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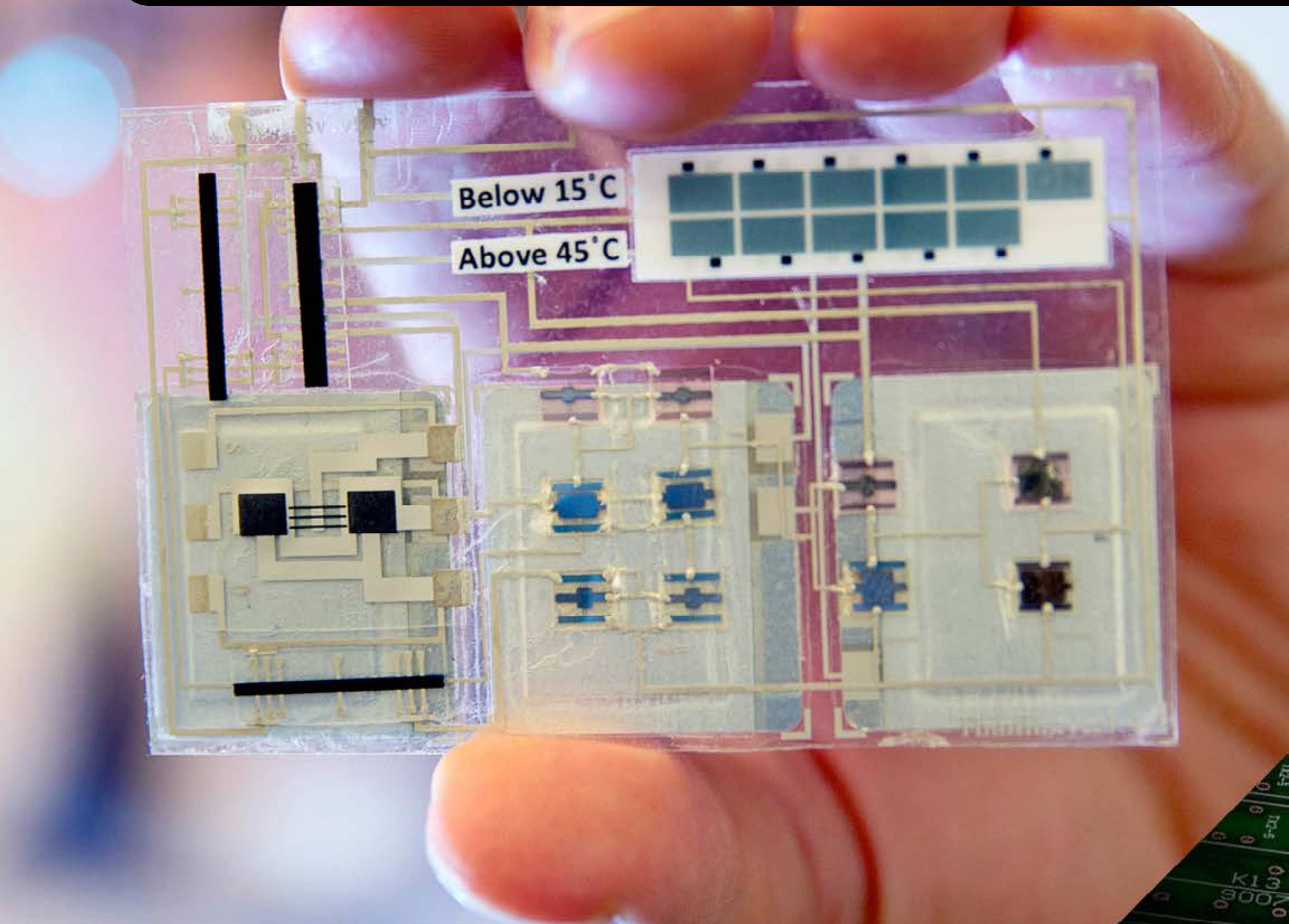

Printed Electronics: Technology Case Study

by Dr. Harry Zervos page 12

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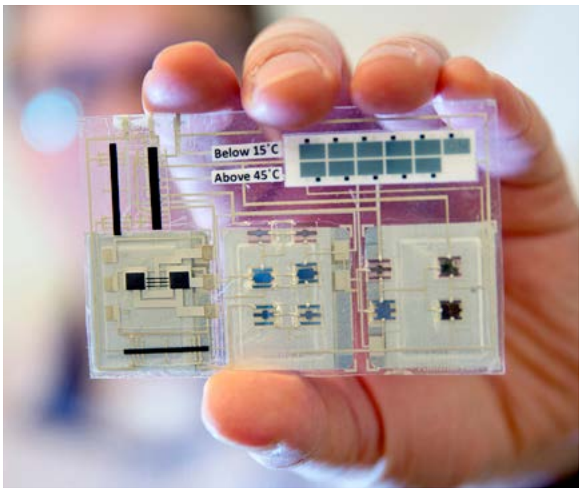
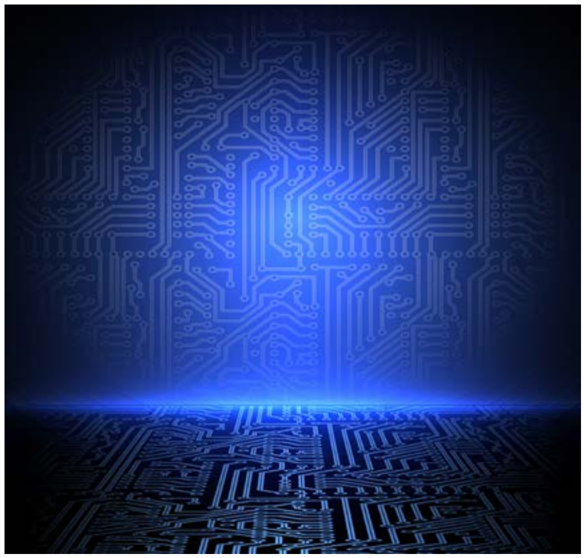
August 2014 Featured Content

PRINTED ELECTRONICS ASSEMBLY

Printed electronic circuits have been in development for a while, but PEC only got off the ground within the last few years, and technologists have more questions than answers. This month, *SMT Magazine* delves into printed electronics assembly with articles from expert contributors Dr. Harry Zervos, Sumit Kumar Pal, Joe Fjelstad, and an interview with Rafael Nestor Mantaring of IMI that focuses on PEC.





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AUGUST 2014
VOLUME 29
NUMBER 8
www.smtmagazine.com

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THE WAY I SEE IT

Bits and Pieces

by Ray Rasmussen
PUBLISHER, I-CONNECT007

The PCB Dream

I had a recent discussion with a board fabricator about the expansion of his business. The company was looking into the possibility of buying an existing facility and asked that I keep them informed if I came across any companies that were interested in selling. My first thought was that these guys know how to run a business; they'll do well with a good, strategic acquisition. Then, after thinking about it a bit, I changed my mind. Why buy someone else's obsolete factory with all of its environmental baggage? You might buy a business for a strong customer base or if you were looking for a new capability, but it would have to be really compelling. Instead, build something new.

What if you could put together a new, state-of-the-art, highly automated factory without waste treatment (no air or water)? I have the opportunity to visit such a factory being built right here in the U.S. by an OEM that is making the necessary investments.

Think about it: Increasingly better CAD and CAM software makes going from design to direct imaging more of a reality. If you fully investigated a one-off panel production flow, just in time, along with a system like Mutracx which guarantees panel quality, you could flow from design through etch without a pause. I imagine a PCB factory looking more like a PCB assembly line, with long columns of equipment moving product through the factory. I believe everything is available to take a board from one end to the other in a smooth flow, without too many stops. And if we just invested a bit more in those areas where product stops, we could build a PCB from end to end, quickly and efficiently.

So, if you were starting a PCB facility from scratch, how would you build it? I know that


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BITS AND PIECES *continues*

many of you out there can see what's happening and what's possible with the newer systems that are now available. I'd love to see your plan for the PCB factory of the future. Please send me your thoughts. I'll share them with the rest of the readers. Let's see what's doable, today.

Watch for my article this fall that describes a new factory currently taking shape, one that is adopting all of the latest technologies in order to become the PCB factory of the future.

PE, 3D PCB Machine

I've been really intrigued by the marriage of printed electronics and 3D printing. After intently watching the emergence of printed electronics over the last 5–10 years, I can clearly see the intersection between the PCB and PE industries. And now, with the rapid advancement of 3D printing, we're starting to see applications for full-blown PCBs. Considering the cost associated with proving out a PCB design, offering up PCB proto machines seems like the logical first market for these systems. With a market PCB protos alone to be in the billions of dollars, with thousands of potential systems, it must look quite attractive to those building these systems. It's not just the cost of the PCB; it's the value of the time as well. Taking a couple of days or weeks out of the product development cycle is worth a lot more than the PCB. With that in mind, we see the introduction of a few new entries to the market.

