will have higher requirements on the reliability of products. However, new technology standards adopted by various manufacturers are different. Automotive electronics materials are quite different from normal consumptive electronic products, because they involve the safety of the automobile and human beings. Therefore, with regard to certain safety standards, such as thermal stability, moisture-proof, anti-CAF, low loss, etc., automotive electronics products require different and higher standards. All these requirements on the product formulas of glass fiber yarn, fabric, copper foil and copper clad are new technology challenges. Moreover, for the time being, all the downstream enterprises need to invest more funds and technology to support and match up these new technology requirements.

Yu: What is Shengyi's focus in this market?

Dong: Shengyi Technology is one of the important global automotive electronics' raw material suppliers. Shengyi Technology will continue to take advantage of our National Engineering Research Center of Electronic Circuits Base Materials, cooperating and working with the well-known automobile end users and continue to be a reliable supplier for the global automotive electronics market. **PCB**

References

1. Wall Street Journal, "The Numbers," August, 2014.

Edy Yu is an editor with I-Connect007 and based in China.

Researchers Develop New Techniques for Creating High-Temp Alloys

A new grant seeking to develop new techniques for creating high-temperature materials is taking advantage of Duke University's expertise in computational materials genomics—the computer modeling of novel materials to identify which might have desirable properties.

Led by NC State University's Stefano Curatolo (pictured), the new initiative addresses fundamental scientific questions that could lead to so-called "entropy-stabilized alloys." The initiative also includes the University of Virginia and the University of California, San Diego, and is funded by a five-year, $8.4 million grant from the Office of Naval Research (ONR).

"The Defense Department has a need for materials that are mechanically and chemically stable at temperatures of 2000°C or more," says Don Brenner, Kobe Steel Distinguished Professor of Materials Science and Engineering at NC State and principal investigator under the ONR grant. "These materials can have significant aerospace applications, but the number of usable materials is currently small, and those materials rely on strong chemical bonding to remain stable. At high temperatures, most materials are simply no longer stable."

These alloys are of interest for use in ultra-high temperature applications because of their unique ability to "absorb" disorder in a material's crystalline structure that otherwise would lead to the breakdown of a material.

Work where you live! The I-Connect007 team is seeking an experienced sales person to generate and manage a revenue stream for content marketing campaigns in new e-publication series and supporting online ad campaigns within our online directories and publications.

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Qualifications:

Successful candidates will have experience with managing and cultivating leads, projecting, tracking and reporting revenue. We are looking for positive, high-energy candidates who works well in a self-managed, team-based, virtual environment.

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- Highly motivated and target driven with a proven track record for sales/meeting quotas
- Excellent selling, communication and negotiation skills
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- Create and deliver proposals tailored to the prospect's needs (strong writing skills mandatory!)
- Relationship management skills and openness to feedback
- Experience in the electronics industry desirable

Successful candidates should possess a BS/BA degree or equivalent and have experience with systems-based management/TQM philosophy. This is a base salary-plus-commission position. Compensation commensurate with experience.

Qualified candidates should submit resumes here.

I-Connect007
GOOD FOR THE INDUSTRY

Dry Film Photoresist Structure and Composition

by Karl Dietz
KARL DIETZ CONSULTING LLC

The three-layer structure of dry film photoresist (Figure 1) is quite familiar to those in the PCB industry, but the functions of the layers and the composition of the photosensitive layer are less understood.

A solution of the photoresist composition is coated onto the polyester support film, then dried, and covered with the polyethylene film before the dry film resist wide-stock roll is formed. The primary role of the polyethylene is to assure that adjacent laps of dry film don't stick to each other. Thickness uniformity of the polyethylene is important so that the photosensitive layer remains of uniform thickness. Gel spots in the polyethylene need to be avoided to assure that the photoresist has no localized thin spots that can lead to dish downs in print and etch processes or underplating in pattern plating. Catalysts and processing aids in the polyethylene may diffuse into the photoresist layer, potentially causing unintended interactions with resist components, especially the photoinitiator system.

