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December 2014

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OUTLOOK FOR 2015

2015 Outlook for the PCB Industry: A Global Perspective

by Francesca Stern, page 12

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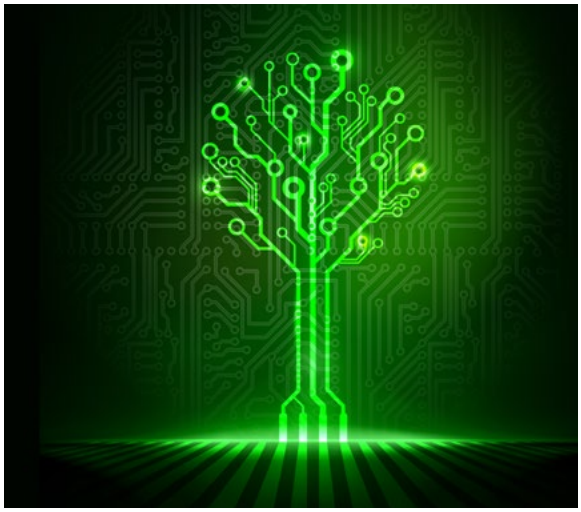
Outlook for 2015

This month, we're wrapping up the year with an eye on 2015: What's in store for the PCB fab industry, at home and abroad? Our industry experts have some definite ideas you don't want to miss!



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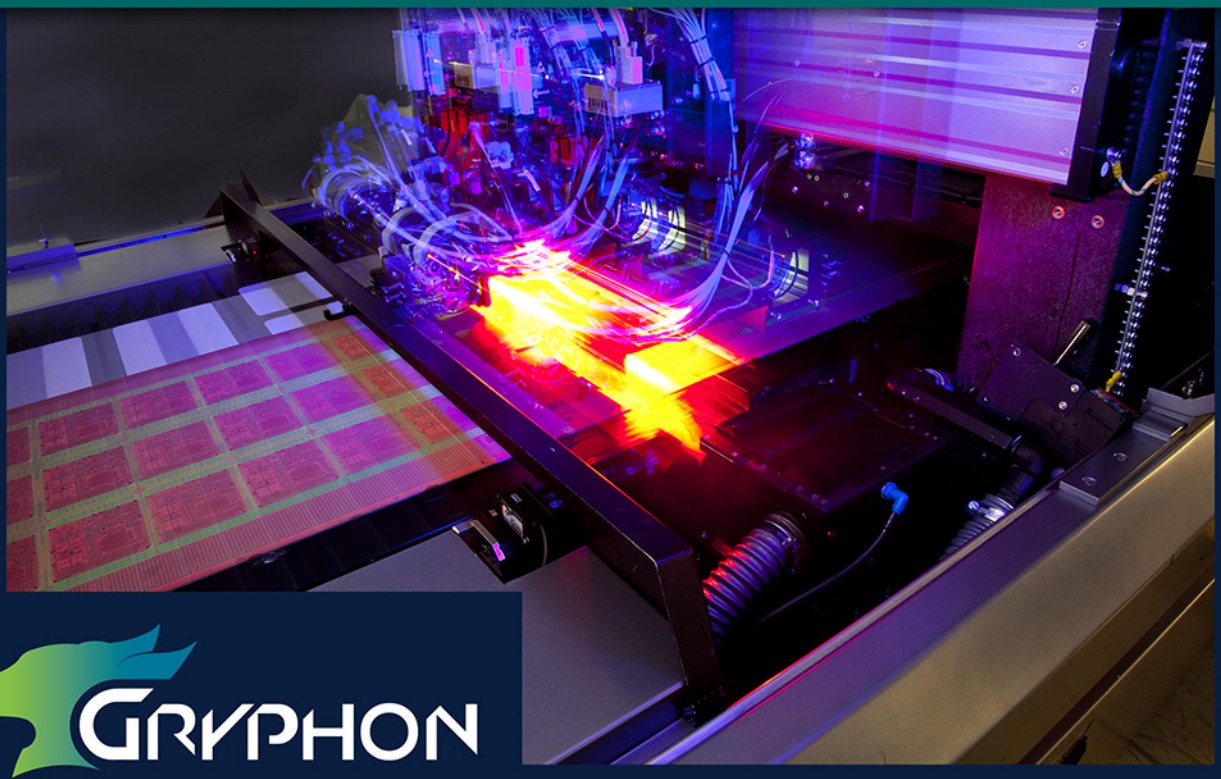

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OUTLOOK FOR 2015

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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

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THE WAY I SEE IT

Predictions

by Ray Rasmussen
I-CONNECT007

In October, the research firm Gartner issued a press release that made predictions for IT organizations. I wouldn't say I was surprised or shocked by the statements, but the implications of the forecasts intrigued me. When I first saw the release, I almost wanted to run it in the place of this column. Instead, I've pulled out a few of the more significant pieces and added my comments to each. The link to the press release appears below.

Before I go into the parts of their release I found most intriguing, I want to explain my role in all of this. I'm captivated by new, upcoming technologies and what's happening in emerging markets. There is an overwhelming amount of evidence that we are on the cusp of amazing change in technology, markets and even society. I see it as my job to share with you all the things I'm discovering. I certainly am no expert, but I see hundreds of news items and articles each week, which help me form a broad understanding of some of the changes coming our way. It's exciting to watch them evolve.

In our industry, the biggest problem I see is that most of the companies will likely be blindsided by what's coming. There's a lot to keep track of. You have to stay on top of all the latest technology, markets, regulations, etc., and still run your business successfully. Now, toss into that mix emerging technology, which could be game-changers for us all, and the continual emergence of competitors from around the globe and it's an almost impossible task to stay on top of everything.

As I was explaining recently to a top EMS exec, it's not the conventional technologies that are emerging in the traditional sense, providing incremental change (smaller, lighter, faster) that we have to pay attention to; it's the new technologies that have the capability to completely change everything that we must keep an eye on. And those game-changing technologies won't arrive in a politely linear fashion, allowing us to pick and choose which way we want to go. Instead, they will be disruptive and appear almost overnight, out of nowhere. Most of us will not see them coming. One day, the business model will change. If you're prepared, you can reap the benefits. And if not…

A couple of game-changers moving into our sectors are printed electronics and 3D printing. I have written about them extensively in this

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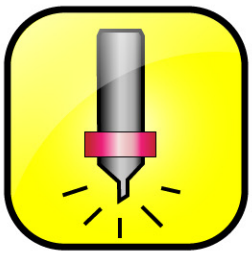

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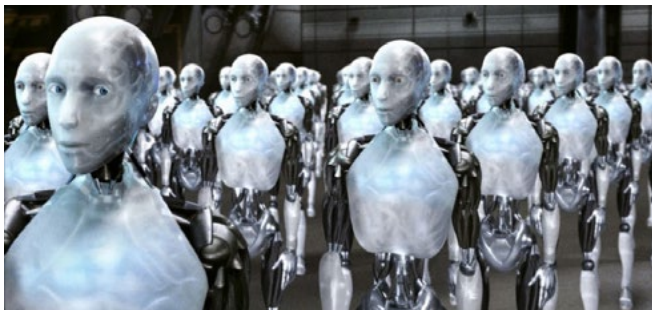
column and we have published dozens of technical articles on this subject in *The PCB Magazine* and *SMT Magazine*.

The way I see it, my job is to help you prepare for what's coming in these columns and in the news and articles we post to our sites and run in our digital magazines. If you're paying attention, at least somewhat, you will see the possibilities before most of your competitors do. There is real opportunity here for those companies led by managers who have their eyes open.

Here are snippets from the Gartner press release I mentioned earlier:

For some time now, there has been an ongoing shift in the roles machines play in our everyday lives," said Daryl Plummer, vice president, Distinguished Analyst and Gartner Fellow. "Compute-based machines are now being used to create an ever-expanding variety of experiences that extend human endeavors. Machines are taking on more human characteristics in order to affect a more personalized relationship with human beings and we find ourselves contemplating a near-term future of a world in which machines and humans are co-workers, and possibly even co-dependents.

How many of you have seen the movie "I, Robot" with Will Smith? Based on the famous collection of short stories by science fiction writer Isaac Asimov, it's a scary glimpse into our future. I'm sure most of you have heard of iRobot, the company building things like robotic vacuum cleaners, pool cleaners, robot-like video consoles for business and medical applications, and the remote systems used for the military to keep soldiers safe. Plummer's quote states the obvious, if you just look around.



I, Robot, 20th Century Fox.

These same types of automated systems, devices and interactions (Siri? Watson?) are all around us now, and will explode into every conceivable market in the coming decade. The proliferation and integration of robotics and automation into our lives is growing at an exponential rate. That's why we have to keep our eyes open: in the short term, it means lots of new business; in the mid term, it means struggling to keep up with the technological changes. And in the long term, it's a new paradigm. The timespan between short term and mid term should give those who are paying attention time to react. From mid- to long term will be the time when most companies try to react to the sea-change, but it will likely be too late.

Here are a few interesting "near-term flag" pieces from the Gartner press release, followed by my thoughts on each:

• *By 2018, the total cost of ownership for business operations will be reduced by 30% through smart machines and industrialized services.*

The first prediction is already happening big-time in our industry. We see more and more robotics companies exhibiting at shows. However, I haven't run into companies offering "industrialized services," sort of EMS for EMS, I guess, yet.

• *By 2015, there will be more than 40 vendors with commercially available managed services offerings leveraging smart machines and industrialized services.*

Consumers' need to get faster, cheaper, better products and services in a mode that supports any time, any place and any channel is fueling the digital business revolution. Business processes and the entire value chain of business operations will shift from a labor-driven and technology-enabled paradigm to a digital-driven and human-enabled model. Smart machines will not replace humans as people still need to steer the ship and are critical to interpreting digital outcomes. Thus, smart machines will not replace labor; rather they will displace the complacency, inefficiency and add tremendous velocity to business operations. With consumers' preference to use Internet and mobile services to drive business efficiencies and optimize

time management, every industry is striving to improve the customer experience by simplifying, automating and making more intelligent end-to-end processes, minimizing manual interventions and allowing the consumer to self-serve.

By 2020, developed world life expectancy will increase by 0.5 years due to widespread adoption of wireless health monitoring technology.

So five years from now, we're all expected to live (slightly) longer, healthier lives. The pace of this improvement will accelerate for some time as science and technology work to extend the ability of our bodies to last longer. That's good news for just about everyone. The technologies described here are just a very small piece of what's going on.

• By 2017, costs for diabetic care are reduced by 10% through the use of smartphones.

Wearable monitors hold huge promise. Today, a simple wristband can collect heartbeat, temperature and a number of environmental factors. Wireless heart monitoring patches, smart shirts and sensors in accessories promise more accuracy, choice and comfort to wearers. Transmission through wireless is straightforward. Data can be correlated against large cloud-based information repositories for sanctioned actions and through social networks for anecdotal advice. Gartner expects data from remote monitoring devices to provide continued access from patients to medical practitioners.

By 2017, nearly 20% of durable goods e-tailers will use 3D printing (3DP) to create personalized product offerings.

This next quote provides some numbers backing up what most have seen coming for the last couple years. 3D will offer personalization, building off of a traditionally manufactured core, but every year, more and more of the core product will be customized until the entire product is built on demand directly by the seller. Some products lend themselves to 3D technology better than others, like a metal airplane parts where you only need a few each month. But that will change. Every year, more and more complex structures will fall to 3D printing. It will change everything.

• By 2015, more than 90% of durable goods e-tailers will actively seek external partnerships to support the new, "personalized" product business models.

3DP is already having a profound impact on enabling startups to reduce infrastructure costs, compared with existing traditional manufacturing processes. As consumers increasingly show an appetite to control more product features and capabilities, e-tailers are recognizing the business potential of moving from "configurable" products to "personalized" made-to-order products enabled by 3DP. Almost every single durable goods category will see a surge in 3DP-enabled personalization and manufacturers will develop capabilities for bringing the consumer closer to the design experience. The companies that set the strategy early will end up defining the space within their categories. This requires a corporate culture that is supportive of nonconformance products, new front office "concierge" business capabilities, and back office IT and operations skills. It will require a new agility that goes beyond rigid process automation, and may require entirely new business systems.

There's much more in this Gartner press release. And I do realize that these guys aren't always right but there's just too much happening out there to believe at least some, if not all of their prognostications. That can't be too far off the mark.

The day after that Gartner release was published, the company issued another one listing the top 10 technology trends. There you can read about IoT, 3D printing, smart machines and more.

We'll continue to do our best to bring you as much information as we can going forward to help you stay on top of this revolution in technology. **PCB**

Ray Rasmussen is the publisher and chief editor for I-Connect007 Publications. He has worked in the industry since 1978 and is the former publisher and chief editor of *CircuiTree Magazine.* To read past columns, or to contact Rasmussen, click here.

2015 Outlook for the PCB Industry: A Global Perspective

by Francesca Stern
FRANCESCA STERN CONSULTING

The total value of global electronics production (excluding components) in 2013 was estimated at $1.5 trillion and the value of worldwide PCB production at $58 billion. In 2013 Asia (including Japan) accounted for 58% of worldwide electronics production, while Japan accounted for less than 5%, Europe (EU28) accounted for 15% and North America (USA and Canada) for 16.5% (Figure 1). Asia, however, accounts for around 90% of total PCB production worldwide, and China in particular with 44% global market share is therefore heavily dependent on the West for its export markets.

In today's global economy, it is not realistic to produce an outlook for one region without consideration of the other ones, as any one region may affect and/or be affected by the events and economies of the others. Western Europe has a mature PCB industry that focuses on small volumes and high value boards. The European PCB industry serves mainly the European markets, but it also exports high-end product to Asia and North America. The key markets served by European fabricators as a whole are industrial, instrumentation and control, medical, military, aerospace, space, and automotive. Unless the PCB is required to be made domestically (e.g., if it's military or it has specific technology or reliability requirements), the fabricators come

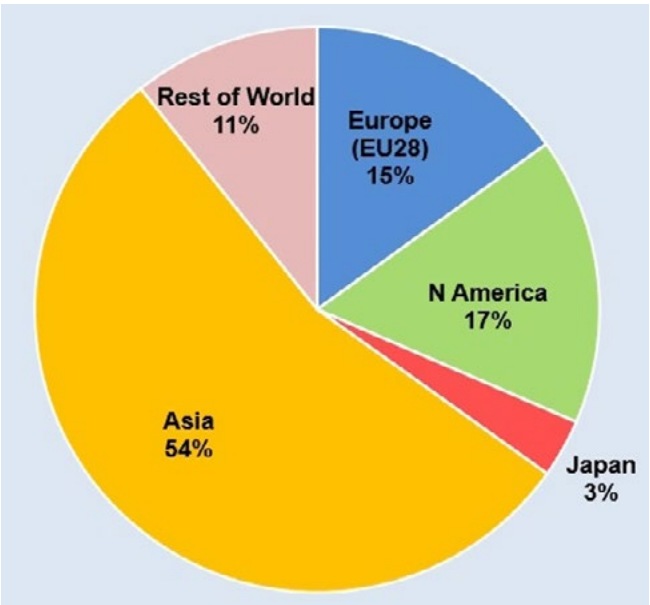


Figure 1: Worldwide electronics production in 2013: $1.5 trillion.

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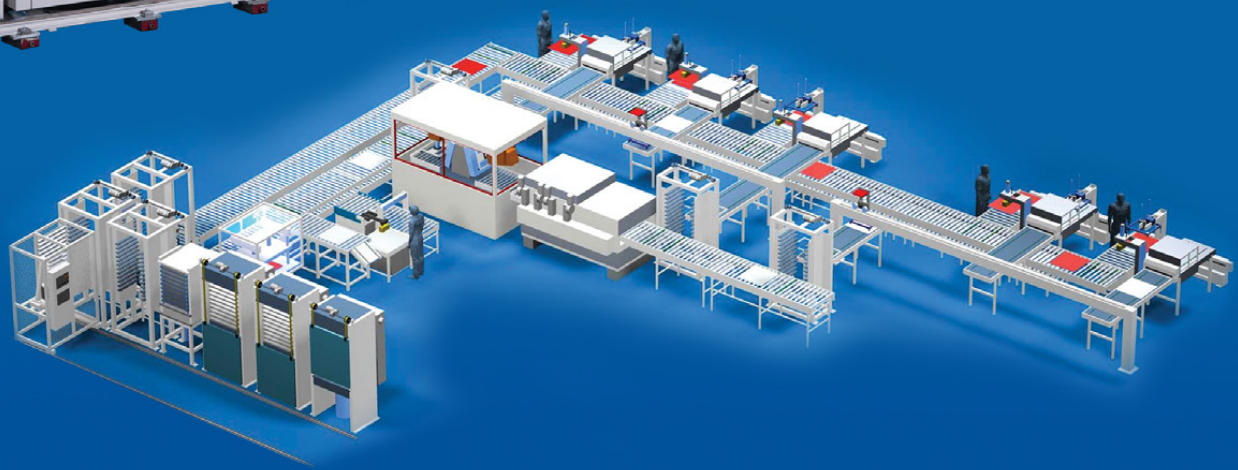

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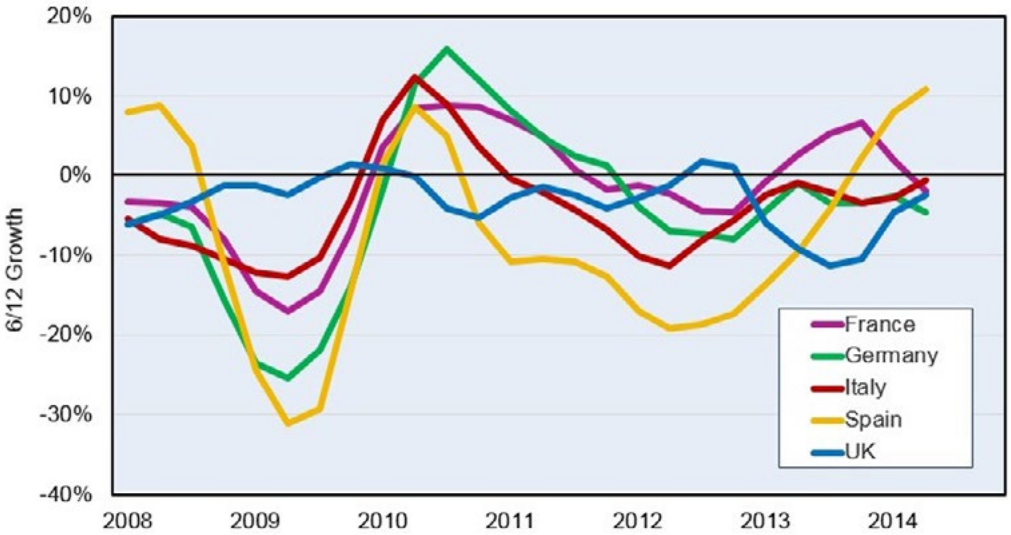

Figure 2: Electronics production growth, 6/12 comparison between France, Germany, Italy, Spain and the UK.

up against competition from lower-priced Asia suppliers. In the automotive segment, although electronics manufacturing remains in Europe, it has become increasingly hard for the fabricators to compete with Asian prices, and therefore all low-end PCBs are imported with only the high-end and prototype production remaining. One solution for fabricators supplying to this market is to take a partner if they do not already own an offshore facility.