> ***"With a market PCB protos alone to be in the billions of dollars, with thousands of potential systems, it must look quite attractive to those building these systems. It's not just the cost of the PCB; it's the value of the time as well."***

Recently, we posted this article on pcb007.com: FirePick Delta 3D: One Step Closer to Desktop Electronics Manufacturing. The system described in the article is quite interesting and gives us a glimpse of where this is heading. Here's a quote:

This machine is capable of doing two of the most important and difficult tasks in the process of assembling working electronic devices. While it's not quite to the point of simply being able to press a button and have it print out an entire working device on its own, it certainly shows us how close we are to one day having a machine that will print and assemble working electronic devices at the touch of a button.

In another recently posted article, Advantech Launches Printing Tech for Microelectronic Industry, we find this quote: Features and devices below 5 µm are typically the realm of Chips/VLSI. Features above 30 µm are the realm of traditional printed circuit and device technologies. The manufacturing processes of these two worlds have rarely intersected. Advantech US has developed a printing process that allows these worlds to merge.

I also came across a video, which introduces a system to make desktop PCBs. It's not so much the system, but who is making it: young engineers. Check it out!

It's not doom and gloom here; it's just that there seem to be opportunities emerging in the PCB and assembly space that we all need to be aware of. That's what I'm trying to do. If it were just a few hobbyists making PCBs on their workbench, it would be one thing. Instead, there are two potentially very large industries emerging that are starting to intersect more and more with what we do each year.

For more on the PE, 3D merger, visit our printed electronics news section.

Internet of Things

It's kind of a corny name for something that's about to have an impact on everything we do. If you haven't heard the term Internet of Things (IoT), you will. With a market size in the trillions (yes, with a "t") of dollars, the IoT will touch just about everything we do. We see lots of interest and investments being made by all the major players from just about every industry. And the IoT isn't just for the factory floor, as we found out recently with Apple's announcement that it was moving into the connected home market along with Google and other major OEMs. IEEE jumped into the fray: "The Internet of Things represents a vast landscape of amazing potential; we are just now beginning to grasp how truly far the growing convergence of many traditionally standalone applications and cyber-physical systems can take us," said Oleg Logvinov, IEEE committee chair who is director, special assignments, Industrial and Power Conversion Division, STMicroelectronics.

To read more about IEEE's efforts, click here.

I wouldn't say I'm mesmerized by all these new and emerging technologies and industries, but I am certainly intrigued. I am quite hopeful that our industries will embrace some of the newer manufacturing technologies as well as the emerging ones and incorporate them into their offerings as soon as is applicable. I hope the industry will not be blindsided by what's coming, but will instead seize the opportunities they offer. That's why we cover this the way we do. It's important. Pay attention.

Sustainability in the Supply Chain

Pam Gordon, of Technology Forecasters, has written an article for Green Biz titled How to make electronic trade groups drive sustainability. With help from IPC, Gordon gathered input from association members to gain some perspective on how industry associations engage their members on environmental sustainability. A couple of questions: First, is it their (the association's) job to drive this in the industry? Second, what is "environmental sustainability"? Here's how the U.S. Environmental Protection Agency describes it: *Sustainability is based on a simple principle: Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.*

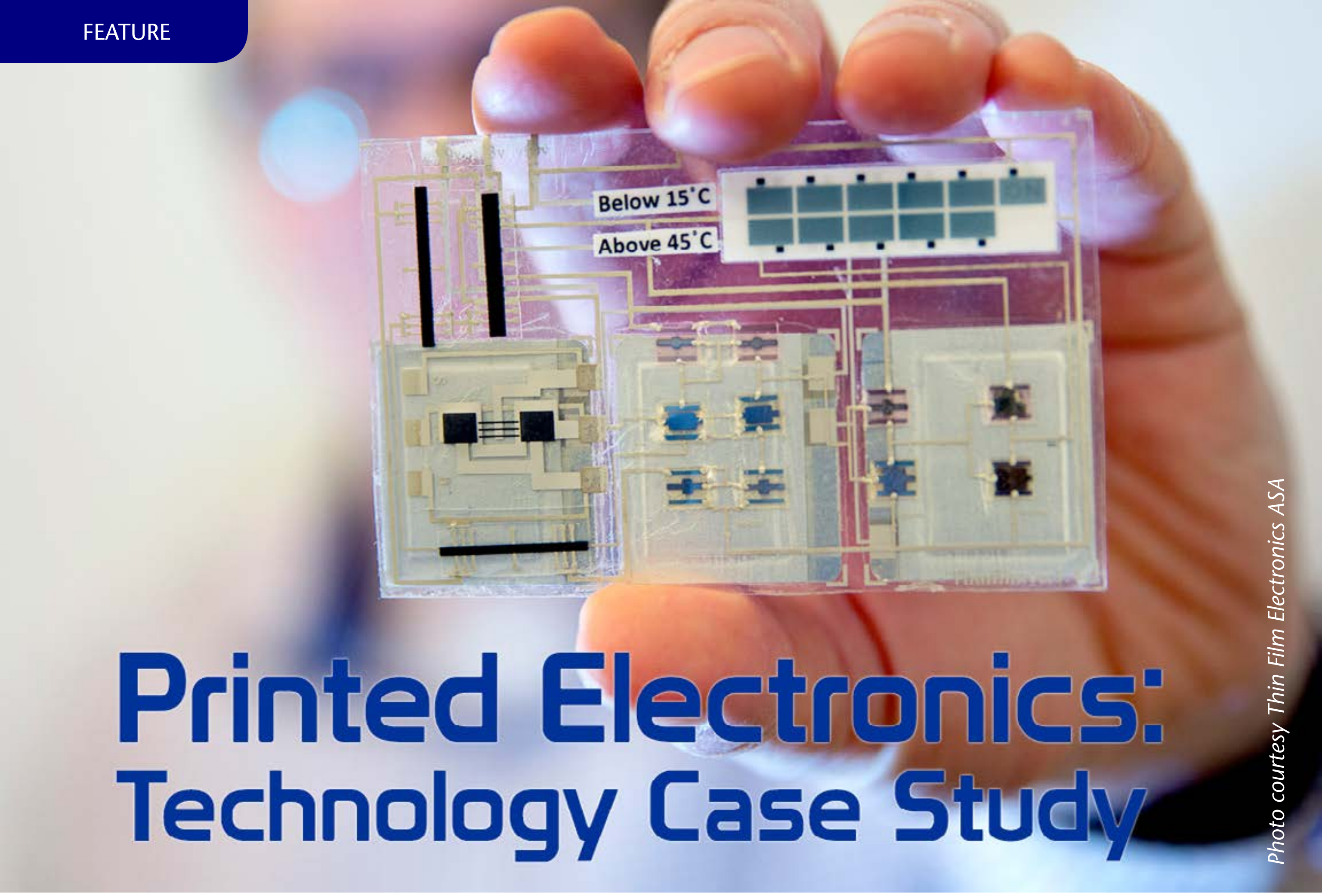
Although I think it makes for an interesting article and it caught my attention, I'm not so sure this is an issue for our associations. Where are we falling short? Yes, we all use dangerous chemicals, but what does that have to do with sustainability? If we're doing our environmental bit, what are we doing that isn't sustainable? If we're keeping the air and water clean and recycling everything that can be recycled, why do we need to make this an industry issue? Can we all do our part to lessen our impact on the environment? Sure. But it's the OEMs and the politicians that will drive the effort toward cleaner tech, not the associations.

"*If we're doing our environmental bit, what are we doing that isn't sustainable? If we're keeping the air and water clean and recycling everything that can be recycled, why do we need to make this an industry issue? Can we all do our part to lessen our impact on the environment?*"

Sustainability is important to making sure that we continue to have, the water, materials, and resources required to protect human health and our environment. And, if you have a flat roof, which most of our factories do, you should be looking into solar options which will lessen your impact by helping to clean the air and reduce the impact of global warming. I suspect that most, if not all, chemical companies have their own sustainability efforts underway, along with all the component makers. Might be best if, as part of our industry-wide PR efforts, the associations took stock of where we stand today with regard to sustainability. But, I don't think we need associations to drive this.

Well, I hope you are all enjoying your summer. See you soon at the next industry event. **SMT**

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.



Printed Electronics: Technology Case Study

Photo courtesy Thin Film Electronics ASA

by Dr. Harry Zervos
IDTECHEX

The following article summarizes the current status of the main printed electronics technologies for components in consumer goods and healthcare applications, providing for each one market drivers, case studies and key suppliers, cost structures and challenges.

These are given in three main sections: displays, power and other components such as logic, sensors, and conductive inks.