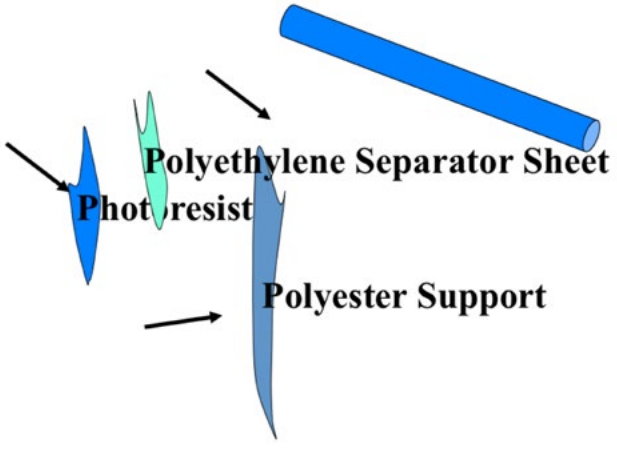

Figure 1: Three-layer structure of dry film photoresist.

The adhesion force between the polyethylene and the photosensitive layer needs, of course, to be lower than the cohesion forces within the resist and the adhesion force between the resist and the polyester base so that the polyethylene peels off cleanly before dry film lamination.

The polyester film serves several purposes. It is the base onto which the photosensitive layer is coated. It needs to be transparent in the exposure wavelength range of approximately 340–400 nm, which it is. The polyester has to have sufficient tack to the resist to stay in place during board handling in lamination and exposure to provide some protection against mechanical damage, but it needs to peel off cleanly before development.

The polyester also provides a barrier against oxygen diffusion into the resist layer. Oxygen is an inhibitor to radical polymerization. It scavenges the radicals formed by the photons before the radicals can initiate photopolymerization. Therefore, the oxygen dissolved in the resist needs to be consumed before the acrylate monomers can polymerize, and replenishment of the oxygen from the air needs to be blocked, which is one function of the polyester film.

The dry film polyester film and the phototool are often supplied with a matte surface[1]. This matte surface is typically created by small particles, partially embedded in the surface, to facilitate air escape during film roll formation and during vacuum draw-down in contact printing. Depending on the size at these particles, their proximity to the resist, and depending on the degree of collimation of the light source, these features will actually image. The imaging may be due to the opaqueness of the particle, or the difference between the refractive index of the particle and its surrounding media, or a small air gap between the two media, or a combina-

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SMTA, INEMI, MEPTEC and OregonBio have joined forces to again host this international conference, focusing on advances in electronic technologies and advanced manufacturing, specifically targeting medical and bioscience applications. Last year's conference attracted about 200 attendees and more than 30 exhibitors. Prior to last year, MEPTEC's and SMTA's conferences were held in Phoenix, Arizona and Milpitas, California, 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).

Marylhurst University, founded in 1893, is Oregon's oldest Catholic university, and the first liberal arts college for women established in the Northwest.

Multiple Track Topics Include:

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This track will focus on critical methods and protocols to ensure that the production of Class II and III medical electronics is conducted in the most effective, efficient and quality-controlled way with full traceability and zero defects.

Track 3:
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This track will focus on advances in next generation, revolutionary microelectronics for medical devices and applications that solve technology challenges and are aligned with solutions for new healthcare models.

KEYNOTES

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John A. Rogers, Ph.D.
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Medical & Healthcare: What are the Opportunities for MEMS and Sensors?

Benjamin Roussel
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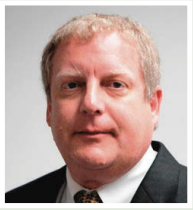
Design Challenges for Home Use Medical Devices



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DRY FILM PHOTORESIST STRUCTURE AND COMPOSITION *continues*

tion thereof. Figures 2a-c illustrate how surface particles of different sizes on polyester films image in a non-collimated printer: The imaged imperfections in the resist, pockmarks on the surface and a fluted sidewall shape, become less pronounced as the polyester surface becomes smoother. Laser direct imaging (LDI) could be considered an exposure with a highly collimated light source. Therefore, the imaging of matte particles on the polyester is an issue in LDI.

Figures 3a and 3b show the effect of collimation for a given polyester surface structure: Higher collimation gives a sharper picture of the particles. Not only are the matte particles in the polyester creating unwanted images, dirt will also image better, and matte features on the phototool surface can image. Even scratches on the backside of the phototool, further away from the resist, can image. Therefore, the introduction of highly collimated printers has to go hand in hand with improved handling and clean room standards.