The outlook for the European PCB industry therefore depends on the health of the European economy, the health of those OEMs that make up their key markets, and whatever value-added and technological advantages the European fabricator can offer to offset against the offshore competition. We start by looking at the current status of electronics production in Europe (which represents the market for both European fabricators and those outside the region). Of total electronics production in Europe, estimated at $223 billion in 2013, the five major economies of France, Germany, Italy, Spain and UK account for approximately 60% (Germany accounts for 33%). Of the Eastern economies, the largest, the Czech Republic, Slovak Republic, Hungary and Poland account for approximately 20%. The 6/12 growth curves of Figure 2 represent the electronics production trends in Western Europe (i.e., France, Germany, Italy, Spain and the UK). These show an initial growth surge in Europe at the beginning of 2014, but this was not sustained. Figure 3 shows electronics production growth in the Eastern European countries: Czech Republic, Slovak Republic, Hungary and Poland. The growth curves are based on data from the national statistics offices.

Note: The 6/12 curves are generated by averaging the production output values over a six-month period and dividing this by the average value for the six-month period one year preceding. Each point of the curve is centred in the six-month period. This has the advantage of smoothing out the monthly and seasonal variations although the most recent point is always three months in arrears. All points below the 0% line correspond to negative growth compared to the point one year earlier. Depending on the data made available by the various statistics offices, these 6/12 growth curves are based on a computer, electronics and optoelectronics production value data series or on the composite date for computer, communications, instrumentation and consumer electronics production value.

As can be seen from Figures 2 and 3, the most recent points on the curves show negative growth in most of these countries. The excep-

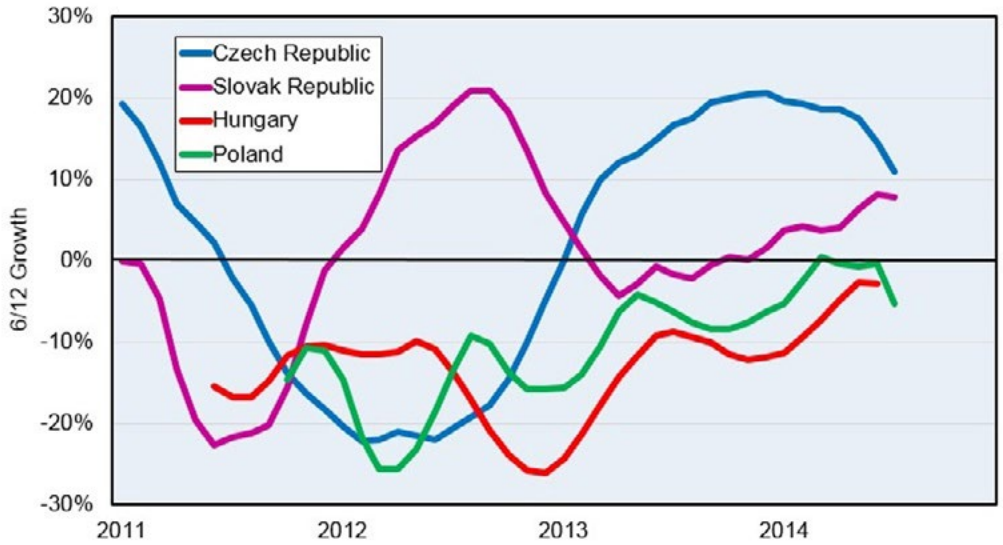

Figure 3: Electronics production growth, 6/12 Eastern Europe.

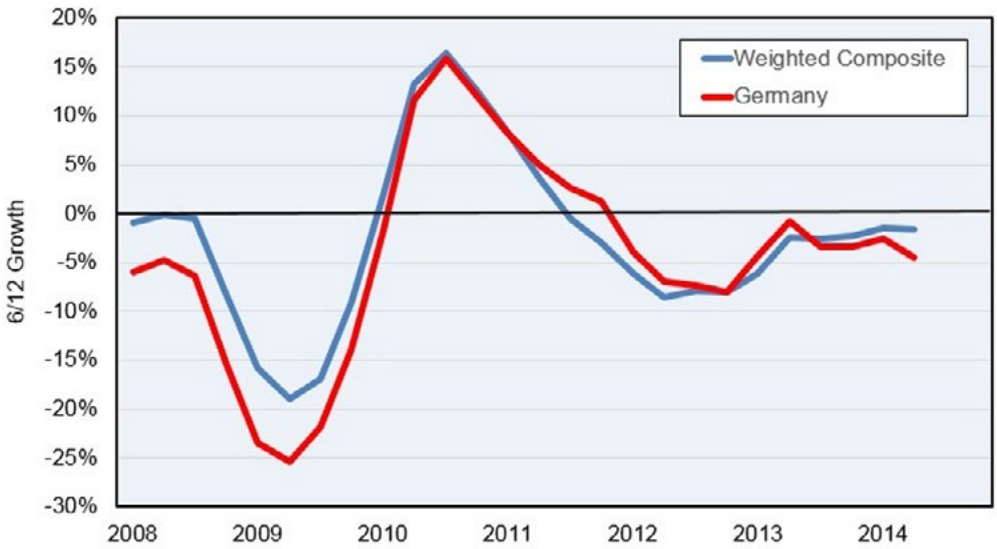

Figure 4: Electronics production 6/12 growth curve, weighted composite of eight EU countries vs. Germany.

tions are Spain, which has been accelerating out of its depression since 2013; the Czech Republic, which remains in positive growth territory but is slowing down; and the Slovak Republic, which is in the ascent but appears to be slowing. The UK, which although appears to be pulling out of the trough of 2012 and 2013, is still in negative growth. Italy, also, appears to be pulling up into positive growth. Nevertheless, at the end of the year, the Eurozone remains a depressed economy aggravated by a slump in output in Germany, which has historically pulled the rest of Europe along with it. Figure 4 shows exactly how much a weighted composite of eight countries is influenced by the German contribution.

In Figure 5, the smoothed 12/12 growth curve based on the German data is projected forward using a regressive analysis methodology and then modified by considerations of

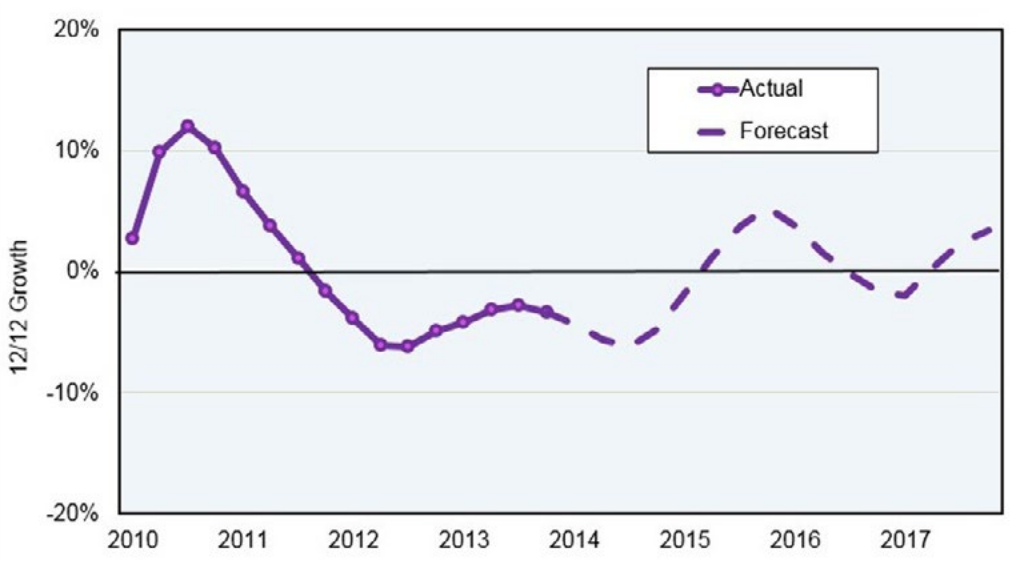

Figure 5: Electronics production in Europe, 12/12 growth, historic and forecast 2014–2017.

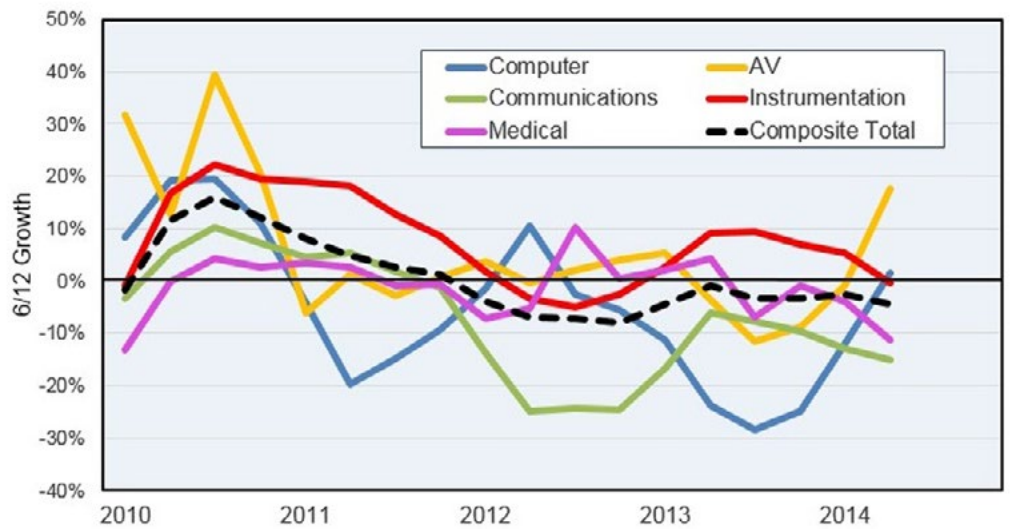

Figure 6: European electronics production, 6/12 growth curve, sector trends.

the economic climate and the markets which the individual European countries serve (e.g., military expenditure is declining but commercial aerospace is a growth sector, with the major OEMs having substantial forward order books). In Europe, therefore, electronics production following a 5% decline in 2014 is expected to grow by 2.5% in 2015 and slightly less in 2016 and 2017. The bad news for the European fabricator is that two key markets, instrumentation and medical, are heading down into negative growth at the end of 2014 as shown in Figure 6.

The electronics production forecast for Europe suggests a suppressed recovery in demand for printed circuits boards through most of 2015. As well as suppressing demand from local fabricators, this will have the effect of slightly suppressing PCB imports. Despite the fragile nature of the Eurozone economy, PCB production has grown in the first nine months of 2014 with

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an expected growth for the whole year finishing at somewhere around 2–3% (and the net PCB imports into the UK have grown likewise following a decline in 2013). This is not expected to last. The smoothed 12/12 growth curve for European PCB production is projected forward in Figure 7 to generate forecast growth rates. The current direction suggests that 2015 will be worse (-1%) before picking up in 2016.

The United States in contrast has staged a small recovery in 2014 although to a lesser extent than in 2012. Figure 8 shows that after a year of negative growth in 2013, electronics production has moved upwards into positive growth in 2014. Electronics production in Canada, having endured a longer depression, is also on course to finish 2014 up 2.6% compared with 2013 although the growth curve for Can-

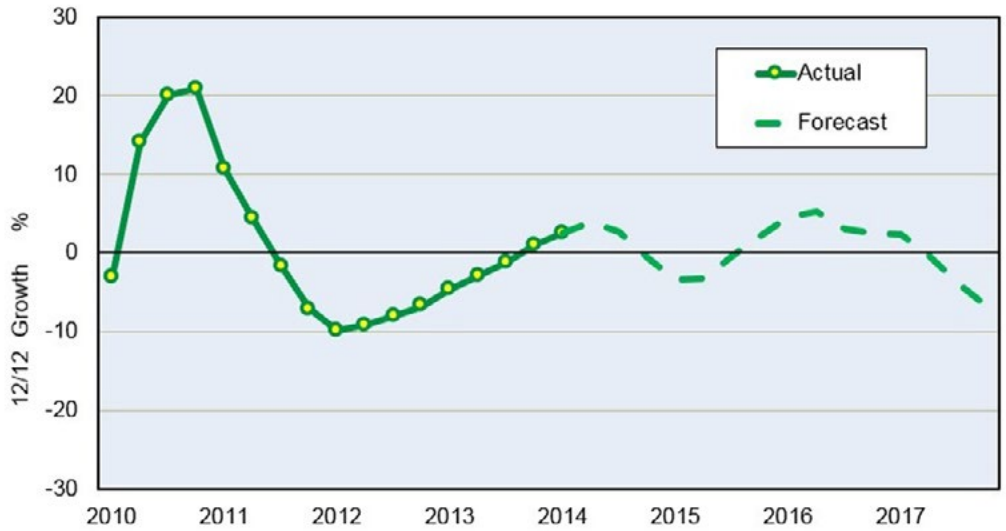

Figure 7: PCB production in Europe, 12/12 growth, historic and forecast 2014–2017.

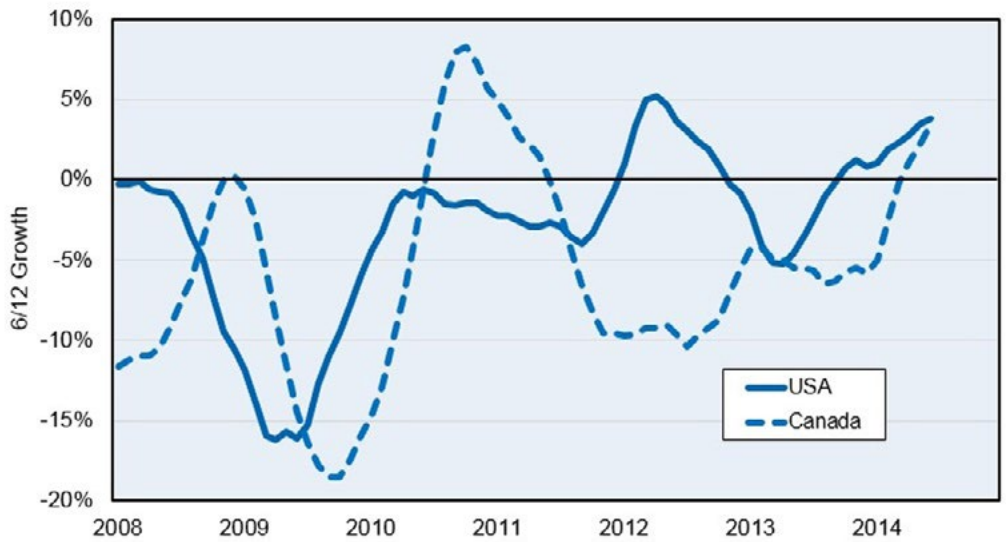

Figure 8: Electronics production 6/12 growth curve, USA & Canada. (Sources: U.S. Dept. of Commerce, Statistics Canada)

ada appears to have peaked already. Electronics production in North America is dominated by the USA, which at $200 billion+ outweighs the $25 billion contribution from Canada. The USA data is therefore used to drive the forecast for North America shown in Figure 9. The total growth in 2014 is expected however to be around 1–2% while for 2015 and 2016 there will be little or no growth according to the forecast in Figure 9.