Displays

AC Electroluminescence

AC electroluminescent displays are simple, screen printed light emitting displays that require an AC power source. They are built of low-cost, light-emitting segments that can be relatively thin and conformable.

Examples of cases studies include moving images on labels for Copoya rum (USA) and Ballantine's Whisky promotional bottles (Europe), as well as promotional off-package signage (posters, etc.) by a large number of companies such as Pepsi, Coca Cola, etc. (off package). EL displays are also widely used on wearables such as promotional/novelty T-shirts. Suppliers include Schreiner, Lighttape, Electroluminate as well as several manufacturers in China.

Figure 1: LED labels are appearing on bottles of liquor.

Advantages of the technology include the fact that lead time is short—four weeks is typical—and lifetime is good enough for packaging applications. In volume, costs can be less than $10 for relatively large (A4 size) promotional posters, including power supply and display driver. On the downside, voltage supply is high (e.g., 120-240V) and tends to emit a hum, It's also difficult to see the active parts of the display in high levels of light, although that's not an issue for darker environments.

Electrochromic

Electrochromic (EC) displays are very simple, screen printed structures, characterized by low power consumption. They are low-cost reflective displays that have been used in promotional material such as M&S gift cards and the CANVAS magazine cover. Beyond those, it's only been mostly prototypes so far, such as displays for smart cards, gift cards, etc.

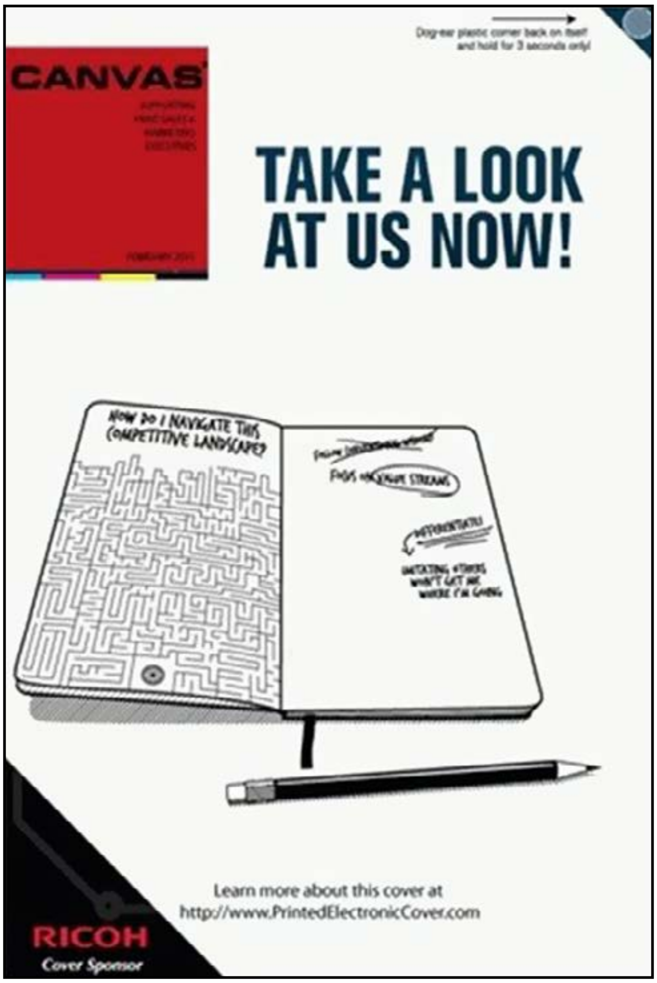


Figure 2: One example of an electrochromic display.

Ynvisible tends to be the most creative company spearheading the technology so far, with BASF active on the material side (working with Ynvisible on better colour rendition) and ACREO of Sweden also having done significant development work on the topic.

In volume, costs would be less than $.05 per active square centimeter. What is problematic and the main reason why there have been several smaller company failures (e.g., Aveso, Ntera, Ajjer) on this segment is the fact that end users do not like the limited colour range (mostly just blue) and slow response time.

Electrophoretic

Electrophoretic displays (EPDs) have proliferated in e-readers such as the Amazon Kindle, but this market is currently in decline. Consumer goods and healthcare applications have seen e-paper displays as one-offs in magazines (Esquire in 2008), POS posters, and in products such as key fobs, memory sticks, locks, etc. These have been fairly niche applications so far, but technology developers are looking to push further adoption in these markets due to the slowdown in the e-reader space. It's important to point out adopters in this market sector demand good colour rendition, a challenge that EPD developers have struggled with.

OLED

Organic light-emitting diode (OLED) displays are currently mostly made by vacuum processes. Printing is possible and extensively researched but not in commercial products yet. The materials are light emitting materials characterized by low power consumption, excellent colour range but still very expensive.

Other than their use in smart phones and televisions (OLEDs are already a $10 billion market in 2013 for cell phone displays, OLED TVs were launched in 2013), in the CPG space there have been very limited demonstrations such as those by Toppan Forms (an OLED powered wirelessly) and DNP.

Figure 3: OLED displays are finding their way onto business cards.

Most important players include Samsung, LG Display, Sony, Panasonic, AUO and in the materials space Merck, UDC, Novaled, Plextronics, Samsung, Idemitsu, DuPont, Dow, 3M.

Drawbacks for further adoption in the CPG space include:

- Costs are still high, approximately $30 for a cellphone display including backplane
- Lifetime for flexible versions is very poor unless a large amount of money is spent on good flexible barriers (which cost more than glass)
- Focus is to make high volume, high margin products like consumer electronics for now to recoup high R&D spend rather than low margin products

Power

Printed Batteries

Thin film batteries—usually MnOZn chemistry when printed but rigid, lithium ion solid state versions are in development also—are very important components in CPG applications, especially since all devices need a power source which needs to be safe and as "green" as possible. Estee Lauder skin patches and audio paper/recording gift cards from Toppan Forms have been successful applications in the past but beyond that, there have only been prototypes such as powering LEDs in gift cards.

Examples of developers of printed thin batteries include Bluespark (primary), Enfucell (primary), Imprint (secondary) and Powerpaper, a company that failed a couple of years ago after commercializing its technology on the Estée Lauder skin patches. On the thin film Li ion front, Cymbet and Solicore are the main developers.

Costs are at approximately $.25 or more for printed batteries and $1+ for thin film Li ion. Unfortunately, lifetime and power output are not as good as a coin cell so still, if a coin cell can be used, it probably will be preferred over the form factor benefits of a thin film cell.

Photovoltaics, OPV & DSSC

In the photovoltaics space, organic PV and dye sensitized solar cells (DSSCs) can perform optimally in indoor applications (i.e., lower levels of light intensity) where other PV technologies fail. Companies are pursuing these to power electronic shelf edge labels, as they work well at low light levels and the solar cell can be designed around the bezel and even coloured to look better than conventional PC cells. Unfortunately, the technology has only been sold in small volumes in bags and wireless keyboards to date, along with some promotional/POS posters that failed due to cost in Japan. Companies working on designing and realising new concepts and new product ideas include Belectric, Solarprint, Dyesol, Armor, and G24i Power.

Reducing costs and optimizing lifetime and efficiency remain the biggest challenges for these technologies, but those specifically working on CPG space face a power output challenge. Wherever larger areas are available, this challenge can be overcome.

Wireless Power Transfer

Wireless power (e.g., via NFC) would remove the power source cost component which would enable smart packaging features at lower costs. Demonstrations such as the interactive Cheerios packaging from Fulton innovations (Figure 4) that is powered wirelessly via induction have already been showcased.

PolyIC and PragmatIC also work on wireless power options, but of course, antenna, component and infrastructure costs remain challenging.

Figure 4: Interactive Cheerios packages are wirelessly powered.

Figure 5: Interactive bottle labels feature wirelessly powered LED sequences.

Other Components

Logic

Printed or organic low-cost, low transistor count devices would satisfy the needs for logic required for many mainstream applications. There have been efforts to print RFID tags, but although these have been demonstrated, they are not commercial yet. PragmatIC is working on many product prototypes and smart packaging concepts with different companies. They have shown winking gift cards, and interactive bottle labels with wirelessly powered LED sequences (Figure 5) have worked with De La Rue and Tiger Print (Hallmark), etc. The company also announced that ITW has licensed their technology. ThinFilm and PARC are also very active in this space.

The end game is to put together an ecosystem that would focus on building complete devices. The challenge remains integration of all the varying components but also identifying the application and need; people are trying a lot of ideas to see what sticks.

Conductive inks

The application here is printed ink for simple conductors, resistors, capacitors, heating element. These elements constitute components that are easy to do, low cost, required to connect different parts of the device and can be deposited directly onto packaging substrates.