The selection of the polyester film thickness is a compromise between processability, cost, and resolution requirement. The thinner the polyester film, the better the contact between the phototool and the resist layer, and the better the resolution. Thinner polyester is also less expensive, but very thin polyester film can lead to film wrinkling in the hot roll laminator. Typical polyester film thicknesses are in the range of 20–25 microns.

The composition of the photosensitive layer was covered in detail in References 2 and 3 and will be summarized briefly as follows:

Photoinitiator System

The simplest "system" is a single component photoinitiator, which is activated by the UV radiation, generates a radical, and initiates the chain polymerization. More often, a system of sensitizers and activators or co-initiators form the active radicals. Occasionally, chain transfer agents or hydrogen donors are part of the photoinitiator system. They form secondary radicals, which are better suited to initiate photopolymerization. Typical structures found as part of the initiator system are aromatic carbonyl compounds and hexaarylbisimidazoles (HABIs).

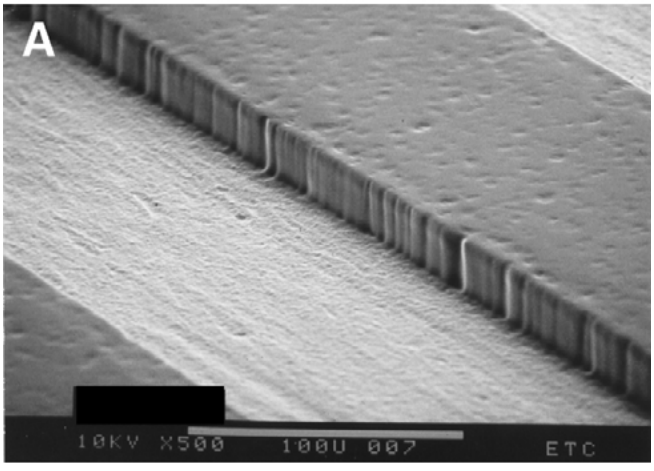

Figure 2a: Coversheet with coarse matte particles.

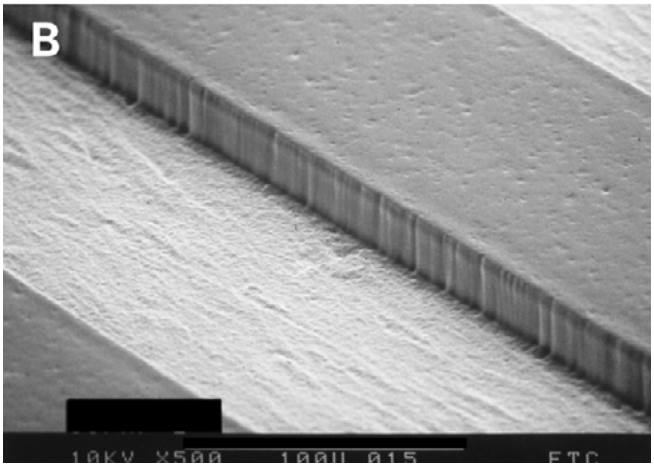

Figure 2b: Coversheet with small matte particles.

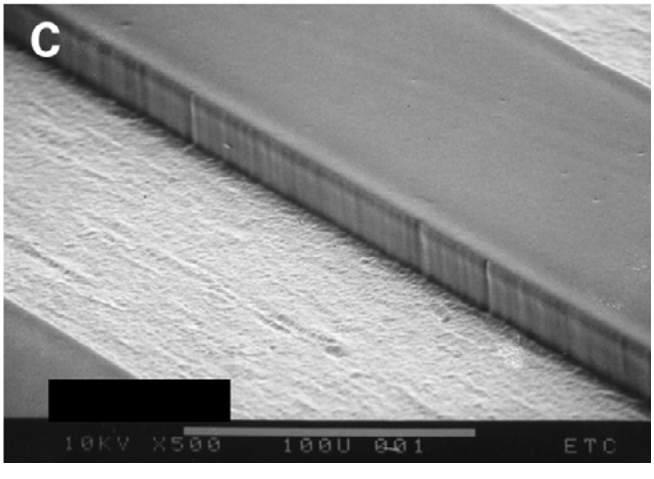

Figure 2c: Clear coversheet.