Despite the upwards trends of electronics production in North America, PCB production has failed to achieve a similar positive growth and expected growth for the full year 2014 is negative, at about -1.5%. Looking forward in Figure 10, the general direction of growth is lacklustre and the upcoming merger of TTM and Viasystems (the two largest fabricators in North America) with an expected resultant consolidation of resources (and mutual customers

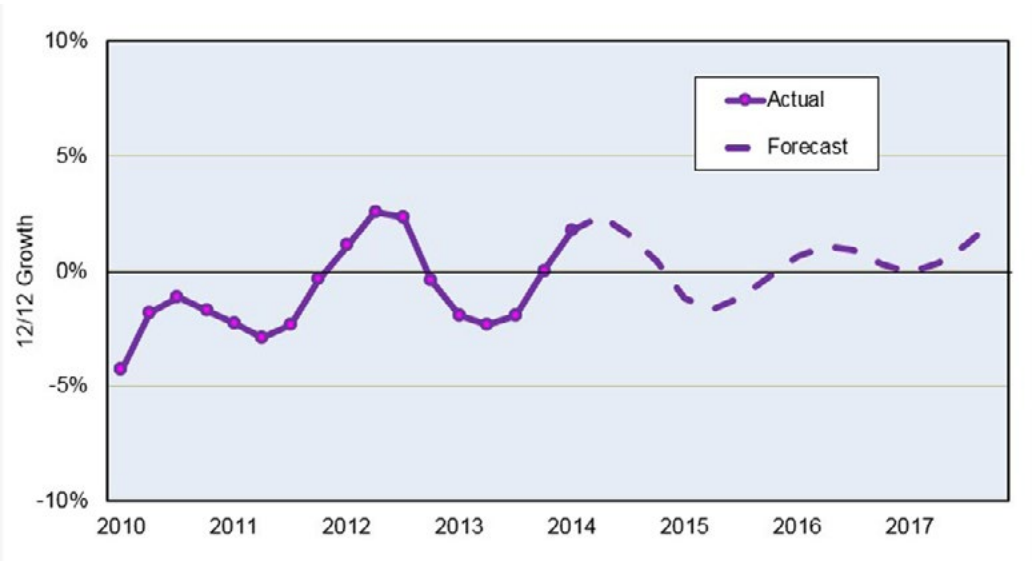

Figure 9: Electronics production in North America, 12/12 growth, historic and forecast 2014–2017.

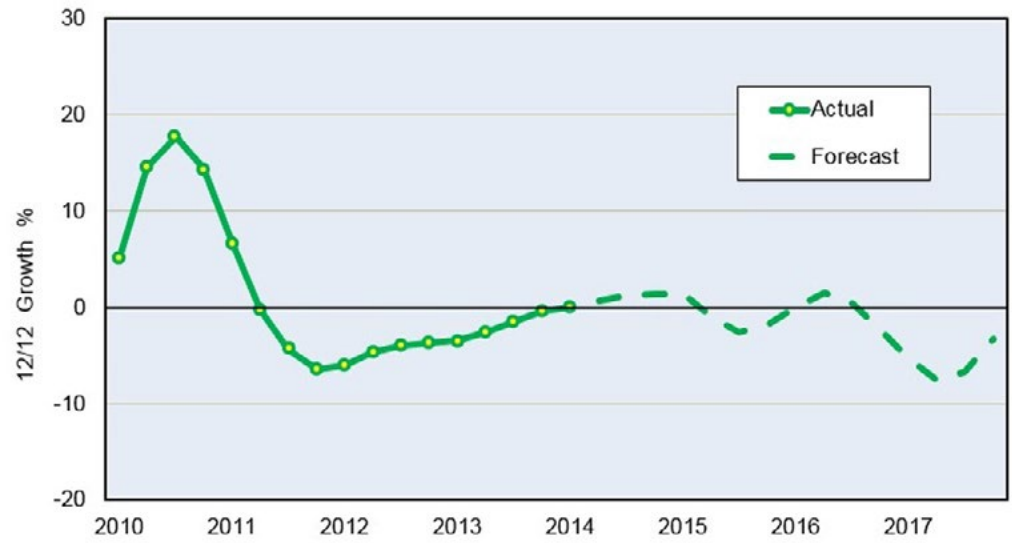

Figure 10: PCB production in North America, 12/12 growth, historic and forecast 2014–2017.

seeking a second source elsewhere) suggest a potential further shrinkage in output and failure to achieve any positive growth over the next couple of years. With the military and aerospace segments accounting for a large share of the domestic market for PCBs, the strong forward order book for commercial airliners should play a part in sustaining demand growth in this region.

Japan has been offshoring its electronics production in recent years and domestic production growth has been mostly negative as can be seen from the 6/12 growth chart of Figure 11, where the growth curve has remained in the negative growth domain for most of the past six years with the exception of 2010 and end of 2013 to early 2014. A short-lived recovery at the end of 2013 almost immediately reversed again and electronics output here would seem to be in decline for the foreseeable future. Even with an immediate and steep upturn in the cycle it will take a year to reach positive growth and history suggests that it would not be sustained.

Similarly, Japan's domestic PCB production has continued its downward slope with closures and consolidations. In 2014, the industry is struggling, and although the decline is likely to be about 5% quantified in yen, it will exceed 20% if converted to U.S. dollars at current exchange rates. Figure 12 shows the negative growth driving the Japanese PCB industry contraction since 2010 and the expected lack of growth going forward to 2017.

With the rest of Asia, and particularly China, dependent on demand from the West for their export markets, the struggling economies of Europe and to a lesser extent North America have not provided a sufficiently strong market and so demand for computers and portable electronics has not increased hugely, with the growing markets for tablets and smartphones offset by reduced demand for PCs and standard handsets. Smartphone makers are also experiencing increased pricing competition which is driving revenues down. Revenue growth in Q3 14 has slowed for South Korean electronics companies. Singapore reported a 10% contraction in demand for computer peripherals in the first eight months of 2014. Taiwan has increased production of portables but demand for audio-visual products has fallen.

One of the strongest sectors has been communications infrastructure, particularly in China where it is driven by large increases in capital expenditure by its three major operators following allocation of the 4G licenses. This has resulted in a large spurt in production of 4G base stations (both for domestic and export markets). This is clearly shown in Figure 13 which compares the production indices for various applications.

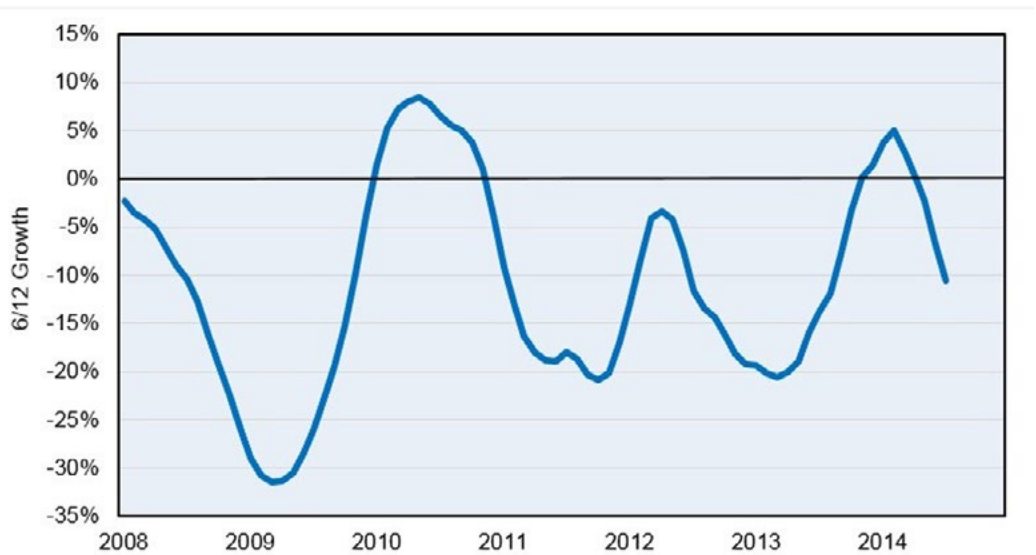

Figure 11: Japan electronics production 6/12 growth. (Source: JEITA)

The resulting 6/12 growth curve for China is therefore somewhat flat (as shown in Figure 13) without the extraordinary bursts of growth seen in previous boom times. Nevertheless it remains at positive growth levels.

Using the forecasting methodology to extrapolate the curve forward (Figure 14) results in forecast growth rates of a modest 3–5% in 2014 followed by an upswing in 2015 of up to 12% and softening again to single digit growth, 7% in 2016 and <5% in 2017.

In 2013, China produced 44% of the total PCBs made worldwide in addition to importing high-performance boards from Japan and Taiwan. However, dependence on imports is reducing as capacity expansion continues. The balance of this capacity expansion is changing as Japanese, Taiwanese and Korean fabricators are shifting away from building additional capacity for production of high performance boards in China where wages and overheads are rising, and setting up in lower cost countries such as Vietnam.

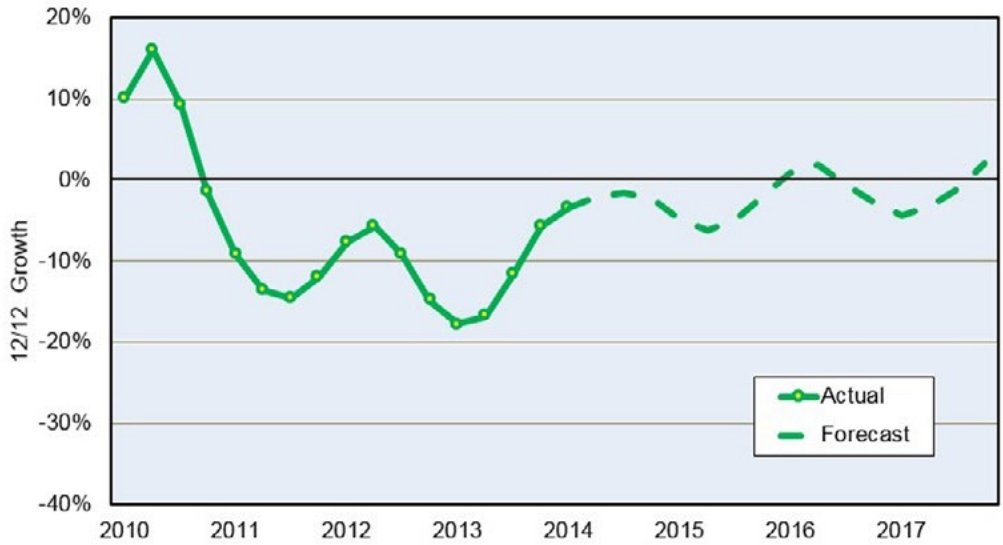

Figure 12: PCB production in Japan, 12/12 growth, historic and forecast 2014–2017.

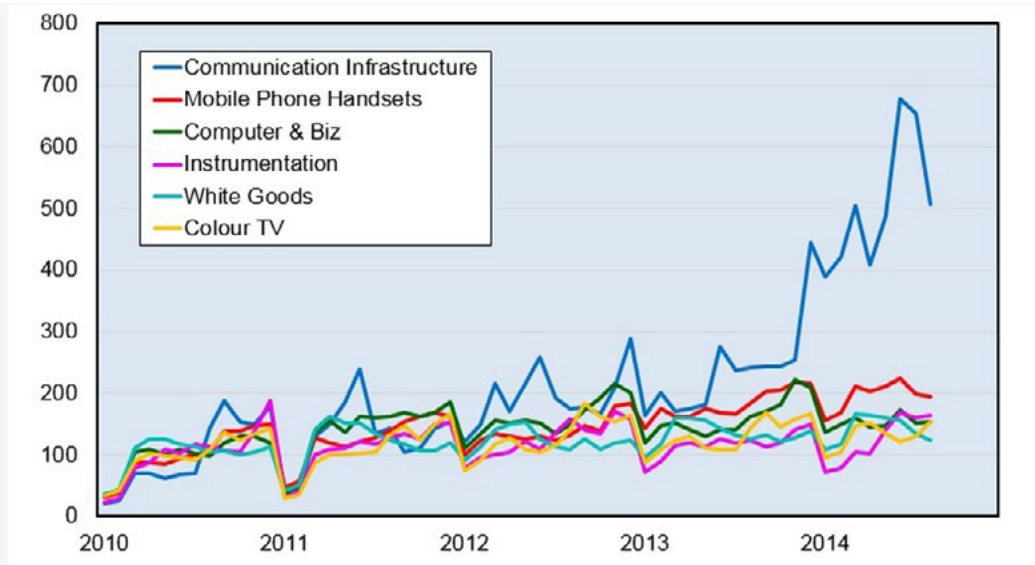

Figure 13: Indices of electronics production in China (100 = average value in 2010).

Figure 14: Electronics production in China, 6/12 growth. (Source: NBSC)

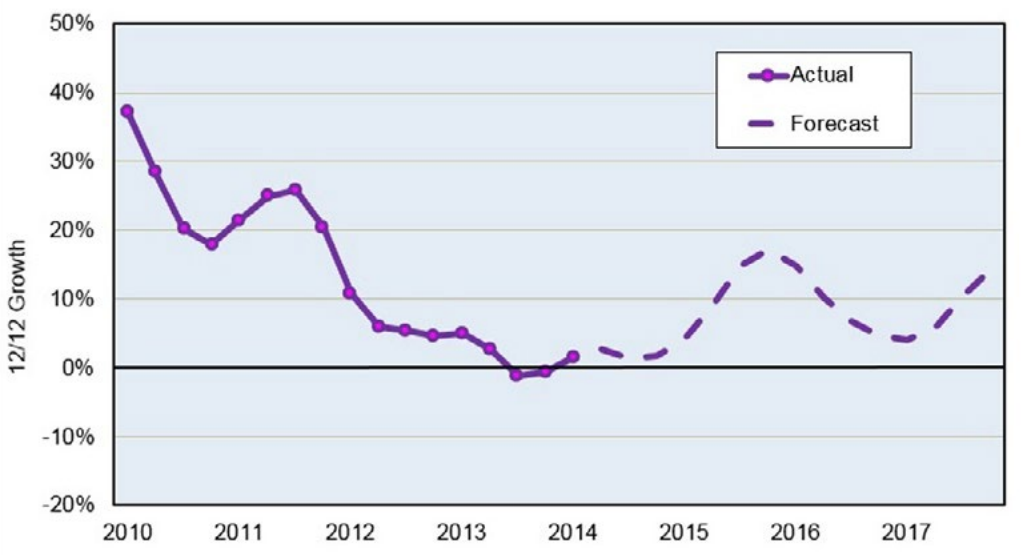

Figure 15: Electronics production in China, 12/12 growth, historic and forecast 2014–2017.

What is certain is that board production will continue to grow in China but the boom factor is absent unless their export markets pick up.

Taiwanese fabricator revenues (which include those from production facilities in China) for the first three quarters of 2014 suggest rigid board production value growth of 5% compared with 2013, while FPC has experienced a fairly astonishing 15% growth. Nevertheless, there has been some slowing of the FPC market which registered nearly 18% year on year for the first six months of 2014. Based on this data, the projected 12/12 growth curve in Figure 15 suggest that 2014 will end with annual growth in low single digits (5% maximum) while the start of a rebound in 2015 could take that year-end growth up to more than 10% and possibly 15%.

Using the derived annual growth rates, the regional forecast values for electronics production and PCB production are summarised in Tables 1 and 2. China growth rates are not reported separately here and the numbers for Asia

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	2013	2014(F)		2015(F)		2016(F)	
	US$ bn	US$ bn	Annual Growth	US$ bn	Annual Growth	US$ bn	Annual Growth
Europe	223	215	-3.6%	220	2.3%	223	1.4%
N America	243	248	1.9%	248	0.2%	250	0.8%
Japan	49	46	-6.9%	44	-4.3%	45	1.1%
Asia (excl Japan)	843	871	3.4%	924	6.0%	967	4.7%
Rest of World	159	160	0.9%	163	1.9%	164	0.6%
Total World	1517	1540	1.5%	1599	3.8%	1648	3.1%

Table 1: Electronics production forecast.

	2013	2014(F)		2015(F)		2016(F)	
	US$ m	US$ m	Annual Growth	US$ m	Annual Growth	US$ m	Annual Growth
Europe	2625	2701	2.9%	2689	-0.4%	2775	3.2%
N America	3054	3009	-1.5%	2924	-2.8%	2864	-2.1%
Japan	5993	5094	-15.0%	4725	-7.2%	4652	-1.5%
Asia (excl Japan)	46632	48274	3.5%	51122	5.9%	53729	5.1%
Rest of World	257	257	0.0%	252	-2.0%	254	1.0%
Total World	58561	59335	1.3%	61712	4.0%	64274	4.2%

Table 2: PCB production forecast.