Innovations include:

- Touch code from Printechnologics: printed conductors on a card that can

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In terms of developers, there are many ink suppliers but the key are the product designers. These include T-ink, MWV, Printechnologics, Soligie, Printed electronics GmbH, GSI Technologies and Ynvisible.

Costs tend to be variable, but are usually high especially since, for the time being, all these are hybrid devices, with several very different technologies to be integrated, where ink is not the dominate cost. The challenge remains in the product design and integration with other components in order to make the final, fully functional product.

Sensors

Integrated sensors of different parameters are the key in this segment. Demonstrators/prototypes are available such as motion sensors that detect someone's presence, used to trigger a sequence only when necessary, photodetectors from ISORG, temperature sensing from PST Sensors, etc. These are still not made in high enough volume but overall, the challenge remains in defining the right complete product for these applications as well as working to put together/integrate the driving electronics. **SMT**

Dr. Harry Zervos is a senior technology analyst with IDTechEx.

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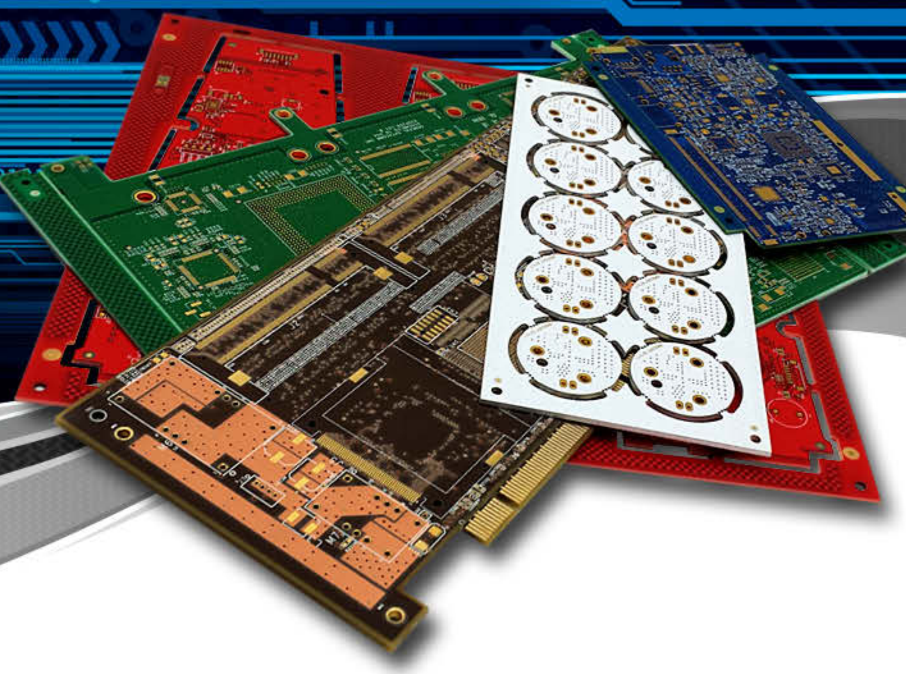

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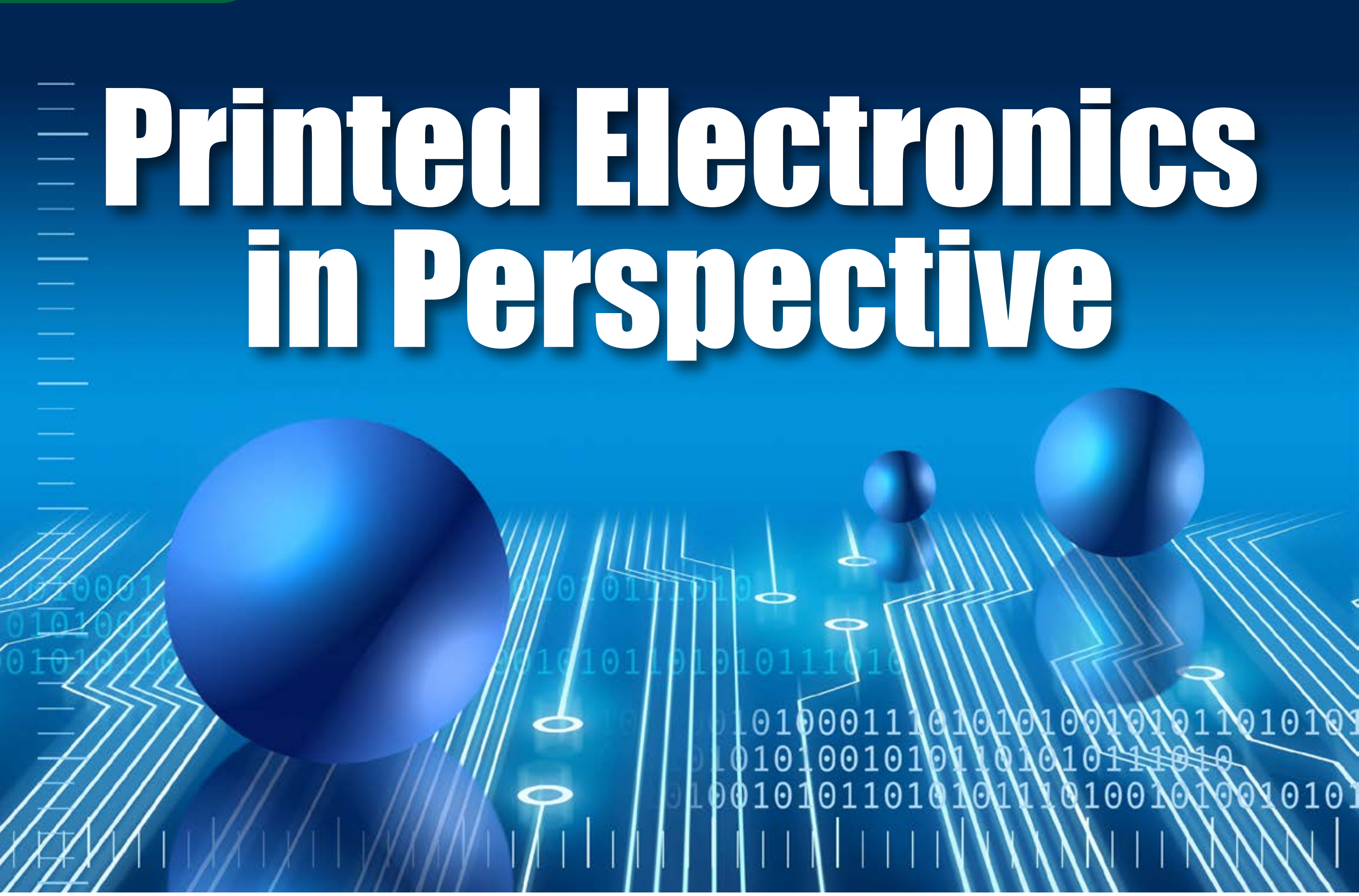