Monomers

Monomers contain at least one double bond to react with a free radical. Suitable monomers belong to the family of polyfunctional acrylates and methacrylates, often modified with alkoxy side chains. Their function is to polymerize upon exposure to form a highly crosslinked web, entangling the binder, so that the exposed area becomes less soluble in the developer solution and exhibits sufficient mechanical and chemical resistance to serve as an etch or plating resist. Monomer content in dry film formulations is typically less than 60%. If higher, the dry film's viscosity would be too low.

Binders

Binder content of dry films tends to be at least 25% to provide the dry consistency and dimensional stability needed. Chemically, the binder, or mixture of binders, is a matrix of polymers and copolymers derived from acrylates, methacrylates, styrenes and, occasionally, vinylacetates. Important binder characteristics that have an effect on end-use application properties (in parentheses) include: molecular weight and weight distribution (strip speed, tenting strength); glass transition temperature (film formation; cold flow resistance; conformation during hot roll lamination); flexibility and tensile strength (mechanical toughness; tenting strength); solubility (strip speed); chemical resistance (survival in plating baths; alkaline etch resistance); toxicity (industrial hygiene; biological waste treatment).

The binder has to have sufficient solubility in the coating solution to yield a homogeneous film without phase separations. This does not mean the absence of microstructures in the final dry film photoresist. Monomers with structural features chemically similar to the binder help solubilize the binder during dry film coating. Occasionally, we find solvent swellable "microgels" added to the formulation to control cold flow.

Stabilizers (Inhibitors)

Stabilizers to prevent premature thermally induced polymerization may be added to the formulation by the resist manufacturer or may already come as an additive with the monomers. The level of stabilizer is carefully chosen to achieve the desired stability without lowering the photospeed too much. Typical chemical structures include hydroquinones and nitroso dimers.

Plasticizers

Plasticizers may be added to modify the flexibility and hardness of the resist. This pertains mainly to the properties of the exposed resist: In the unexposed areas the high abundance of monomer plasticizes the resist, but the depletion of monomer during exposure, the polymerization and cross-linking embrittle the resist, causing it to chip and flake off. The addition of plasticizers counteracts

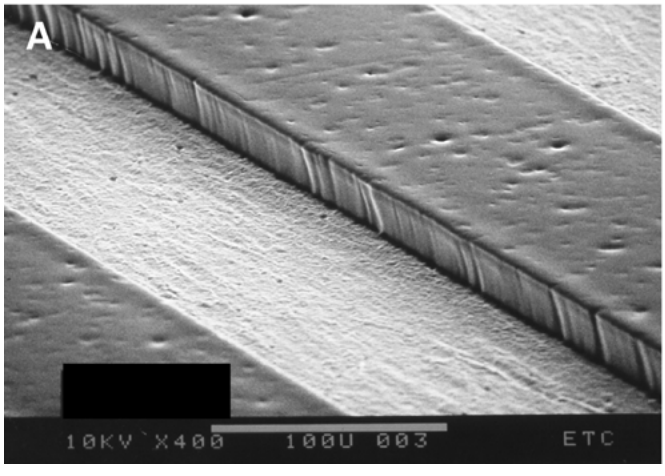

Figure 3a: Low collimation exposure.

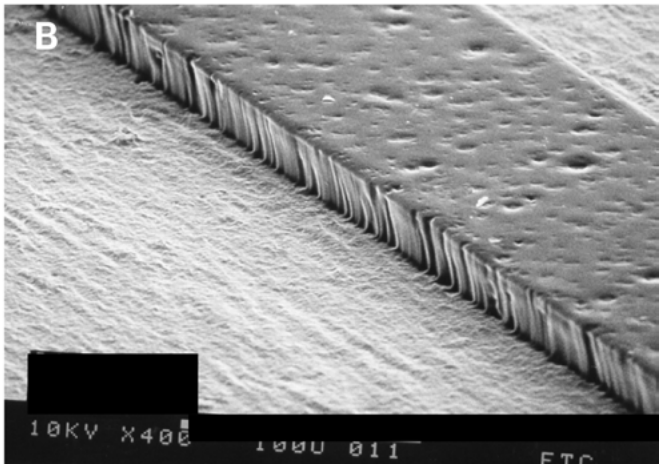

Figure 3b: High collimation exposure.

this undesirable performance. The plasticizers should be inert with regard to the photochemistry (i.e., they should not absorb in the region where sensitizers absorb or otherwise interfere with the photopolymerization). It is also desirable that the plasticizers have a low tendency to absorb water for improved storage stability. Plasticizers often belong to the family of phthalates or polyglycols. Polyglycols can also act as foam control agents in the developer and stripping chemistries.