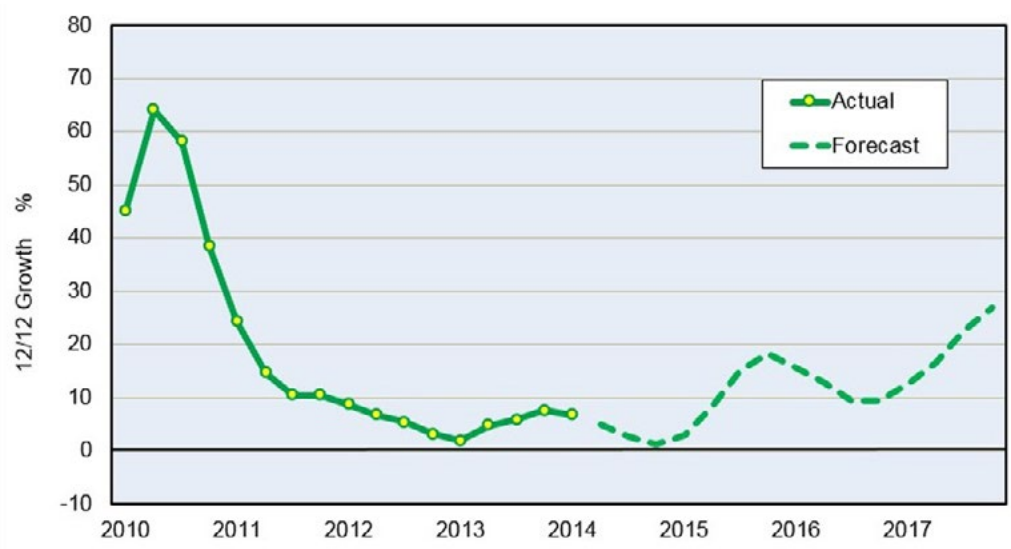

Figure 16: PCB Production, Taiwan (including China), 12/12 growth, historic and forecast 2014–2017.

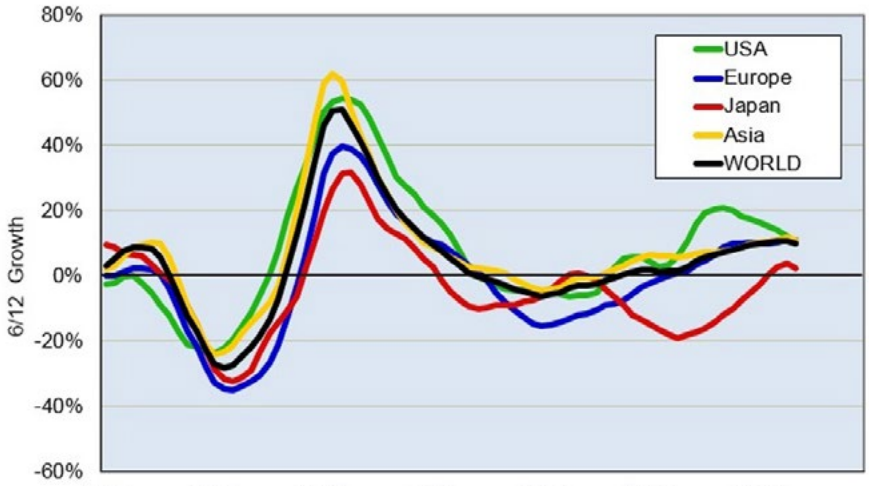

Figure 17: Semiconductor market, 6/12 growth.

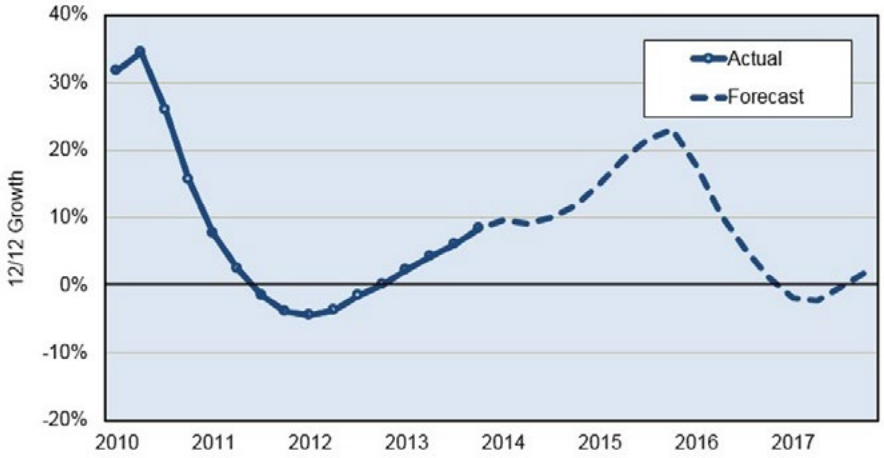

Figure 18: Semiconductor market, historic and forecast, 12/12 growth.

are tempered by all the countries in that region.

On a final note on the outlook for 2015 and onwards, Figure 16 shows a 6/12 growth curve up to end August 2014. In line with the outlook for electronics, it shows a softening of the market in North America, Asia and Europe while Japan, having barely surpassed negative growth is contracting again.

Projecting 12/12 growth for the total world semiconductor market in Figure 18 indicates a softening but still 9% growth in 2014 followed by 12% in 2015 and 8% in 2016.

Seasons greeting and best wishes for a happy, healthy and prosperous 2015. **PCB**

Francesca Stern, BSc MSc, is an independent business consultant working with companies and organisations in the electronics supply chain. Her career has included stints in engineering at ITT, STC and then CMAC, followed by four years in the U.S., during which some experience was acquired in the field of U.S. patents. As a consultant at BPA from 2000–2014, she contributed to the research, strategic analysis, data acquisition and forecast generation for a wide variety of topics encompassing the electronics and particularly the PCB industry. Francesca left BPA in March of 2014 to form Francesca Stern Consulting). A key activity of FSC is a statistical analysis and forecasting service for the trade association TechUK.

China Market Outlook for 2015

by Canice Chung
HONG KONG PRINTED CIRCUIT ASSOCIATION

Since the 2008 financial crisis, the global economy has faced big challenges, with an excess of global money supply triggering high inflation regionally. Emerging markets were hit quite seriously. These exceptionally high inflation rates impacted countries such as China, which has had to defend against it by periodically regulating its economic policies. High inflation has dampened the recovery speed of China's economy, as well as prolonged the recovery of the already shaky global economy.

Per N.T. Information, the total PCB market is forecasted to reach US$62.7 billion in 2014, US$64.9 billion in 2015, and US$67.7 billion by 2017. PCB market growth has been minimal or flat these past few years, and looks to be gradually gaining momentum to grow again in the next few years. China has been one of the fastest growing PCB markets in the last decade, and it will continue to not only exceed the growth of the world PCB market, but will grow at a quicker and steadier rate than that of the rest of the world.

China's PCB Market Today

China has been the largest PCB producing region for the past few decades. Substantial market share for lower-technology products like 4–6 layer PCBs, which started in the early 1990s, and the higher-technology microvia HDI products, also emerged in the last decade. Per Prismark's report this year, 18+ layer PCBs, silicon platform and flex circuits are expected to grow at a faster rate in the coming years.

China's electronics and PCB industries are also entering into another phase of technology transformation, with government policies promoting the migration of product technology towards the production of semiconductors, substrate and chip packages, and other cutting-edge technology.

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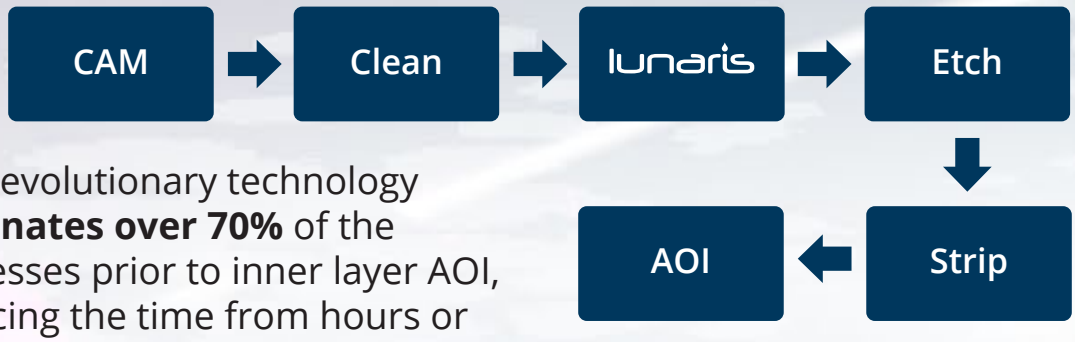

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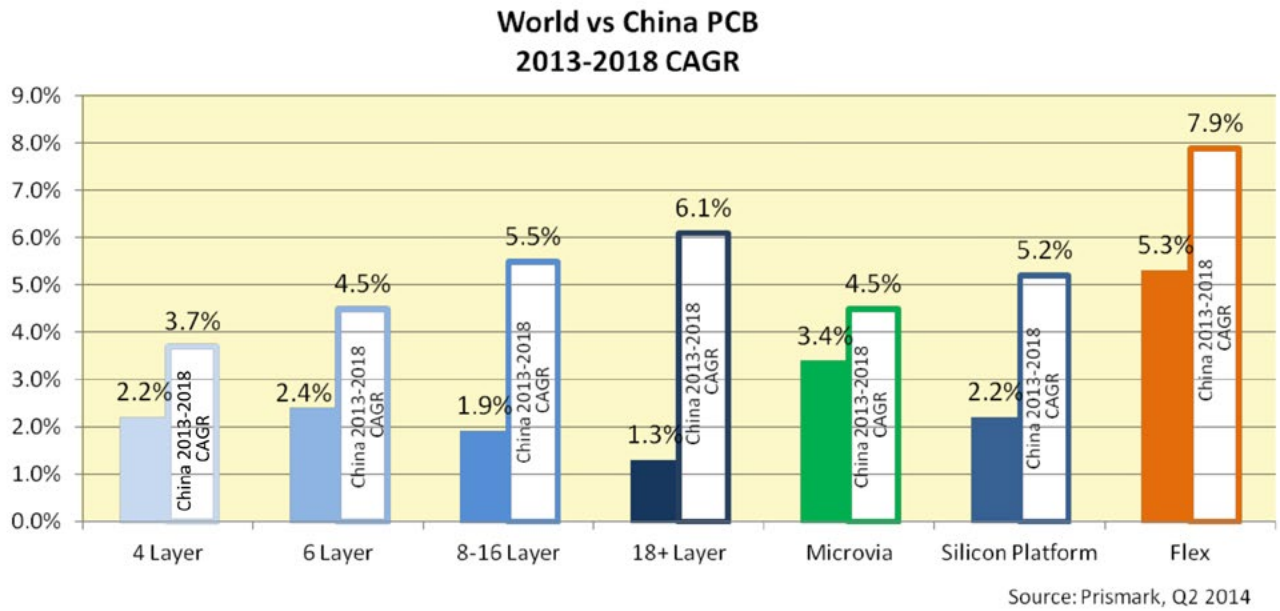

Figure 1.

Currently, China's PCB growth opportunities are still primarily centered on handheld mobile devices such as smartphones, tablets, and wearable electronics, etc. Most of these end products are being manufactured and assembled in Asia, particularly China and some parts of Southeast Asia. This kind of PCB application is classified as small and thin PCBs, which were largely produced by Japan's manufacturers in the last decade. Due to the heavy CAPEX involved, capacities for technologies such as HDI, flex and flex assembly, and rigid-flex are being set up mainly by major players.

U.S. and European PCB makers formerly dominated the large PCB market consisting of backplanes and large form-factor, high layer-count PCBs. However, globalization and cost-saving initiatives are driving the big and thick boards into China, even though the end-products are assembled globally. With continuous investments, and developments being made in the right technology, improved capabilities in China can better support this outsourcing trend—a trend that is expected to continue and become even more prevalent into the future. As technology gaps narrow between the East and West, China's players will also be able to penetrate into even higher value-added and more difficult-to-build PCBs, which in turns means there will be very keen competition in this market segment.

China's Future

As long as OEMs, ODMs and EMS providers are still manufacturing cell phones, tablets, wearable and health electronics, computers, notebooks, storage peripherals and consumer products in China, PCBs production will continue on a growing trend. This is especially likely because China is such a huge market, as well as being suitably supplemented by a well-established PCB supply chain.

So, what is in store for China's PCB market? Opportunities will likely continue to be in the end-markets for handheld mobile devices, which ultimately translates to continuous growth in microvia HDI, flex PCBs and rigid-flex.

This trend, along with the IoT, will also further encourage the growth of better networks, higher bandwidth and speed, and large form factors, as well as the creation of a world of connections (i.e., connected cars and homes, etc.). All of this only means that there will be an increasing need for electronics in homes, offices and even automobiles. Continuous outsourcing


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trends to China are expected to service these competitive communication and networking market segments.

China PCB Market Challenges

With opportunities come challenges. From the macro view, challenges will come mainly from the unstable economic environment, including the ongoing financial drag in the Eurozone, the slow pace of the U.S. recovery,, the up and down policy-driven economy of China, and the long and extremely slow recovery of Japan's economy. Additionally, inflation caused by the increase in money supply after the financial crisis drove increased costs in materials, labor and overhead, while the average selling price of PCBs trended downward, due to shrinking demand and surplus capacity from manufacturers' expansion.

Local challenges in China continue to linger in several areas related to rising costs. As China becomes more affluent and high-tech-conscious, more stringent environmental requirements are levied on production plants, which have inevitably driven environmental costs higher. GDP growth as well as active foreign investment into China due to local market opportunities has kept the local economy hot, though slower. PCB manufacturers these days face huge turnovers as workers hop between manufacturers for the sake of earning 100–200 more RMB, due to rising standards of living, especially in the coastal areas. This also translates into increasing labor costs and an unstable work force.

Another factor associated with labor costs are PCB manufacturers' operation costs, which in recent years have further increased and been impacted by many customers who are now committed to the new stringent code of conduct requirements (limited overtime, more rest hours, etc.) under the Electronic Industry Citizenship Coalition (EICC) standard. Other factors affecting labor costs include policies on conflict-free minerals, and comprehensive mandatory provident fund and insurance costs.

All's Not Gloom

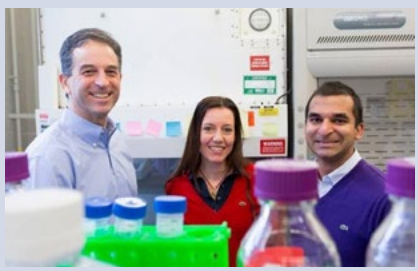
In conclusion, China's market will continue to grow, with the survival of the fittest. Companies will need constant innovation to manage rising costs; economies of scale may drive a consolidation in business services in the region. It is therefore important that companies remain focused on being either a leader in cost (low layer-count but large volume conventional PCB player) or being a leader in technology for high value-added products. In short, market conditions will be tough, but survivable, for those who manage their business correctly! **PCB**

Canice Chung is chairman of the Hong Kong Printed Circuit Association.

MIT Furthers Development of Biological Circuits

Researchers have made great progress in the creation of biological circuits—which, like electronic circuits, can take a number of different inputs and deliver an output. But while individual components of such biological circuits can have precise and predictable responses, those outcomes become less predictable as more elements are combined.

A team of researchers at MIT has greatly reduced that unpredictability with a device that could ultimately allow such circuits to behave nearly as predictably as their electronic counterparts, according to the journal Nature Biotechnology.



Pictured are lead author Deepak Mishra (r), and co-authors Domitilla Del Vecchio and Ron Weiss (l).

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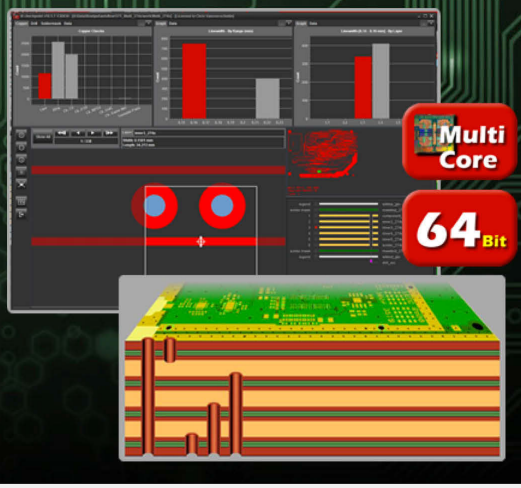

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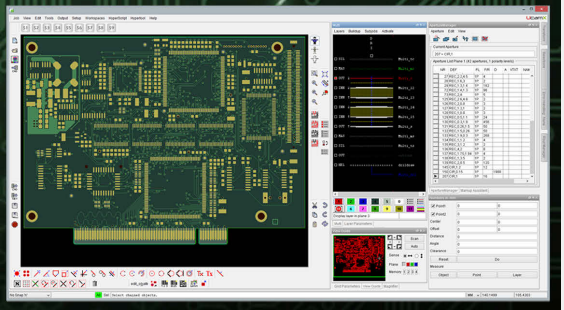

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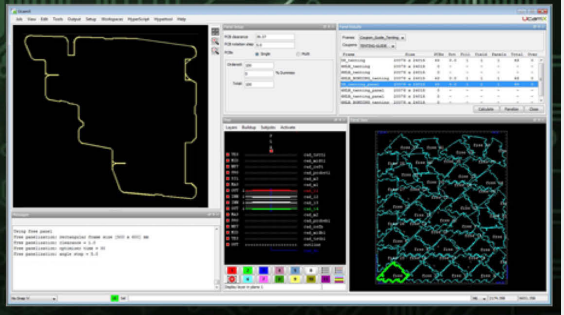