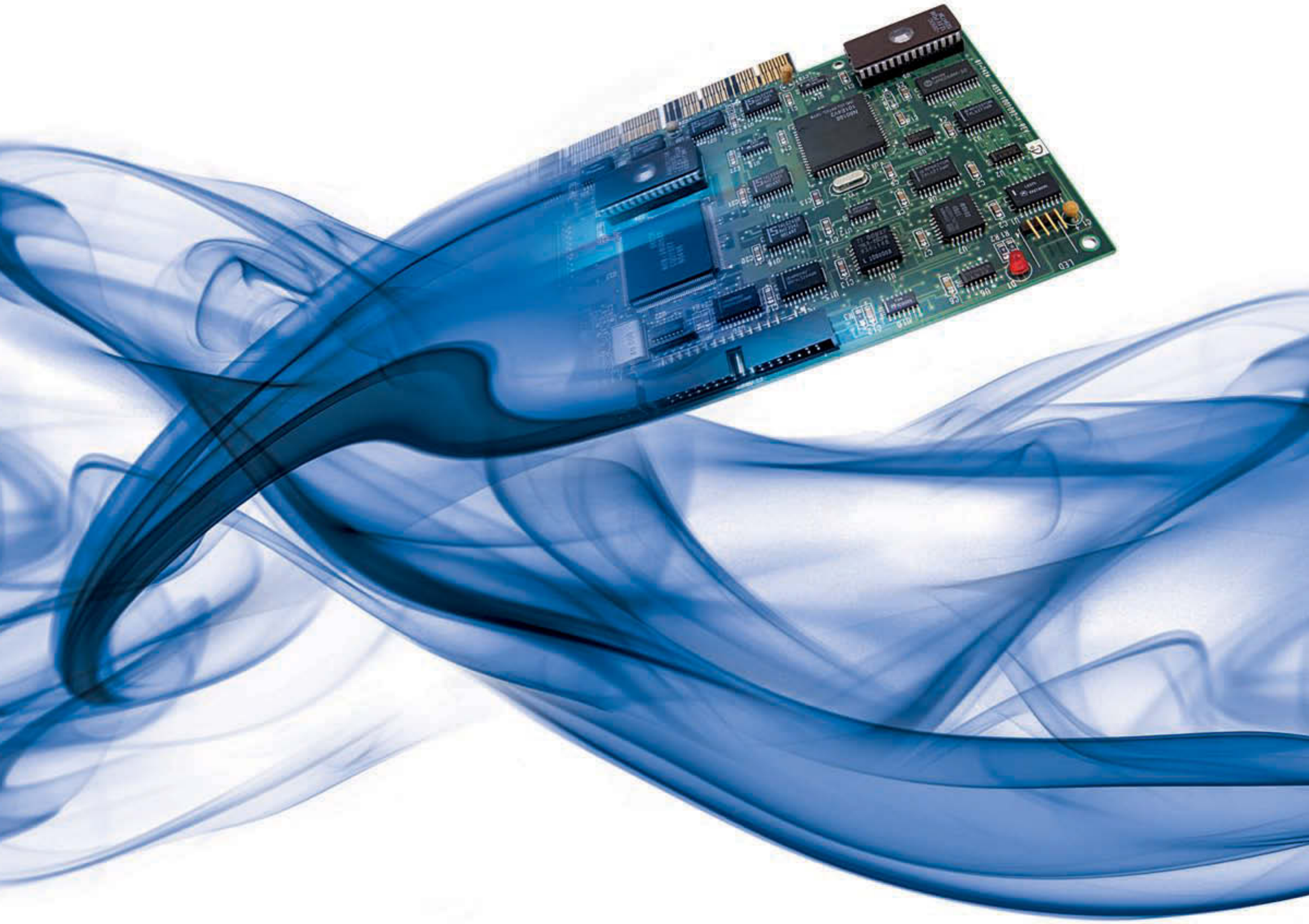
Printed Electronics in Perspective

by Joseph Fjelstad
VERDANT ELECTRONICS

Printed electronics have garnered a significant amount of press coverage over the last several years. What appears to have precipitated the explosion of interest in the middle of the last decade was a report that suggested that printed electronics would dominate electronic production by the mid-2020s with an annual market of over $300 billion. $300 billion is a big number and it not surprisingly captured a lot of attention. Since that announcement there has been a significant paring down of the market expectations to a number closer to one quarter the one projected earlier. It is, one can perhaps safely assume, an acknowledgement of the persistence of incumbent technologies. It seems clear to many knowledgeable observers that the potential of printed electronics was much more modest than early projections, but as Yogi Berra observed and has been often quoted, “Predictions are hard to make, especially about the future.”

The hyperbole surrounding the reports released in 2007 was met with some bemusement by those such as this writer, who having been first been involved in what would be called direct write printed electronics startup (using today’s broader definition) in 1990 had a different perception of the technology’s “newness.” Moreover, as one seeking to give credit where credit is due, it should be evident (if one puts in a bit of effort and does a little digging) that printed electronics is a technology that is arguably more than six decades old, thus predating my earlier company’s efforts by some 35 years.

The very first printed electronic circuits were called printed circuits because they were exactly that…printed, using conductive and resistive inks. Moreover, Xerox’s technology (then called the Haloid-Xerox Company) was applied to printing etch-resistant films for circuit production in the mid-1950s and more than 45 years ago, there was demonstration



Flexible circuits printed by machine on paper, aluminum foil, or film may make possible cheap, disposable radios, hi-fi's, and many other electronic devices

Now They're Printing TRANSISTORS ON PAPER!

Some 100 printed transistors decorate corner of playing card—a demonstration of new process that forms semiconductors and circuits on any material.

By W. STEVENSON BACON

Someday soon you may be able to buy a pad of operating electronic circuits just the way you now buy a pad of paper. On its pages will be printed amplifiers, radio receivers, computer circuitry, oscillators—anything you can name. They'll be so inexpensive you'll be able to tear them out, use them, and junk them.

It's made possible by a method of printing transistors on paper, film, plastic, foil, and many other materials. Developed by Westinghouse, the process is unbelievably simple and economical.

The art of depositing passive thin-film components (resistors, capacitors, and interconnects, for example) is well known. Design an automatic circuit-printing machine to deposit both active (transistors) and passive components and you can turn out circuits in continuous rolls for just pennies. Here are only a few of the possibilities:

- Credit and data cards, documents, checks, and other papers with flexible printed-component circuits will help speed identification and processing.
- Revolutionary new medical devices that can be implanted in the body will, for the first time, become really practical.
- A narrow-band TV system that can operate over ordinary telephone lines could become a reality. Such a project is now under way.
- Textbooks and teaching aids, toys, hobby kits, novelties will be based on flexible circuits.

How it's done. Thin-film components are made in a vacuum chamber by vaporizing conductors and other materials and then depositing them in layers on an ultrasmooth base. Thin-film transistors, a relatively recent development, go a step further. A sandwich of metals, insulators and semiconductors is laid down in several steps.

Until recently, it was thought that the base had to be an expensive, polished insulating material such as sapphire, quartz, or glass.

What is new is that Westinghouse researchers, headed by Drs. T. P. Brody and Derrick J. Page, have discovered that transistors and other components can be deposited on almost anything. Another first: By using a stenciling method, they deposit hundreds of transistors simultaneously with a single "pump-down" of a vacuum chamber. Formerly it was necessary to deposit each transistor layer separately, pumping out each time.

Printing press for circuits. So simple is the new process that it should lend itself to automation—machines that automatically turn out millions of circuits a year. According to Dr. Brody, such a machine would wind a roll of tape through a printing station, a testing station, and an encapsulating station, and onto a takeup roll—just like a movie camera.

At the printing station, transistors would be formed by depositing on the tape, in sequence, layers of gold, tellurium (the semiconductor), glass, and aluminum. Passive components would be similarly formed.

After the circuits were tested, they would be sealed with covering tape brought up from another roll, then wound onto a takeup reel. Final step, with the run complete, would be to remove the reel and slice it into individual circuits.

So far, paper transistors have proved versatile and reliable for any device that does not have to operate at high temperature, power, or very-high frequencies. About the size of the crossbar on this letter "T" and much thinner than the layer of ink used to print it, they have been operated for more than 1,000 hours with no measurable loss. They can be bent, twisted, and coiled. Cut them in half, and you have two transistors.

Transistors by the yard, hot off the printing press, are inspected by Westinghouse scientists. The two arrays of semiconductors at right (inset) total 1,316 transistors, some of which are shown in enlarged photomicrograph. Cage-like apparatus below is printing press that stencils thin-film transistors on paper, film, foil. They're flexible but durable.

Phonograph uses an amplifier (in model's hand) printed on kitchen foil. In addition to making cheap electronic devices, paper circuits may be printed in books, on credit cards and documents.

NOVEMBER 1968 | 125

Figure 1: The November 1968 issue of Popular Science predicted the rise of printed electronics. The article opens with the following paragraph: *"Someday soon you may be able to buy a pad of operating electronic circuits the way you now buy a pad of paper. On the pages will be printed amplifiers, radio receivers, computer circuitry, oscillators—anything you can name. They will be so inexpensive, you will be able to tear them out, use them and junk them."*

of a printed transistor in roll-to-roll fashion by Westinghouse as evidenced by Figure 1.

This does not in any way impugn or diminish the important improvements that have been made in recent years in the field now called "printed electronics." The advancements are impressive, but there are limits to where and how printed electronics can be used, which will be discussed in more detail shortly. But to conclude the thought relative to how printed electronics might be better viewed one that is resurgent rather than new, one might consider the myth of The Phoenix. That myth came to mind while the author was pondering the origins and what might be next for the printed electronics industry.