Fillers

Fillers can be highly crosslinked polymer beads, or carbonates and silicates. They serve as tack modifiers at the resist surface and they may improve thermal shock performance in soldermask resists.

Coating Agents

To improve the quality of the coating or the coating speed, certain surfactants have been used successfully. These may be polyethyleneoxides, which can also act as plasticizers and foam control agents.

Adhesion Modifiers

Aromatic triazoles, thiazoles, and aliphatic imidazoles can be part of the resist formulation to tailor the chemical adhesion forces between the resist and the copper surface. These compounds tend to form copper complexes and are also often employed as antitarnishes to protect freshly cleaned copper surfaces from rapid reoxidation. With regard to the adhesion of the resist to the polyester coversheet (Mylar® tack), resist adjuvants have been in use to achieve the proper balance of tack: Too little adhesion to the polyester may cause premature coversheet release during lamination or during panel handling before development; too much polyester tack can cause resist to peel off with the coversheet.

Antihalation Agents

Radiation, which is not absorbed by the resist, can scatter or reflect off the substrate into non-exposure areas, blurring the image and limiting resolution. Such undesired polymerization in non-exposure areas was first observed with silver halide film in the form of halo ghost images, thus the name antihalation. Ideally, antihalation agents are applied as a layer between the resist and the backing support structure where they can absorb reflected radiation. However, in PWB imaging the resist touches the copper directly, and antihalation agents have to be mixed into the resist matrix. There, they are less effective and also lower the photospeed since they also absorb direct incident radiation.

Dyes, Pigments, and Dye Precursors

Color and color contrast are resist attributes that are only remotely related to its functionality. The blue dye that is typically added to the resist offers good contrast to the copper color to help in the visual inspection of developed boards. The conversion of a dye precursor to a dye during exposure creates a print-out image to visualize the latent image of the polymerization pattern. The print-out image is sometimes used to verify the registration of the image relative to registration holes. **PCB**

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2. Fine Lines in High Yields, Part XCIV: Dry Film Photoresist Components and Their Functions (Part A), Karl H. Dietz, CircuiTree Magazine, July 2003, pg. 48.

3. Fine Lines in High Yields, Part XCV: Dry Film Photoresist Components and Their Functions (Part B), Karl H. Dietz, CircuiTree Magazine, August 2003, pg. 40.

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2015 Programs

September 9–11
IPC India Pavilion at electronica India / productronica India 2015
New Delhi, India

September 15–17
PCB West
Santa Clara, CA, USA

September 26–October 1
IPC Fall Standards Development Committee Meetings
Rosemont, IL, USA
Co-located with SMTA International

September 28
IPC EMS Management Meeting
Rosemont, IL, USA

October 13
IPC Conference on Government Regulation
Essen, Germany
Discussion with international experts on regulatory issues

October 13–15
IPC Europe Forum: Innovation for Reliability
Essen, Germany
Practical applications for meeting reliability challenges like tin whiskers, with special focus on military aerospace and automotive sectors

October 26–27
IPC Technical Education
Minneapolis, MN, USA
Professional development courses for engineering staff and managers:
- DFX-Design For Excellence (DFM, DFA, DFR and more)
- Best Practices in Assembly
- Advanced PCB Troubleshooting
- SMT Problem Solving

October 28–30
IPC Flexible Circuits-HDI Conference
Minneapolis, MN, USA
Presentations will address Flex and HDI challenges in methodology, materials, and technology.