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Japan's PWB Market 2015

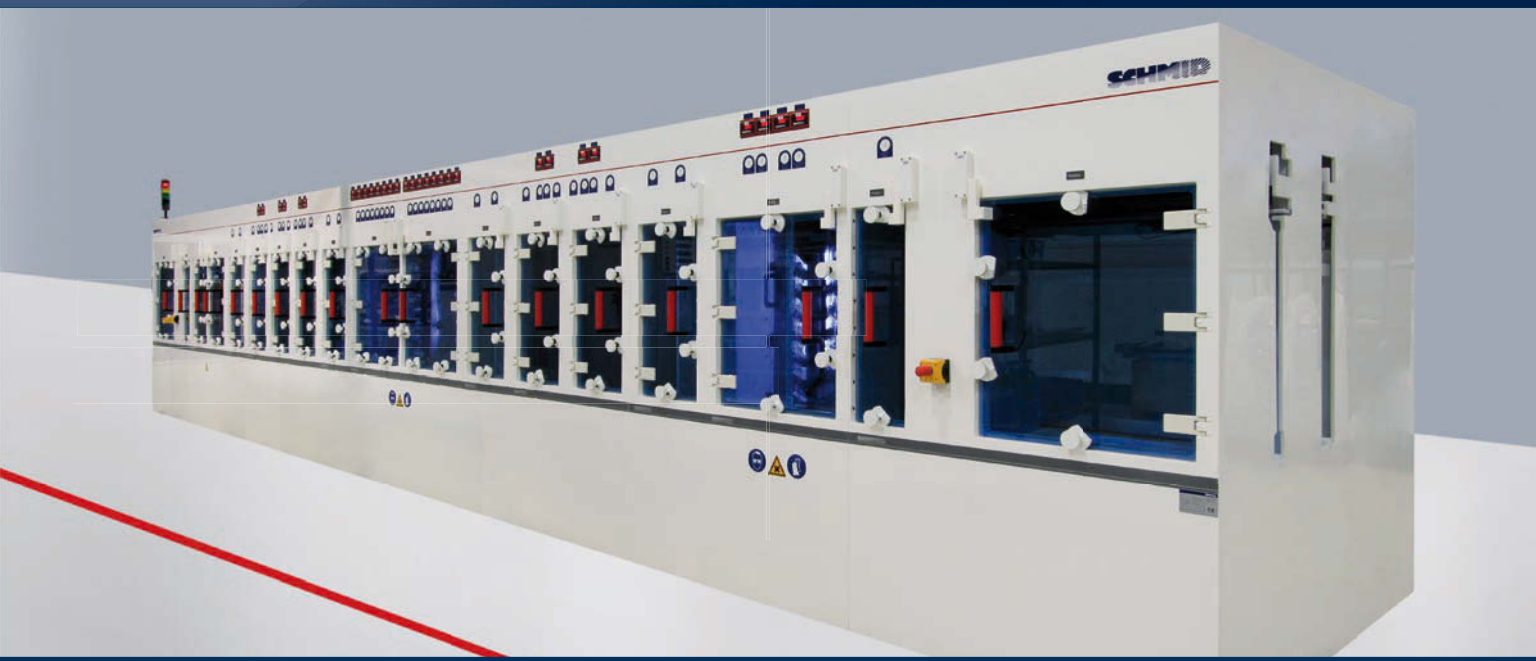
by Dominique Numakura
DKN RESEARCH LLC

The Japanese were arguably the leaders in the PWB industry for technology and gross revenues during '80s and '90s. Portable electronics, laptop computers, and audio and video products generated a remarkable demand for HDI multilayer boards and flexible circuits that helped Japanese remain industry leaders. During the '80s and '90s, Japanese manufacturers developed many new technologies to satisfy market demand for build-up multilayer boards, high-density rigid-flex and semiconductor substrates. The Japanese PWB industry grew year-over-year, and many electronics companies budgeted a lot of money for R&D, and at the same time reduced manufacturing costs by shifting much of their manufacturing facilities to low-cost labor regions—mostly in China and Southeast Asia.

The double-digit growth rate hit a roadblock when the U.S. IT recession was in full bloom during 2001 (Figure 1). Fortunately, the PWB industry in Japan rebounded thanks to new electronic products such as cell phones, digital cameras, and LCD televisions. The multilayer rigid-flex segment posted significant growth when cell phones evolved into smaller devices, and a new market for module substrates was created by the introduction of new semiconductor packaging technologies. Total volume returned to the same level as it was in 2000 (the best year since the recession began).

Unfortunately, a second global recession hit in 2008. This slowdown once again started in the U.S, but this time it crippled the Japanese PWB industry. A small rebound in 2010 (Figure 1) could not sustain its momentum, and business continued to spiral downward.

The Japanese PWB manufacturers were not optimistic over the next few years, and they do not expect any significant growth for the next four years. (Forecasts for years 2014, 2016 and 2018 in Figure 1 are provided by more than 180 PWB manufacturers in Japan). Conversely, the



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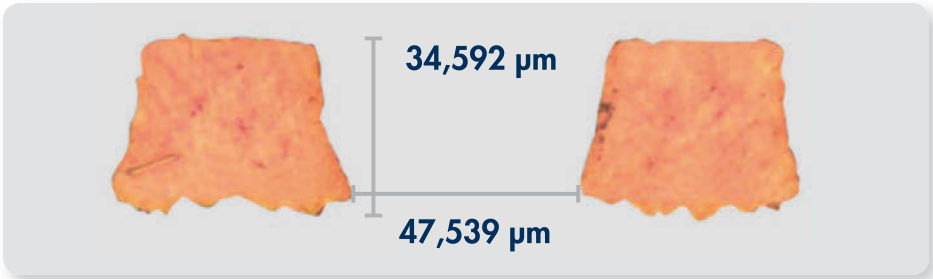

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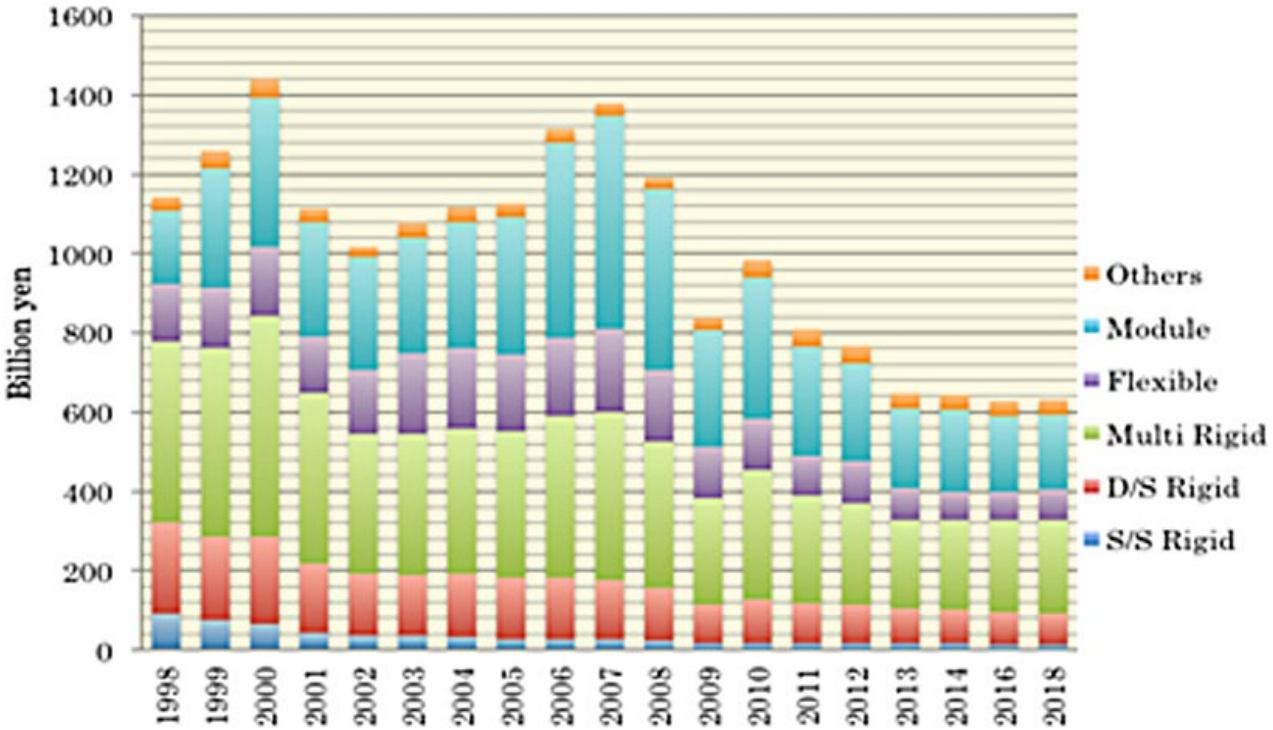

Figure 1: An estimation of PWB production in Japan for 2014, 2016 and 2018. (Source: JPCA/DKN Research).

PWB manufacturers in Taiwan, Korea, China and other Asian countries are very optimistic. Their sales forecast for the next few years shows no signs of weakening, and they continue to invest in capital improvements for manufacturing capacities.

Let's review some trends from the Japanese PWB market, and the appropriate action plan for next year. Figure 2 shows monthly shipments from PWB manufacturers in Japan over the last three years, and Figure 3 indicates the percent change from the same month of the previous year. Shipments continued to decline; however, the rate of decline is slowing and actually decreased when comparing month over month. Figure 3 shows positive growth in volume but a negative growth in revenue. This tells us that volume has stabilized, but prices are lower. Japanese PWB manufacturers have cut prices to secure business; this race to the bottom cannot continue. Several manufacturers dropped out of the race to the bottom, and probably even more will exit this low-margin, cutthroat market.

The downturn in business for the Japanese PWB industry can be blamed on a domino effect. The rigid circuit board segment relied heavily on business from domestic electronics companies such as Panasonic, Sony and Sharp. Unfortunately, these electronics giants continue to lose market share, and the downturn in business directly impacts the PWB industry.

The manufacturers in the flex circuits segment have a customer list for both domestic and overseas markets. The domestic customers did not evolve with new market trends for consumer products. In the past few years, they saw a steady decline in business for flat-panel TVs and other mobile products (another domino effect). Japanese manufacturers are still the main supplier for digital cameras, but digital cameras are going the way of the VCR; the business trend looks bleak. Flex circuit manufacturers are the main suppliers for Apple's iPhones and iPads, and they should keep this business stream as long as they remain competitive with Taiwanese manufacturers.

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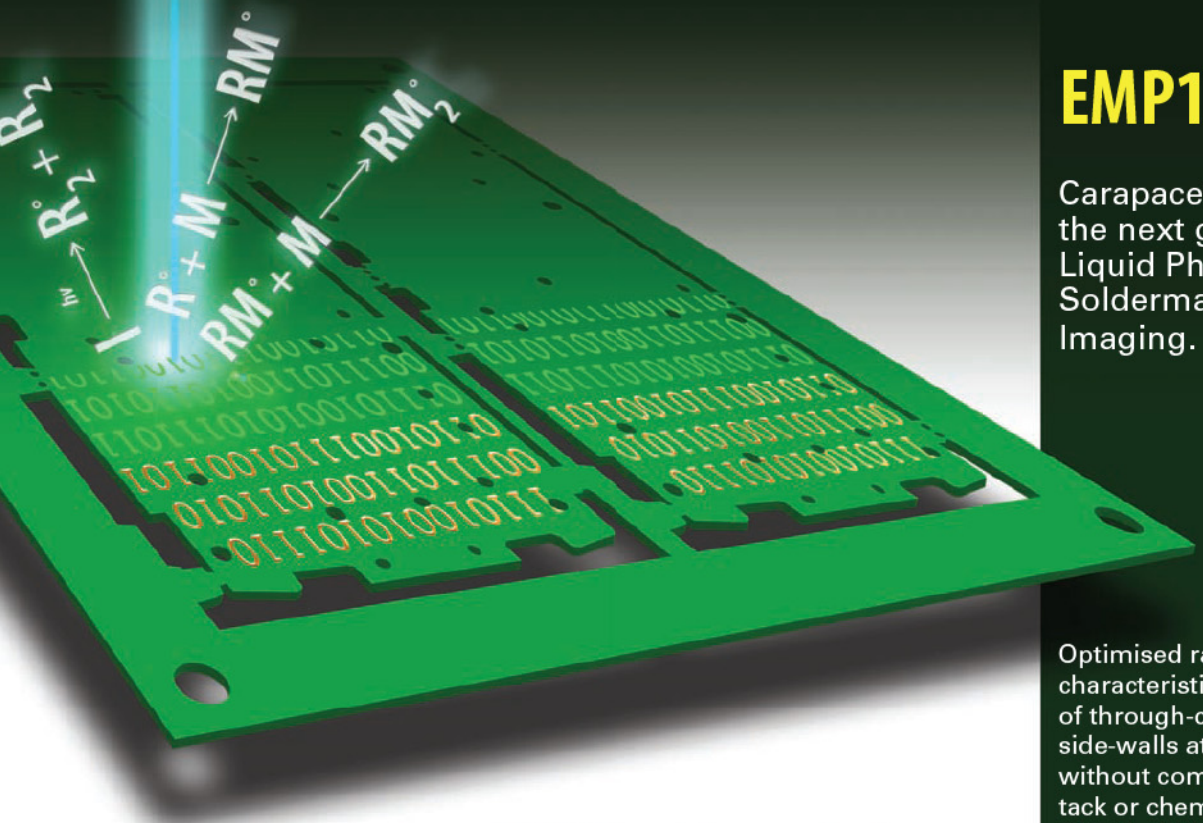

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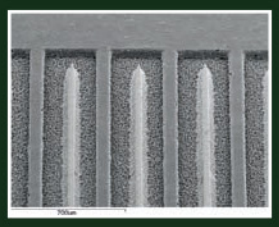

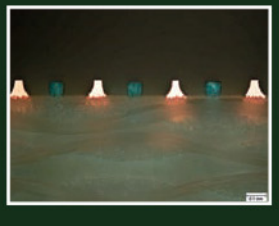

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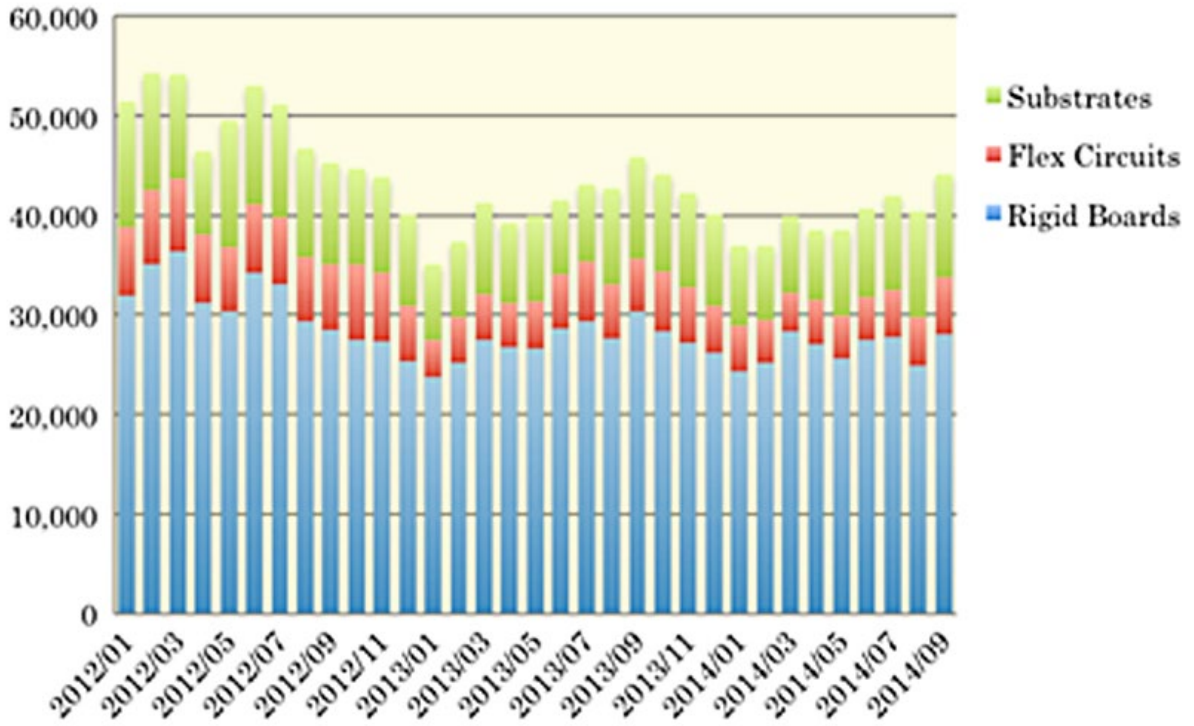


Figure 2: Monthly PWB production in Japan (million yen). (Source: METI/DKN Research.)