With hopes of forgiveness for a quick digression and for those who might be unfamiliar with the ancient story, the phoenix is a mythical bird having a multi-century lifecycle. As it nears the end of its expected life, the phoenix builds itself a nest that it then causes to ignite and the bird is reduced to ashes, from which a newborn phoenix arises to live again and repeat the cycle. It is like world history, which is, for better or worse (and too often for the worse), also cyclic. In fact, George Santayana warned that those who will not learn from history are

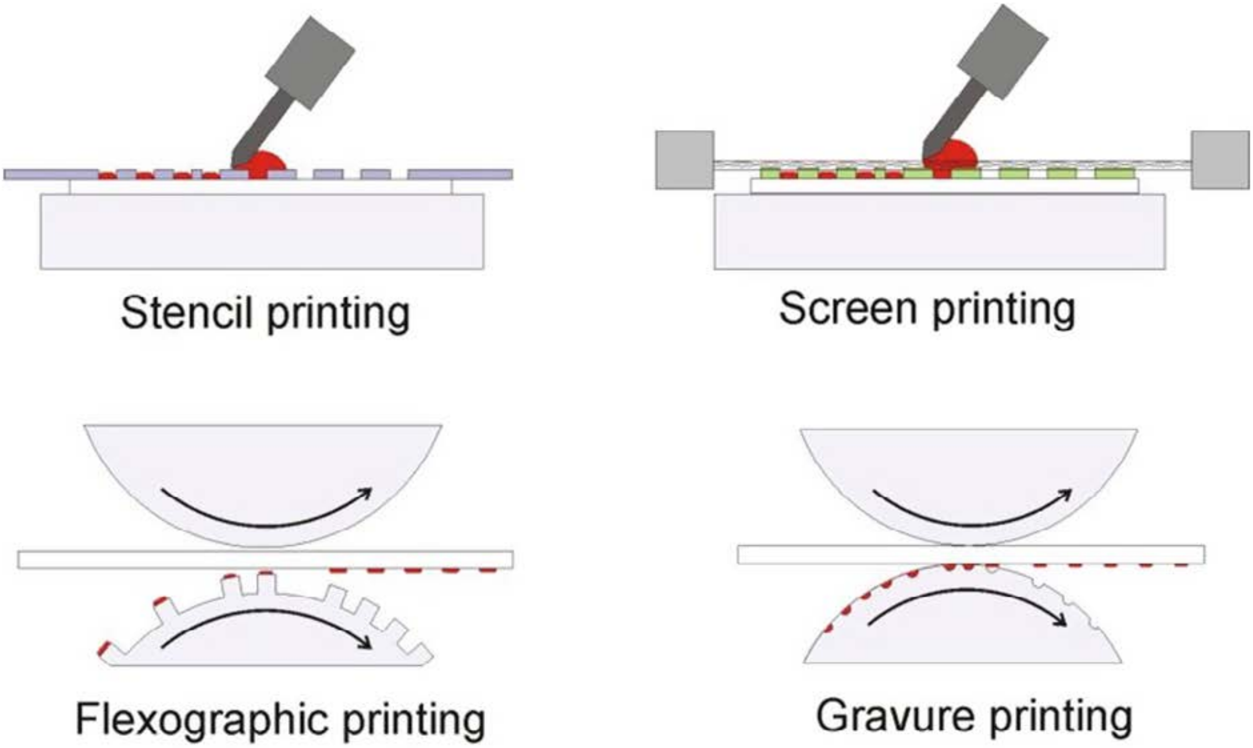


Figure 2: Four basic methods of the printing process.

destined to repeat it. Thus, printed electronics presently seems to be on a third or fourth incarnation, having, like the phoenix, risen from the ashes of earlier existences. To better appreciate the scope of printed electronics technology's impact, it is helpful to parse it into technology (materials and equipment) and markets, as they are interwoven like threads in a fabric.

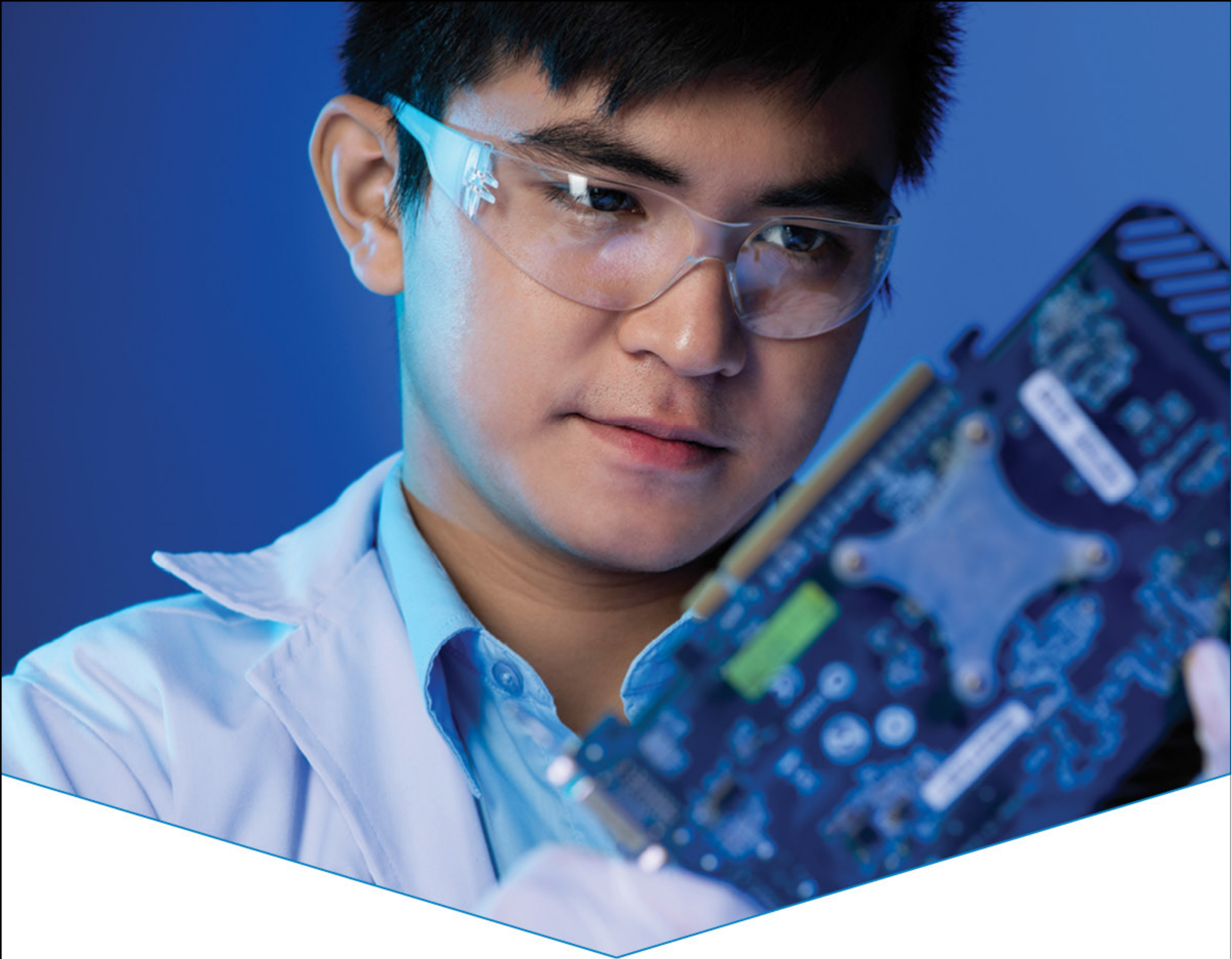
Printing is obviously the foundation technology for printed electronics. Printing has historically been accomplished using one of four basic methods: stencil printing, screen printing, flexographic printing and gravure printing. These are illustrated in Figure 2.

Fundamental Printing Technologies

From the simplest stenciling, to the most sophisticated gravure, these printing technologies are still the mainstay of much of today's commercial and industrial printing, and stencil and screen printing are still widely used in electronics manufacturing. Figure 2 illustrates only the last step of the rotary printing processes. For flexographic printing, the previous step meant contact with an ink-coated roller where the ink thickness had been adjusted by means of a doctor blade. For gravure printing, the previous step included contact with a doctor blade to remove excess ink from the coated surface. The latter process offers more control over ink by controlling the depth of the cavities in the print roller.

In addition to these fundamental methods, laser printers and inkjet printer technology have also been adapted to the task of manufacturing printed electronics. These offer the ability to manufacture directly from a data stream and the potential to produce an economical run unit of one, which is one of the "holy grails" of manufacturing. As alluded to earlier, the author was engaged in making the technology work with a laser printer in 1990 (US Patent No. 5,250,758). In addition, newer photolithographic based methods are evolving that show great promise for making additive circuits. One example is a novel technology from the company eSurface. The technology may be amenable to use with inkjets at some point.

Improvements in inkjet printers are making



very fine featured circuits possible and concurrent with that has been a push to make improved inks that boast higher conductivities, an important requirement for many applications. Moreover, there have been important developmental improvements in resistive and semiconductive inks making possible the printing of transistors in addition to conductive circuit patterns.

As for base materials, a wide range of materials are available to match the needs of the product from inexpensive polyester for "throw away" products to ceramics used in LED lighting assemblies.

That brings us to the other half of the technological equation, the markets for printed electronics. It is evident and agreed to by most industry pundits that printed electronics will never compete with the semiconductor industry in terms of size or manufacturing efficiency of transistors and thus cost. However, the technology does have some niche applications. Current display technology is proving well suited to the technology as are certain lighting applications.