November 2–6
IPC EMS Program Management Training and Certification
Chicago, IL, USA

November 4
PCB Carolina 2015
Raleigh, NC, USA

November 10–13
productronica
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December 2–3
IPC Technical Education
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- DFX-Design For Excellence (DFM, DFA, DFR and more)
- Best Practices in Assembly
- Advanced PCB Troubleshooting
- SMT Problem Solving

December 2–4
International Printed Circuit and APEX South China Fair (HKPCA & IPC Show)
Shenzhen, China

December 7–11
IPC EMS Program Management Training & Certification
San Jose, CA, USA

IPC
Technical Education
Professional development for engineering staff and managers
October 26–27, Minneapolis, MN
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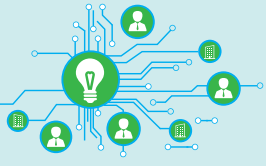

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Recent Highlights from PCB007

1 CS Show 2015 to Highlight the Latest in PCB/FPC Industry

Highlighting the latest developments and trends in this industry, the Shenzhen International Circuit Sourcing Show 2015 (CS Show) will be held in Hall 6 of Shenzhen Convention & Exhibition Center from August 25 to August 27. It is China's only trade show with PCB/FPC sourcing as its theme.

2 i3 Electronics Wins Medical Opportunity

i3 Electronics, Inc. (i3) announced that it has earned the opportunity from an industry leading medical OEM for the development and manufacture of advanced, flexible, circuitized substrates. The product is a flexible, LCP substrate that will be used in the neurostimulation market.

3 Keeping on Top of Laser Safety

With consumer electronics continuing to get thinner and packed with more functionality, laser processing systems have become a permanent part of the manufacturing landscape. Lasers are used to produce ever-smaller microvias in increasingly delicate flexible and rigid-flex circuits.

4 New Battlegrounds Emerge for Conductive Inks and Pastes

Core applications of PV and touch panels continue to grow demand, but new opportunities emerge in the form of wearable technology, circuit boards and structural electronics.

5 It's Only Common Sense: Marketing Makes Selling Superfluous

From Peter Drucker: The aim of marketing is to make selling superfluous. The aim of marketing is to know and understand the customer so well that the product or service fits her and sells itself. Ideally marketing should result in a customer who is ready to buy….the right motto for business management should increasingly be "from selling to marketing."

6 Is Wearable Technology Just a Fad?

It wasn't too long ago when every techno blogger was writing about the newest wearable technology, perhaps predicting the next technology avalanche that would rival smart phones. The granddaddy of wearable technology was Google Glasses, which apparently was leading the revolution. Analysts were predicting a mega industry upheaval. Then Google Glasses crashed and burned.

7 Supply Chain in the 21st Century

The shift away from vertical integration has pushed the topic of supply chain management to the forefront of strategic planning for many manufacturers. Having a supply chain that provides a competitive advantage will be the differentiator in today's business environment.

8 Taiwan: The Barometer for Consumer Electronics

The Tankan Survey is a popular economic survey of Japanese businesses issued by the central bank of Japan. The survey focuses on companies with a specified minimum amount of capital and is a valuable tool to determine market trends.

9 A Well-Designed Laminate Supply Chain has to Own It!

Designing a supply chain for the provision of laminates and pre-pregs to the PCB fabricator shouldn't be that complicated, should it? The laminate is simply manufactured and then shipped...what could possibly go wrong? It turns out it is more complicated, partly because the supply chain is not fully owned by one supplier, and hence cannot be fully customized to the needs of each customer.

10 Start-up Identifies Market Potential for Flexible Printed Electronics

EU funding has enabled Portuguese printed electronics start-up Ynvisible to fully assess the potential of applying flexible printed electronics to consumer objects. The six-month feasibility study completed at the beginning of August 2015 involved carrying out tests on the new platform – called PRINTOO – which enabled the company to better understand the needs of various end users.

EVENTS

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PCB West
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Medical Electronics Symposium 2015
September 16–17, 2015
Portland, Oregon, USA

IPC Fall Standards Meeting
(Co-located with SMTA International 2015)
September 26–October 1, 2015
Rosemont, Illinois, USA

SMTA International 2015
September 27–October 1, 2015
Rosemont, Illinois, USA

IPC Conference on Government Regulation
October 13, 2015
Essen, Germany

IPC Europe Forum: Innovation for Reliability
October 13–15, 2015
Essen, Germany

Long Island SMTA Expo and Technical Forum
October 14, 2015
Islandia, New York, USA

TPCA Show 2015
October 21–23, 2015
Taipei, Taiwan

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