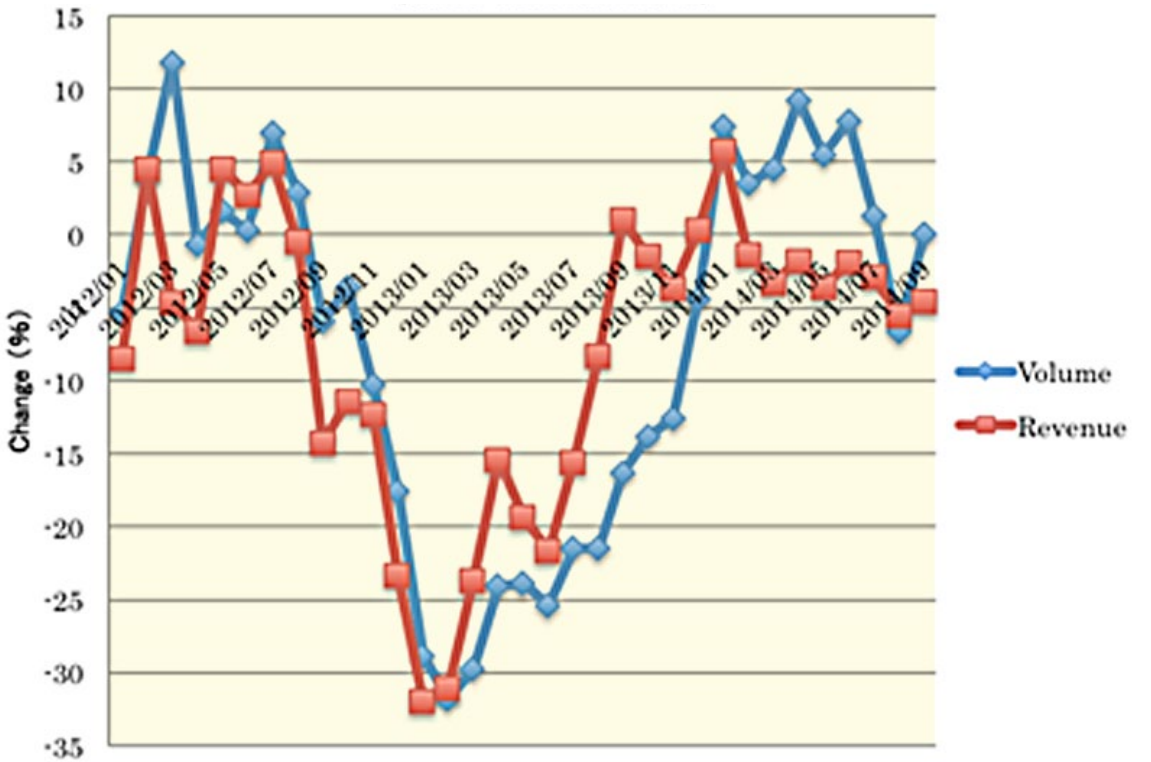


Figure 3: Shipment change from the same month of the previous year. (Source: METI/DKN Research)

The Japanese suppliers for module substrates remain at the top of the food chain in the global market for semiconductor packaging thanks to Intel. Intel recognized that Japanese manufacturers are the most reliable partners, and they continue to use them as an approved vendor. Unfortunately, some new competition from Taiwanese and Korean manufacturers will force the Japanese to lower their margins in the near future. Japanese PWB manufacturers forecast negative growth over the next four years from their traditional product line. The manufacturers are trying to generate business opportunities in new areas such as automobiles, medical devices, health care equipment and more. This could still take a few years to recognize any substantial business. **PCB**

Dominique Numakura is managing director of DKN Research LLC.

Heat Transfer Sets Noise Floor for Ultrasensitive Electronics

A team of engineers and scientists has identified a source of electronic noise that could affect the functioning of instruments operating at very low temperatures, such as radio telescopes and advanced physics experiments.

The findings, detailed in the November 10 issue of the journal Nature Materials, could have implications for the future design of transistors and other electronic components.

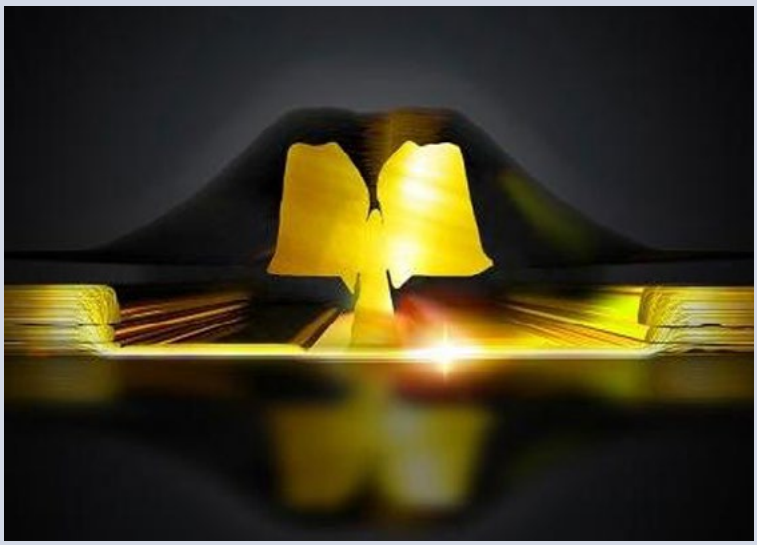
The electronic noise the team identified is related to the temperature of the electrons in a given device, which in turn is governed by heat transfer due to packets of vibrational energy, called phonons, which are present in all crystals. "A phonon is similar to a photon, which is a discrete packet of light," says Austin Minnich, a corresponding author of the new paper. "In many crystals, from ordinary table salt to the indium phosphide crystals used to make transistors, heat is carried mostly by phonons."

How swiftly and efficiently phonons ferry away heat from electronics is partly dependent on the temperature at which the device is operated.

One way that engineers have traditionally reduced phonon scattering is to use high-quality materials that contain as few defects as possible. "The fewer defects you have, the fewer 'road blocks' there are for the moving phonons," Minnich says.

A more common solution, however, is to operate electronics in extremely cold conditions because scattering drops off dramatically when the temperature dips below about 50 kelvins, or about –370 degrees Fahrenheit. "As a result, the main strategy for reducing noise is to operate the devices at colder and colder temperatures," Minnich says.

But the new findings by Minnich's team suggest that while this strategy is effective, another phonon transfer mechanism comes into play at extremely low temperatures and severely restricts the heat transfer away from a device.



North American PCB Opportunities: Investment is Crucial

by Sharon Starr
IPC

North America was the one bright spot in PCB production growth in 2013. Although 0.8% real growth may not seem like a cause for celebration, North America was the only major PCB-producing region with positive real growth in 2013. The estimated value of North American PCB output in 2013 was US$3.05 billion, 5% of the world market, according to IPC's World PCB Production Report for the Year 2013.

PCB production in North America is expected to grow at a slow but steady pace over the next three years, averaging 2% growth per year. The North American PCB market, estimated at $3.44 billion, is delivering zero growth so far in 2014, but is expected to resume slow growth in 2015, based on forecasts in IPC's monthly North American PCB Market Report.

Some opportunities and positive indicators for the North American PCB market are evident in the industry data IPC published in its 2013–2014 Analysis & Forecast for the PCB Industry in North America. The industry is projecting growth in PCB sales to the North American military and aerospace market this year which, if it materializes, could push mil/aero ahead of communications to become the largest vertical market for PCBs in North America. Growth is also projected in PCB sales to the industrial and medical electronics markets in 2014.

Even more encouraging is the increase in projected research and development spending among North American PCB fabricators surveyed by IPC in 2014. Research and development spending as a percentage of sales was reported to grow from 3.5% in 2013 to 4.3% this year in the rigid PCB segment of the industry. For the flexible circuit segment, R&D spending growth is equally noteworthy, climbing from 2.2% of sales in 2012 to 2.8% in 2013 and reaching an estimated 3.5% this year.

R&D activity is a crucial driver of demand in electronics through the introduction of new products. Electronics manufacturing is a cyclical industry, with growth patterns that reflect the ups and downs of the world economy. While the patterns look similar, growth in electronics markets has tended to outpace economic growth due to the demand created by new products.

Investment in new equipment and processes has become the North American PCB industry's life blood, enabling the industry to main-

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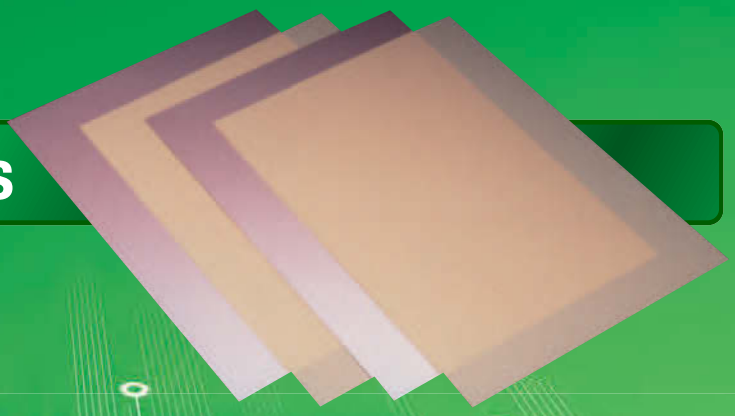

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tain its technological leadership as it restarts its engine of growth. There is evidence that this is occurring. Data IPC collected for its 2014 PCB Technology Trends study, due to be published by the end of this year, indicates that some North American fabricators are already embedding passive components and a few are embedding active components. Many more anticipate embedding both passives and actives within the next five years, as well as incorporating printed-in-place features.

IPC's market research focuses on the core elements of industry vitality: the market (demand), production and inputs (supply), and the enabling technologies. Labor is one of the crucial inputs that is a current subject of IPC's research. A new study on issues in the North American labor pool for electronics manufacturing will also be published by the end of this year.

For more information about the referenced IPC market research reports, visit www.ipc.org/market-research-reports. **PCB**

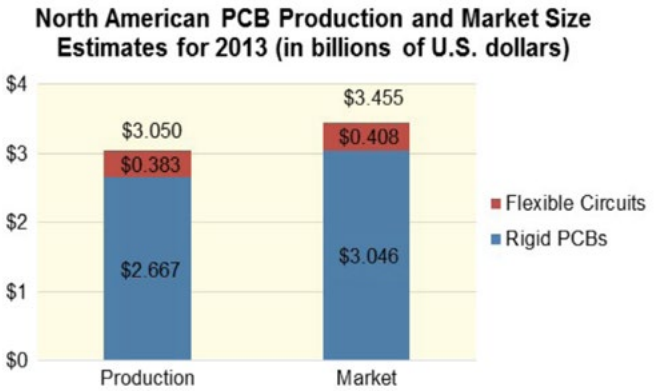

Figure 1.

Sharon Starr is director of market research at IPC.

VIDEO INTERVIEW

IPC to Release New Market Studies

by Real Time with...IPC APEX EXPO 2014

IPC Director of Market Research Sharon Starr discusses a number of soon to be released IPC market studies with Guest Editor Dick Crowe.

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LUTHER & MAELZER

Mil/Aero007 News Highlights

Miraco Earns ITAR Registration

Miraco Inc. recently received an ITAR registration from the U.S. Department of State, Directorate of Defense Trade Controls (DDTC). Registration is a primary means to providing the U.S. Government with necessary information on who is involved in certain manufacturing, exporting, and brokering activities.

Survey Reveals Cost of Conflict Minerals Compliance

The first year of conflict minerals reporting has come and gone, but how much did it cost? What lessons have we learned? A comprehensive Tulane University survey of 2013 issuers shows average costs per issuer, identifies qualitative measures issuers are currently using, and identifies common supply chain practices.

DSG Honored with Supplier Award from Honeywell Aerospace

Dongguan Somacis Graphic (DSG) has received the 2014 Supplier of the Year Award for service and delivery performance at the 2014 Honeywell Aerospace Supplier Summit. "We are honored to receive this award in recognition of our service and delivery performance, but also as a testimony to the strong partnership we have enjoyed with Honeywell over the years," commented Giovanni Tridenti, CEO of DSG.

Invotec Receives BAE Systems Supplier Award

This achievement is a reflection of Invotec's close working relationship with BAE Systems, the UK's largest manufacturer and provider of complex military equipment and technology and a founding member of the Aerospace Defence Security (ADS) 21st Century Supply Chain (SC21) program.

NPI Applauds Federal Competition to Create IP-IMI

The National Photonics Initiative (NPI), an alliance of top scientific societies uniting industry and academia to raise awareness of photonics, applauded the Funding Opportunity Announcement (FOA) issued by the DOD, through the Air Force Research Laboratory, calling for concept papers for the establishment of an Integrated Photonics Institute for Manufacturing Innovation (IP-IMI).

Teledyne Broadens Portfolio with Oceanscience Acquisition

"Through the acquisition of Oceanscience, as well as the recent investment in Ocean Aero and the pending acquisition of Bolt Technology and its Seabotix division, we will have significantly broadened Teledyne's portfolio of remotely-operated and autonomous marine systems," said Robert Mehrabian, chairman, president, and CEO of Teledyne.

Aerospace Suppliers Ramp Up to Meet Surging Orders

The aerospace supply industry is still in the early days of a long-term boom in orders say industry participants at a recent suppliers' summit hosted by GE Capital at GE Aviation's headquarters in Cincinnati, Ohio. "We are in the midst of a 'supercycle' of aerospace manufacturing," said Gib Bosworth, managing director of aerospace financing at GE Capital, Corporate Finance.

North America, APAC: Largest Military Radar Markets

The global military radar market is expected to experience a CAGR of 1.05% during 2014–2024; North America and Asia-Pacific are expected to be the largest military radar markets, with a cumulative market share of more than 72%.

Global BYOD Security Market to See 35.23% CAGR

Enterprise mobility and flexibility in operations are essential for organizational success, leading many large enterprises to encourage employees to access enterprise data from their personal devices. However, this introduces many security concerns.

Cybersecurity Spending to Reach $109 Billion by 2020

ABI Research calculates cybersecurity spending for critical infrastructure protection will reach US $109 billion globally by 2020. The majority of spending will focus on securing the financial sector and the ICT infrastructure, with the North American and European regions pumping the most into network, systems, and data security.

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AS9100 is the quality management standard specifically written for the aerospace and defence industry, to satisfy authorities such as the Federal Aviation Administration, ensuring quality and safety in the "high risk" aerospace industry.

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POINT OF VIEW

Star Trek Inspires Medical Technology for 2015

by Steve Williams
STEVE WILLIAMS CONSULTING LLC

In a galaxy far, far away, the March 2012 issue of The PCB Magazine, to be exact, I wrote a column entitled, "How William Shatner Changed the PCB World." A short two and a half years later, *Star Trek* is still inspiring bleeding-edge medical technology that will impact all of us in the very near future.

Qualcomm Tricorder XPrize Contest

Close to 50 years after Dr. Leonard H. "Bones" McCoy of the Starship Enterprise first used a fictional tricorder to scan patients for ailments and anomalies, real-world medical science is turning that science fiction into a reality.

Figure 1: *Star Trek's* Tricorder.

Recently, at the opening ceremony of the IEEE Engineering in Medicine and Biology Society International Conference in Chicago, 10 teams were named finalists in a $10 million prize competition to create a lightweight, portable, wireless device that can diagnose and monitor medical conditions.

More than 300 teams from around the world competed in the Star Trek-inspired challenge that was launched in January 2012, and four of the 10 finalists are from the USA. The finalists come from start-ups, medical device manufactures, non-profits, and academia. The first-, second- and third-place winners will be named to coincide with the 50th anniversary of the TV series' debut and take prizes worth $7 million, $2 million and $1 million, respectively. Qualcomm Foundation, the charitable arm of mobile technology company Qualcomm, provided the prize money.

Contest Rules

There are four basic rules for the Tricorder Challenge. Each entry must:

1) Be a handheld device
2) Continuously take a patient's vital signs
3) Detect a prescribed set of 15 diseases
4) Weigh less than five pounds

"The theme of *Star Trek* is really about what the future is going to be like and the kind of technology we're going to see," said Erik Viirre, Technical & Medical Director of the competition. The interesting takeaway of this competition is that creating a handheld medical laboratory might just give us

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Aezon (US)	Utilizes a wearable monitor that continuously tracks the patient's vital signs, includes a disposable cartridge lab box and a smartphone app that identifies diagnostic tests needed based on the symptoms.
Clouddx (Canada)	Necklace and cuff that records biological data from 11 physiological parameters including blood pressure, pulse and respiratory rates, and heart arrhythmia. Results are available immediately on any tablet via the cloud.
Danvantri (India)	Combines blood pressure, temperature and pulse oximeter, with future generations adding ECG, blood chemistry and glucose analysis.
DMI (US)	With help from NASA and NIH, a universal blood sensor that integrates a very broad set of medical diagnostics using technology based on DMI's rHEALTH Sensor.
Dynamical Biomarkers Group (Taiwan)	Five subsystem modules: Smart Vital Sense Patch/Wrist, Smart Blood Sense, Smart Scope, Smart Exhaler and Smart Urine Sense. All subsystems connect with a smartphone app.
Final Frontier Medical Devices (US)	Portable, consumer-friendly device capable of collecting and interpreting large amounts of diagnostic data giving real-time insight into 22 medical conditions.
MESI (Slovenia)	Medical-grade wristband with user-friendly analysis modules called "To see," "To hear," "Pee," and "Blood." The device also continuously monitors basic vital signs and provides additional patient information.
Scanadu (US)	Bluetooth-enabled device that scans vital signs including heart rate, temperature, respiratory rate and blood pressure. The device also includes disposable urine analysis paddles for testing for pregnancy and health conditions.
Scanurse (UK)	Utilizes existing technology to solve a number of sensing challenges like breath, movement and visual analysis without requiring biological samples.
Zensor (UK)	Wearable, non-invasive monitor that detects heart arrhythmias and securely and immediately transmits the data wirelessly to a physician for review and diagnosis. The device also detects temperature, respiration, blood and urine.

Table 1.

insight into what the next generation of cell phone capabilities might include!

The following is a brief look at the products and capabilities as provided by the 10 finalists.

The Not-So-Final-Frontier

While Bones and his medical crew were the users of this technology in Star Trek, the purpose of this contest is to develop medical diagnostic devices that the average person can use to improve their health.