Another area of high interest is in photovoltaic applications with the increasing interest in alternative energy sources and printed electronics' potential for cost-effective mass production. Sensors are another frequently cited area as are battery applications. Since the materials can be printed on thin flexible materials, there are also projected markets for wearable electronics. Other target markets will surely be defined and attacked as time progresses and with perhaps several dozen or more major and minor OEMs, universities, research institutes and startups in pursuit of printed electronic opportunities it is a pretty good bet that there will be more printed electronics based products in the markets and on the shelves in the future. **SMT**

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Verdant Electronics Founder and President Joseph (Joe) Fjelstad is a four-decade veteran of the electronics industry and an international authority and innovator in the field of electronic interconnection and packaging technologies. Fjelstad has more than 250 U.S. and international patents issued or pending and is the author of Flexible Circuit Technology.

Researchers Develop Revolutionary Battery Technology

A UCF spinout company is at the forefront of perfecting specialized nanotechnology designed to extend the longevity of batteries and superconductors. Batteries will be lighter, stay charged longer and need to be replaced less frequently--and that's a win for our smartphones and our environment.

HyCarb, led by Sigrid Cottrell, recently signed an exclusive license agreement with UCF for a patented and patent-pending carbon nanotube material, developed by UCF nanotechnology researcher Lei Zhai and his team.

HyCarb is in the process of applying for Small Business Innovation Research (SBIR) grants, citing the licensed technology as a key component in the creation of energy storage and advanced sensor prototypes for government agencies.

Upon successful completion of Phase I and Phase II SBIR grants, HyCarb will work with prime contractors to supply various federal agencies with state-of-the-art energy storage devices and sensors to detect hazardous materials.


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Mil/Aero007 News Highlights

Sparton Earns Raytheon 5-Star Supplier Excellence Award

Sparton Corporation was recognized for their outstanding performance as a supplier to Raytheon Integrated Defense Systems (IDS) at the Supplier Excellence Conference held in Waltham, Massachusetts on June 4, 2014.

TT Electronics-IMS Earns Nadcap Accreditation

With the recent certification in its Perry, Ohio operation, the company has achieved Nadcap accreditation in its factories across Europe, Asia, and North America. The Nadcap accreditation has been awarded in the category of Electronics—AC7120, for printed circuit board assembly, strengthening its commitment to the growing aerospace market.

Modernization Drives Man-portable Military Electronics Market

The global man-portable military electronics market is expected to grow at a CAGR of 3.8% during the forecast period from 2013–2019 to reach a market size of US $19,674.5 million by 2019.

$12.6B Market for Battlefield Management Systems by 2019

Land-based BMS has the highest CAGR across the three platforms and will account for 80.33% of the market size during the forecast period. There will be an increasing demand in command and control (C2), soldier modernization, and armored vehicles.

DoD Spending Driven by Geospatial Tech Innovation

The DoD is leveraging innovations in geospatial technologies to ensure commanders at every level have a deeper understanding of evolving operational environments. "After engineering and integration, improvements in dissemination and targeting will command the most attention, with spending in 2018 likely to stand at $712.6 million and $579.4 million, respectively," said Industry Analyst John Hernandez.

Power GaN Market to See 80% CAGR through 2020

Overall, 2020 could see an estimated device market size of almost $600 million, leading to approximately 580,000 x 6 wafers to be processed. Ramp-up will be quite impressive starting in 2016, at an estimated 80% CAGR through 2020, based upon a scenario where EV/HEV begins adopting GaN in 2018–2019.

Global Commercial Satellite Imaging Market Forecast

This report analyzes the commercial satellite imaging market on a global basis, with further breakdown into various sub-segments. It provides thorough analysis and market growth forecast of the global commercial satellite imaging market, based on its applications, end-use industry, and geography for the period from 2013–2019.

Passive Radars Gain Popularity in Aviation Sectors

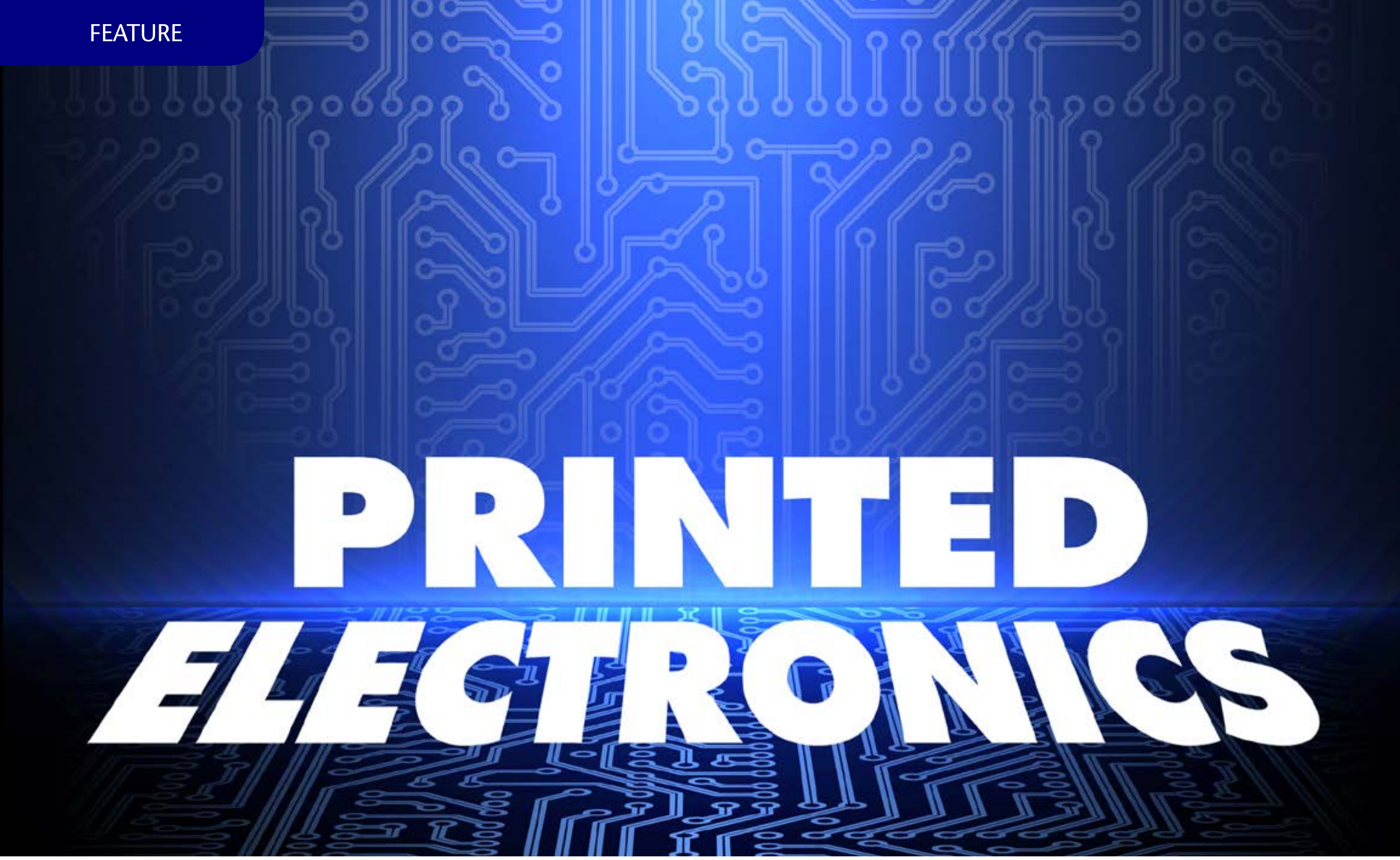
This report analyzes the worldwide markets for Radars in US$ million by the following end-use Segments: Land Based Surveillance, Air Defense Surveillance, Naval Surveillance, and Others.

API Technologies Lands Amplifier Orders from U.S. DoD

API Technologies has received a new order to supply high-power amplifier systems as part of a DoD maritime requirement.

NASA Launches Mission to Monitor Earth's Breathing

NASA's Orbiting Carbon Observatory-2 (OCO-2) aims to locate Earth's sources of and storage places for atmospheric carbon dioxide, the leading human-produced greenhouse gas responsible for warming our world and a critical component of the planet's carbon cycle.



Traditional Processes Enabling Next-Generation Electronics

by Sumit Kumar Pal
FROST & SULLIVAN'S TECHNICAL INSIGHTS

In electronics, most R&D has traditionally focused on developing novel technologies that can have either incremental or path-breaking benefits. However, printed electronics is an example of how an established technology finds new applications due to innovation in diverse fields of study. Printed electronics involves the use of printing technologies for manufacturing electronic devices using conductive inks and non-silicon substrates. Silicon has been the key material for use in electronics. Though, with increased demand for flexible, low-cost electronics catering to innovative and futuristic applications, the electronics industry has turned towards the traditional technology of printing.