It should be noted that the original Star Trek series that has inspired 50 years of innovation only ran for three seasons! If I didn't double-check it for myself, I wouldn't have believed it. This just goes to show that there is no time constraint for game-changing innovation. I'm not sure Bones could ever see a time when a computer could be held in our hands…

Captain Kirk: *"Well Bones, do the new medical facilities meet with your approval?"*

McCoy: *"They do not. It's like working in a damn computer center!"* **PCB**

Steve Williams is the president of Steve Williams Consulting LLC and the former strategic sourcing manager for Plexus Corp. To read past columns, or to contact Williams, click here.

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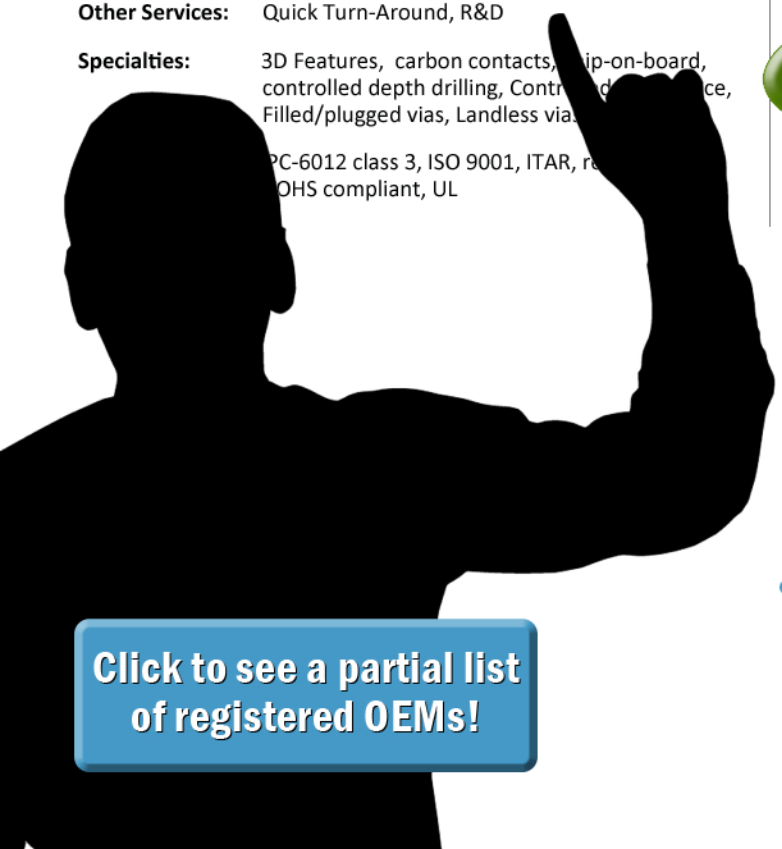

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PCB007 Supplier/New Product News Highlights

Orbotech Unveils Next-generation DI Solution

Orbotech Ltd. announced that it will be launching its newest Direct Imaging (DI) system, the cutting-edge Nuvogo 800, for digital imaging of fine-line HDI, MLB, flex, and rigid-flex applications for mass production, at the TPCA Show.

DuPont Debuts Pure Copper Conductive Ink

DuPont Microcircuit Materials (DuPont) is introducing its first pure copper conductive ink for photonic curing, DuPont™ PE510 copper conductor. DuPont™ PE510 is a cost-effective alternative to silver conductor inks for a variety of possible applications and is the newest product in a suite of conductive ink materials specifically tailored for use in certain types of antenna, membrane touch switch (MTS), radio-frequency identification (RFID), and consumer electronic applications.

ESI Unveils New Laser Micromachining Platform

Electro Scientific Industries, Inc. has announced the μFlex Series multi-axis precision laser micromachining platform, enabling new levels of price-performance in laser applications for consumer electronics, medical devices, automotive components, and many other industries.

MacDermid Electronics Solutions Launches M-Speed

The company has announced the release of M-Speed, a complete chemical process supporting fabrication of high-frequency PCBs. This uniquely-formulated process provides low-profile innerlayer copper while delivering reliably strong adhesion to all high-speed dielectrics.

Technica USA Installs Second Maskless DI Machine at APCT

"We are very pleased with the continued sales activity and interest in the Maskless DI equipment. We have installed four units in the past quarter and have had several successful evaluations during this same period," said Frank Medina, president.

LPKF: Renewed Growth Expected in 2015

After having experienced average annual growth of 23% over the past five years, in October 2014 the TecDAX company had to adjust its annual profit forecast downward for the first time in six years and prepare its investors for lower revenue and earnings in 2014.

Molex Develops 3D Moulded Technology

This innovative 3D technology combines advanced MID technology with LDS antenna expertise to deliver integrated fine-pitch 3D circuitry in a single molded package suitable for high-density medical devices meeting stringent medical grade guidelines.

Orbotech Defies Market Weakness; Posts Solid Q3 Growth

Commenting on the results, Asher Levy, CEO, said, "The overall business environment was solid during the quarter, notwithstanding some weakness in the PCB industry. For Orbotech, the quarter was marked by a strong momentum of innovation." Revenues for the first nine months of 2014 totaled $385.3 million, compared to $317.8 million recorded in the first nine months of 2013.

Rogers Printed Circuit Materials Sets Q3 Sales Record

Bruce D. Hoechner, president and CEO, commented, "We are very pleased to report that in the third quarter, we set another all-time quarterly revenue record and posted our seventh consecutive quarter of year-over-year revenue growth. All three of our business segments contributed solid results and, overall, we saw strong gains in both gross margin and operating margin resulting in excellent earnings."

Isola Completes Testing of Laminate Materials

The company has announced the successful completion of Class 2 testing of laminate materials for Conductive Anodic Filament (CAF) resistance. The laminate materials were constructed with glass fabric woven at Isola Fabrics, a subsidiary of Isola Group S.à r.l.

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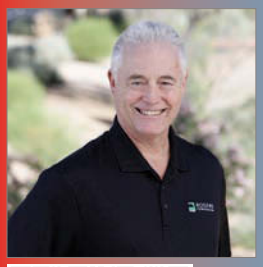

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Getting to the Root Cause: Solderability Defect Analysis

by Michael Carano
OMG ELECTRONIC CHEMICALS

In this case study, the PCB fabricator investigates the root cause of solderability defects on ENIG-processed circuits. It was determined that the fabricator, due to process errors, caused hyper-corrosion within the nickel deposit, which led to the defects.

Introduction

A PCB fabricator received a number of returned PCBs from one of its assembly customers. The issue, according to the assembly team, was dewetting, and in some cases, non-wetting of surface mount pads. In addition, some of those components failed to make a reliable bond to the pad, leading to significant failures. And as so often is the case, someone invokes the ghost of black pad as the culprit. Certainly while such an anomaly is a possibility with respect to the root cause failure mechanism, this case requires significant study in order to properly reach a solution to the problem.

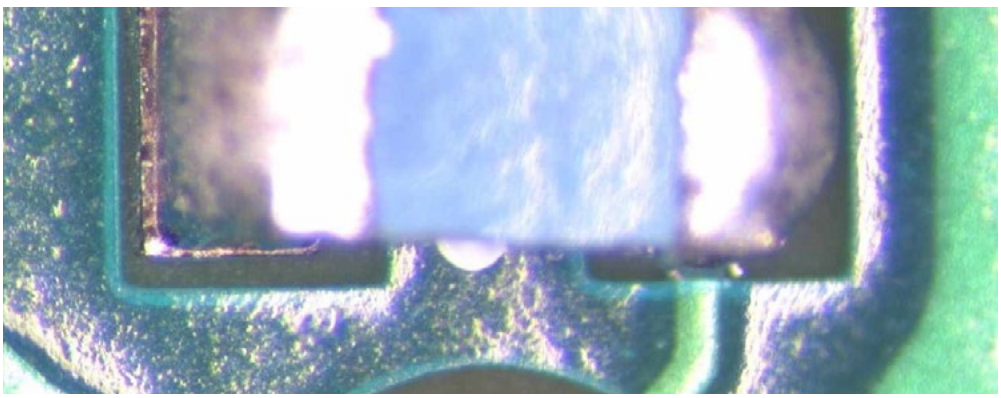

Figure 1: Note area where solder did not completely wet-out.

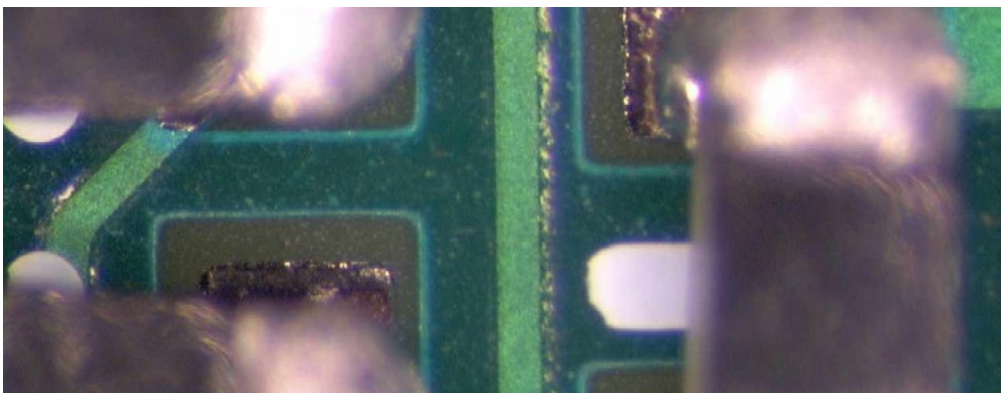

Figure 2: Some additional dewetting.

Problem Identification

First, one must identify the problem or defect (Figure 1 and Figure 2).

I consider this a very minor issue considering the board design, reflow temperatures, and paste print could have a great deal to do with what is seen here.

Now a few other points to consider. The surface finish used for these parts is electroless nickel-immersion gold (ENIG). As is often the case, the first thing one does when seeing any type of solderability/assembly defect is to suggest ENIG is the issue and the root cause is black pad. Sometimes that is

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true. However, further analysis is required before one can accurately draw any conclusion.

It was suggested that cross-sectional analysis be performed in order to look at the interface of the solderjoint and pad on those areas that appeared dewetted or non-wetted (Figure 3).

Note in Figure 3 the very non-uniform electroless nickel deposit. In addition there appears to be corrosion spikes of the immersion gold into the nickel deposit. Now with this information there are a few critical questions the troubleshooter needs to ask and find answers to:

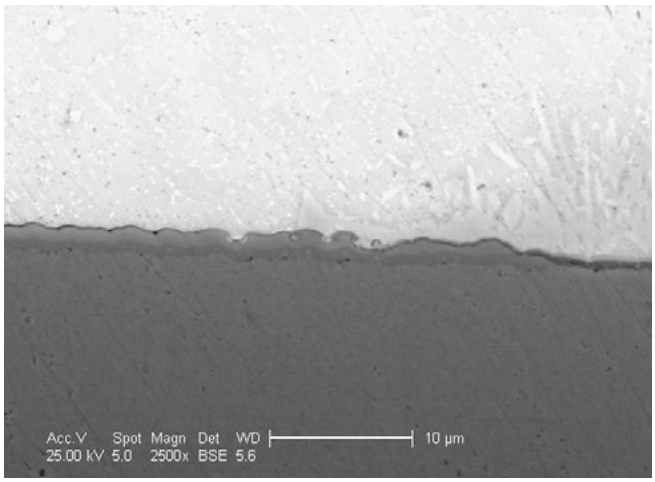


Figure 3: After assembly.

1. What gold thickness is being deposited on the nickel?
2. What is the phosphorous content of the nickel being deposited?
3. How long of an immersion time is used for the gold process?

With additional analysis performed, a number of these questions are answered (Figure 4).

A closer look at the cross-sections in Figure 4 provides evidence of corrosion spikes in the nickel after the deposition of the immersion gold. What accounts for such a stark contrast? These are both of the same design. The only difference was that the board represented by the coupon on the left was processed down the ENIG line by a member of the tech team. In this case, that individual adhered to strict procedures as to dwell times, operating temperatures in each process tank and checked the analysis of each process step to ensure all of the key additives and concentrations were within the prescribed ranges.

With this information in hand, the team found out that due to a customer request for a thicker gold deposit (4–5 µin as opposed to that called out in the IPC Spec 4552), the PCB fabricator processed those parts in the immersion gold for a longer period of time (essentially 19-minute dwell time as opposed to the 10-minute dwell time recommended by the supplier). The idea for the longer dwell time

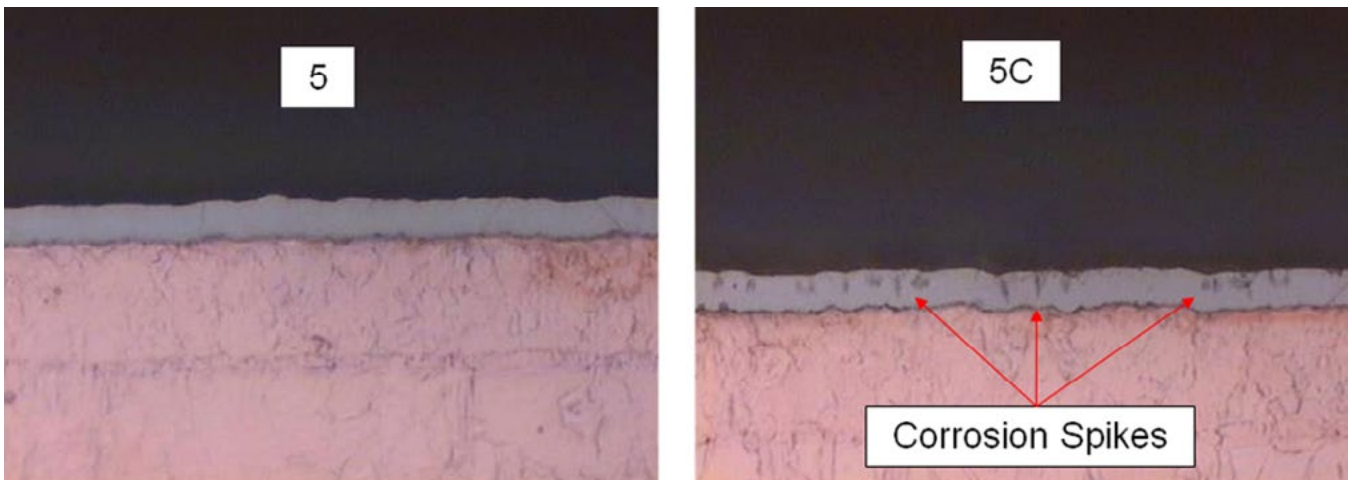


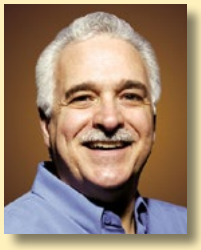
Figure 4: Normal nickel structure on test coupon performed by trouble shooting team (left). On right, coupon from board processed by the PCB fabricator.

was to achieve a greater gold deposit thickness. As one can see, the outcome was undesirable. Longer dwell times can certainly lead to hyper-corrosion of the nickel, which in turn affects solderability. Clearly, this particular ENIG system was not designed to deposit a higher thickness. This should be the job for a true electroless gold, not an immersion gold. Certainly it has been shown that for solderability purposes 1–2 µin of gold is sufficient. Wire bonding is a different story and requires a thicker gold deposit.

A phosphorous content analysis of the nickel deposit (prior to immersion gold) provided additional insight to this problem. Phosphorous concentrations were on the low end (4–6%) of what is normally expected for ENIG plating process. With low phos content in the nickel, the deposit is more susceptible to corrosion. This situation promotes higher gold thickness deposits and leads to hyper-corrosion. It is suggested that in order to promote good solderability and reduce or eliminate the chance of hyper-corrosion, a mid- to high-phos nickel (8–10.5%) process be used.

Summary

In this case, poor solderability of the nickel was caused by the hyper-corrosion of the deposit. However, the root cause of the corrosion was two-fold. First, the fabricator was operating the ENIG out of specification. Essentially, this was caused by extended immersion dwell times in the gold solution. A second cause was the use of a low phosphorous nickel process. Low-phos nickel has a greater tendency to corrode than the mid- to high-phos nickel process. **PCB**



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

New Semiconductor Device for Better Photodetectors

UCLA researchers have developed a perovskite photodetector that could reduce manufacturing costs and improve the quality of medical and commercial light sensors.

Photodetectors are semiconductor devices that convert incoming light into electrical signals. They are used in a vast array of products, from visible and infrared light detection systems to television remote controls.

Perovskite is an organic-inorganic hybrid material with a crystal structure that is extraordinarily efficient for converting light into electricity. In recent years, the use of perovskite materials has led to rapid advances in the efficiency of solar cells.

A research team led by Yang Yang, the Carol and Lawrence E. Tannas Jr. Professor of Engineering at the UCLA Henry Samueli School of Engineering and Applied Science, has developed a photodetector that uses thin coatings of perovskite—rather than silicon or other common materials. The perovskite coating is roughly 300 nanometers, about the width of a single bacterium, while the silicon layer in common photodetectors is 100 micrometers, or more than 330 times as thick. As a result, the device efficiently and quickly transports signals with minimum loss. It also offers improved sensitivity under dim light.

"Our innovation is using the perovskite material on a photodetector, and then putting it in the proper structure so that the material can work most efficiently," said Ziruo Hong, one of the authors of the paper and a research engineer in Yang Yang's lab.

The research was published recently in Nature Communications and supported by the National Science Foundation and Air Force Office of Scientific Research.

PCB007 Market News Highlights

Global OE Market to Grow $75.82B in Coming Years

The organic electronics market is expected to grow from $16.45 billion in 2014 to $75.82 billion by 2020 at a CAGR of 29%. This growth is heralded by the growing display applications for organic electronics market. The lighting applications for this market are also expected to grow rapidly in the coming five years.

Top 20 Global Semiconductor Sales Ranking for 2014

The top 20 worldwide semiconductor (IC and OSD-optoelectronic, sensor, and discrete) sales ranking for 2014 includes eight suppliers headquartered in the U.S., three in Japan, three in Europe, three in Taiwan, two in South Korea, and one in Singapore, a relatively broad representation of geographic regions.

Smart Grid Infrastructure Gets $13.6B Investment from SEA

"Smart grid investment over the next decade will shift from North America and Europe to emerging market regions," said Ben Gardner, president of Northeast Group. "Southeast Asian countries are just beginning on the path of modernizing their electric infrastructure."

Industrial Internet Sensors to See $20.1B in Revenue

In a newly released report from NanoMarkets, the firm predicts the value of Internet-connected sensors for industrial applications is expected to grow to $20.1 billion by 2019. This report also identifies and quantifies where the opportunities are for makers of these sensors and provides eight-year forecasts for a variety of industrial sensors types.

Power Electronics Market Outlook Shows 9.6% CAGR

The Global Power Electronics Market 2014–2018 research report forecasts the industry to grow at 9.6% CAGR during 2013–2018. The Global Power Electronics market can be segmented into five end-user segments: commercial, industrial, consumer electronics, transportation, and other.

Wearable Technology to Continue Evolution

New research shows that wearable technology will evolve beyond its current ecosystem, which is very dependent on smartphone integration. New business models will develop that place wearable tech at the center of communications, applications, content, and commerce without the need for handheld devices of any type.

APAC to Retain Growth in Nanotech-enabled Printing

BCC Research reveals the global market for nanotechnology-enabled printing technology is expected to grow at a projected CAGR of 17.7% over the next five years to total $31.8 billion by 2018. The Asia-Pacific region is the largest buyer of printing technologies and will retain growth through the forecast period with 17.3% CAGR and reach revenues of $20.2 billion.

Bluetooth Low Energy Dominates Wearable Connectivity

"Wearables are about the quantified self, more than likely, communicated via Bluetooth to a smartphone to view the results and then possibly from there to a cloud-based service for aggregation and further analysis," states Nick Spencer, senior practice director, Mobile Devices at ABI Research.

Critical Innovation Stage to Drive Cloud Services Market

Public IT cloud services spending will reach $56.6 billion in 2014 and grow to more than $127 billion in 2018, according to a new forecast from International Data Corporation (IDC). Among the factors driving public IT cloud services growth is the adoption of "cloud first" strategies by both IT vendors expanding their offerings and IT buyers implementing new solutions.

3D Printing Materials Market to Grow Significantly

The 3D printing materials market is expected to grow significantly in the next few years, due to high demand for 3D printing technology in various industries such as electronics, consumer products, automotive, aerospace, and medical.

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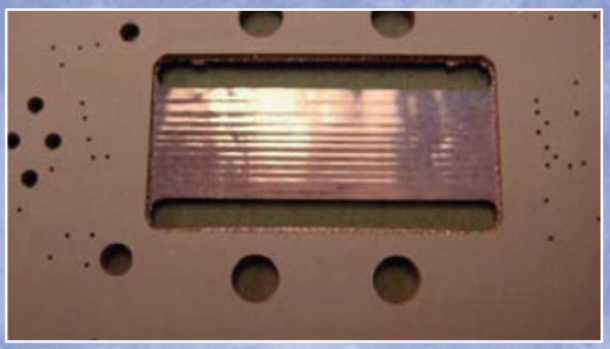

POLYIMIDE FLEX WINDOW IN RIGID FLEX CIRCUIT BOARD.

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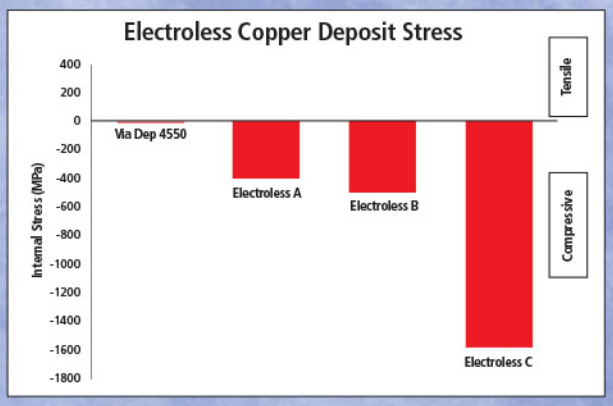

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TESTING TODD

Electrical Test Coverage

by Todd Kolmodin
GARDIEN SERVICES USA

Recently, I was asked what 100% electrical test coverage is. An interesting query, considering that with electrical test, the answer comes with yet another question: Is 100% really 100%?

The first question is are all nets tested? If that answer is yes, then 100% test has been achieved.

However, this is where the scenario gets a bit cloudy. It comes down to what is tested and how many actual contacts of the PCB are tested.

In standard industry practice for almost all IPC Class II (Level 2) product, the end points of every net are tested for continuity (opens) and all nets are checked for shorts (Figure 1). Keep in mind that with flying probe, shorts are checked by the use of an adjacency window (as discussed in my November column). This standard practice optimizes the intermediate or "mid-points" in a specific net and validates only the end-to-end connectivity based on the continuity threshold parameters. To make it simple, think of this as your light switch at home. The power company supplies the power from the sub-station to your home and all you are really concerned about is that when you flip that switch, the light comes on. This validates your electrical test. You are not necessarily concerned about each pole that the connection comes through, only that your light comes on. Since your light comes on the circuit is valid.

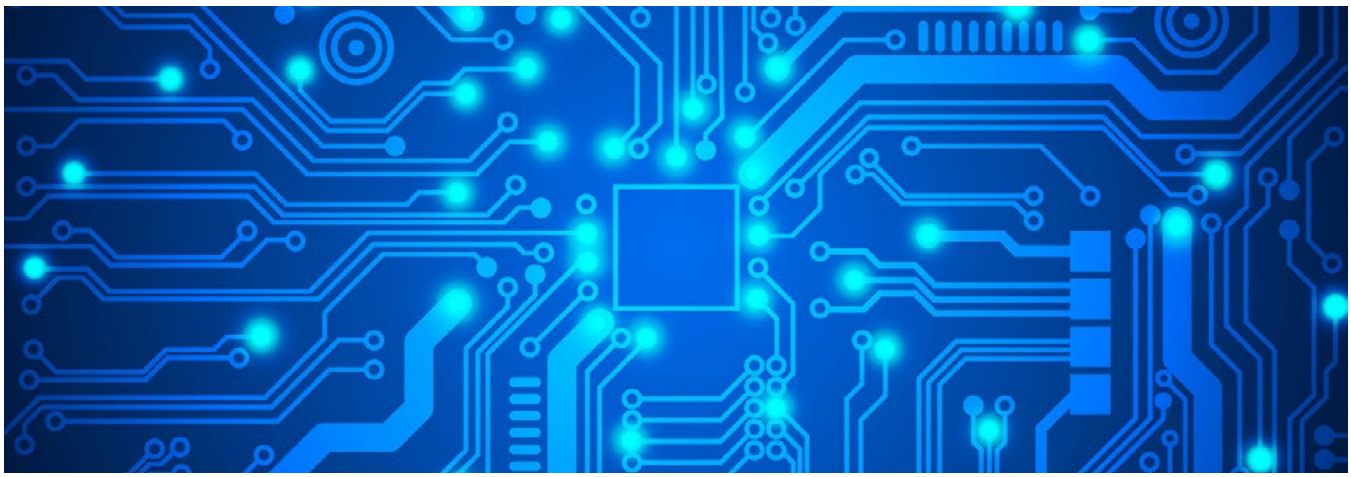
Also in conjunction with this, you wish your 60w bulb to light according to voltage supplied. Again if the light illuminates as expected you are not concerned. The circuit is not interfering with any other. The test is 100%. No errors are detected.

However, in higher-reliability applications you may wish to add a light to one of the poles between you and the substation, but you see that you cannot because a local avian species has decided to take refuge on that specific pole and has covered the insulators where you need your connection! Does this make your test less than 100%? No. You already validated that your light works at your house.

This is where the question arises. In Class III (Level 3) product, the inclusion of mid-points is indicated. Is this "more" of a 100% test? No. The nets have already been 100% tested for functionality but now we are adding redundancy testing of the nets already tested.

IPC- 9252A states that Class III incorporates mid-point testing, but also has a footnote regarding accessibility to the mid-points. Processes such as via fill and via cap can remove the accessibility of test points.

In the standard optimization process the nets are validated end-to-end, meaning feed-through holes or vias are only validated to the



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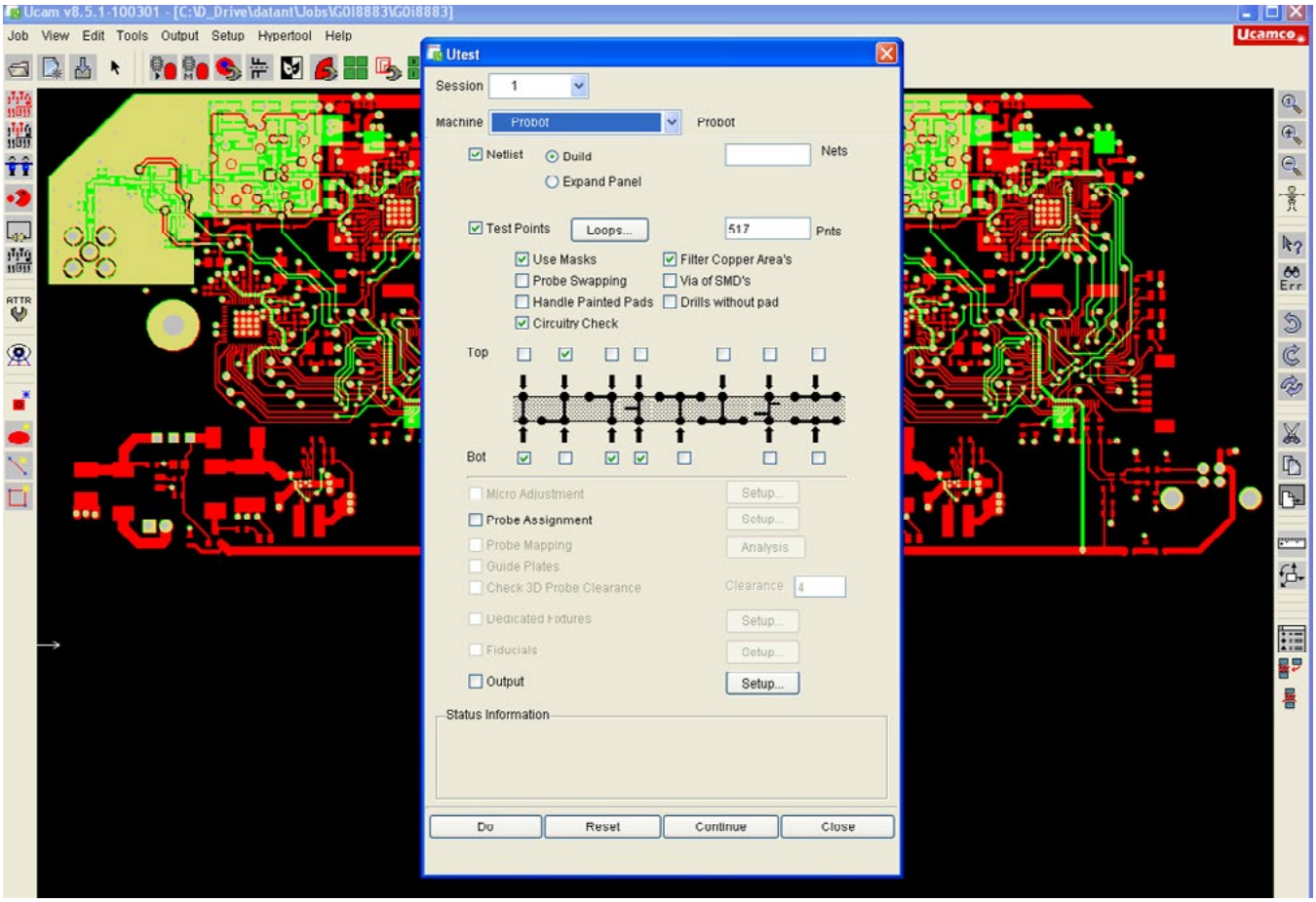

Figure 1: Optimization.

extent of signature pass-through. Depending on the design copper above or below, however, the signal pass-through is not validated as irrelevant to the final "light switch" at the end. This is where problems can arise at the CM. There can be a void above or below the signal pass-through that allowed a signal validation during ET, but now that components are installed the via or feed-through cannot validate the signal even though the board is functional. Does this mean the board was not 100% tested? The answer is no. In a Class II board no violation has occurred. In a Class III board the void should have been detected if the test point was available. One must remember in a Class III scenario that the test point must be available and not just because the design shows it. Manufacturing processes such as via fill or via cap to the opposing side must be taken into consideration as mask may be pressed into the via from the opposing side, filling the barrel and actually insulating the ability to accurately probe the landing pad or annular ring. These all must be considered from the OEM/design side to ensure that a class III test can be performed if indicated.

100% test is always achieved for end-to-end "light switch." For enhanced redundancy testing the OEM must be aware that design options such as via fill and capping can put an "owl's nest" on the redundant connections that may not allow the enhanced test.

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

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TOP TEN

PCB007 News Highlights This Month

① Viasystems' Faces Challenging Third Quarter

"Regarding Viasystems' operating activities in the third quarter, we had to overcome several challenges, including a temporary work stoppage by employees in our largest factory in China, a sudden downturn of demand for products assembled in our Juarez, Mexico factory, and a temporary disruption in the supply chain for certain raw materials used to produce our printed circuit boards," says David M. Sindelar, CEO.

② Dragon Circuits' Drone Division Experiments with Deliveries

The company announces the successful completion of 14 autonomous and semi-autonomous delivery test runs with payloads ranging from a few ounces to a few pounds. With the recent interest in drone-based delivery by internet giants like Amazon and Google, Dragon Circuits looks to capitalize on a forthcoming demand with the expansion of their drone department.

③ TTM Reports Sequential Increase in Q3 Revenue

Net sales for the third quarter of 2014 were $345.3 million compared to $297.6 million in the second quarter of 2014 and $338.7 million in the third quarter of 2013.

④ Q3 PCB/EMS Market Snapshot

I-Connect007's latest market survey—a one-minute survey designed to provide a snapshot of the current state of the PCB and EMS industries—offers a good sampling to give us a snapshot of where we've been and where we're headed.

5 IPC: N.A. September PCB Orders Strengthened

"The North American PCB industry's solid sales and order growth over the previous month reflects normal seasonal patterns," said Sharon Starr, IPC's director of market research. "Despite strong order growth in September, orders continued to lag shipments by a small margin, pushing the PCB book-to-bill ratio just below parity."

6 MFLEX Rebounds in Q4, Expects Sustained Growth

"We had a strong fiscal fourth quarter with net sales results at the high end of our guidance range, gross margin exceeding our guidance range, and a return to profitability, an important milestone for the company. Our net sales increased 32 percent sequentially, driven by new programs that ramped across our customer base," says Reza Meshgin, CEO.

7 AT&S Reports Improved Profitability in 1H of 2014/15

In the first six months of the financial year 2014/15 (April 1–September 30, 2014) leading PCB manufacturer AT&S generated revenue of EUR 302.1 million, which was in line with the high level of revenue reported for the same period last year (H1 2013/14: EUR 299.9 million).

8 Continental Named PACE Award Finalists for BD-HDI PCB

Continental, a leading international automotive supplier, has three product innovations advancing as finalists in the 2015 Automotive News Premier Automotive Suppliers Contribution to Excellence (PACE) Award program.

9 SCHWEIZER Posts Strong 3Q14 Results

"Our business results after the first nine months of this fiscal year are really satisfying and come up to our expectations. In the third quarter, successes in our portfolio management already had an important influence on the improved results compared to the second quarter," says Dr. M. Schweizer, CEO Schweizer Electronic AG.

10 Aspocomp Reports Positive 2014 Amid Q3 Sales Drop

Deliveries slowed down significantly in July–September, and third-quarter net sales amounted to EUR 4.9 million, a year-on-year decrease of EUR 0.3 million. Sales decreased mainly because telecommunication customers had placed over-large orders at the beginning of the year.

EVENTS

For the IPC Calendar of Events, click here.

For the SMTA Calendar of Events, click here.

For the iNEMI Calendar of Events, click here.

For the complete PCB007 Calendar of Events, click here.

International Printed Circuit & APEX South China Fair
December 3–5, 2014
Shenzhen, China

Space Coast and Tampa Bay Expo & Tech Forum
December 4, 2014
Kissimmee, Florida, USA

Counterfeit Electronics Components—Avoidance and Detection
December 4, 2014
Exeter, UK

SMTA Pan Pacific 2015
February 2–5, 2015
Hawaii, USA

MEDIX 2015
February 4–6, 2015
Osaka, Japan

IPC APEX Expo 2015
February 24–26, 2015
San Diego, California, USA

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