Various printing methods can be applied for printed electronics. However the most promising ones are gravure, flexography, inkjet and screen printing. According to Frost & Sullivan analysis, in 2011, screen printing accounted for about 70.3% of the global printing technology equipment market.

The screen printing process is highly versatile and can be used on a wide range of materials. A major advantage of screen printing lies in the ability to apply thicker levels of ink than other printing processes. Screen printing equipment, on an average, is less costly than other equipment for different processes. Although screen printing normally follows a sheet-fed method, it can also support a roll-to-roll process. As a matter of fact, roll-to-roll manufacturing will realize the true potential of printed electronics as it enables higher production rates, although

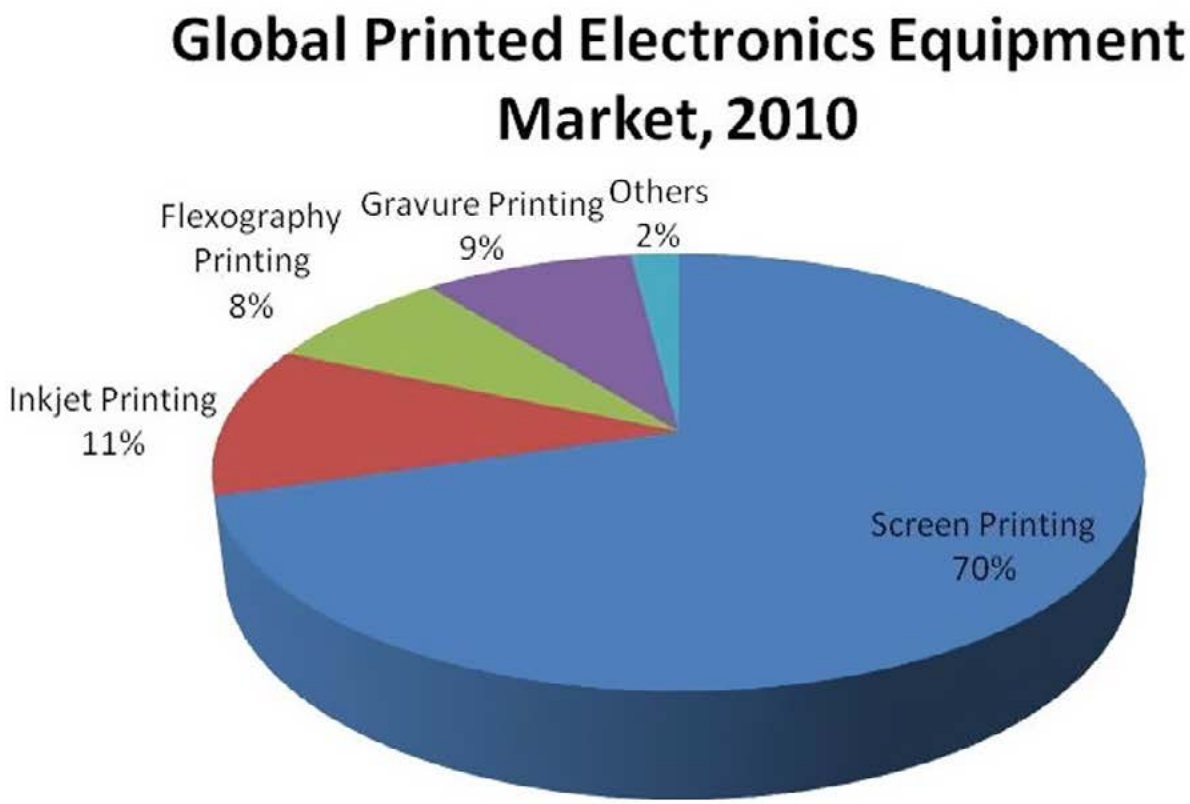


Figure 1: Global printed electronics equipment market, 2010. (Source: Frost & Sullivan Analysis)

there is still a need to have the entire process roll-to-roll compatible. Certain steps in the production line, such as atomic layer deposition, have traditionally been incompatible with roll-to-roll processes, but there have been efforts to develop atomic layer deposition (ALD) systems for industrial scale manufacturing that use this process by companies like Finland-based Beneq and Picosun.

Key Applications for Printed Electronics

Because printed electronics generate low-cost devices, the profitability of companies will be substantial only if they cater to mass markets. Perhaps the most common usage of printed electronics is in the manufacturing of low-cost radio frequency identification (RFID) tags that can be used in innumerable industries and can be a disruptive technology for the currently widely-used technology of barcodes. Printed sensors are another major application area for printed electronics where volume production will drive profitability of companies. For applications requiring disposable sensors, the key is to mass manufacture at a low-cost, and printing technologies will enable this.

In terms of revenue, the maximum potential currently lies in the field of printed displays, lighting, and organic photovoltaics. Printed displays are in the emerging stage with an ecosystem consisting of a significant number of companies and research institutes that are actively investing in R&D to improve the technology. The major focus areas include efficient manufacturing methods, improved lifespan and display quality. Printed displays were initially applied for small-screen applications, such as mobile phones, digital media devices, and cameras, due to their higher fabrication cost. With lower manufacturing costs, increased penetration will be seen in large-screen applications such as high-end televisions, digital displays, signage, and so on. Electroluminescent and organic light emitting diode (OLED) displays offer high tech-

Figure 2: Key application areas of printed electronics.

nical performance and value, relative to competing reflective displays and thin film transistors (TFTs). Printed electroluminescent displays have already made inroads into mobile phones and e-readers/tablets. There is huge potential for printed displays in television. Samsung and LG are reportedly working on printed displays for TVs after introducing their bendable phones.

The ongoing technology advancements in manufacturing methods, materials, conductive inks, and transistors, are expected to lower the cost of OLEDs to a level suitable for the mass-volume TV market. Leading advantages printed displays are its new form factors, which include flexibility, light-weight, and thin structure, enabling a variety of applications, such as wearable devices.

Printed displays are highly energy efficient as the displays are self-emitting and no energy is thus wasted because of filtering, which allows higher power efficiency and lower power consumption. Printed displays also have various performance advantages that include high contrast ratio, improved brightness, a swift response time and enables a wider viewing angle of 180 degrees.

Printed lighting is finding increased interest and usage in applications such as signage, architectural and industrial lighting, vehicular lighting, a general illumination and in backlights. Printed lighting is still in the development phase and many technological modifications are expected in the coming years. The comparatively shorter lifespan of printed lighting against

LED lighting is currently hindering commercial adoption of OLEDs. Ongoing research has focused on increasing the lifetime and luminous efficacy of OLED light bulbs. While laboratory experiments have delivered favorable results for luminous efficacy (more than 100 lumens/watt) and lifetime (100,000 hours), technical difficulties still persist for mass manufacturing and commercialization. Furthermore, printed lighting has not been adopted as widely as printed displays.

The most important factor for the potential wide-scale adoption of printed lighting lies in the fact that it enables new form factors. OLED lighting surfaces can be made flexible, which opens up numerous possibilities of applications on curved surfaces, wearable devices, and so on. The devices could be made as a transparent surface, so it could be used as a room divider and reflect as mirror. In addition, OLED lighting panels are compact and thin with dimmable features.

In printed lighting, OLED lighting holds maximum potential for adoption as it is not only safe per environmental regulations, but also offers low energy consumption. Companies such as Philips and Osram Opto Semiconductors are working on the printed OLED lighting sector. However, the cost of OLED and technical attributes such as efficiency, stability, and operation lifetime will initially hinder the adoption of printed lighting. Printed and flexible OLED lighting is expected to gain traction in the luxury and design lighting segment where cost is of lesser importance than aesthetic features. Wide-scale adoption of such decorative lighting is expected.

The other key application areas of printed electronics are in memory and batteries, which can be enabling technologies for next generation wearable electronics that have garnered a lot on interest in recent years.

"Silicon oxide and aluminium oxide are the top choices for utilization in electronic applications. Mixed oxides and nitrides, such as silicon oxynitride, are also gaining popularity. To achieve better barrier properties, multiple layers of organic and inorganic materials have shown promise."

The Challenge of Encapsulation

Organic substances used in printed electronics are inherently prone to reacting with moisture and air. There is thus a need to properly encapsulate the materials. Encapsulation is a major challenge faced by OEMs. Different products require different levels of encapsulation, which is normally measured using the water vapor transmission rate (WVTR) that is specified in grams per square meter per day. While RFID and electrophoretic displays require WVTR to be around 10-2g/m2/day, some demanding applications, such as organic PV and OLEDs require the WVTR to be around 10–6g/m2/day. Various technologies have emerged in encapsulation and most are thin-film encapsulations. Glass provides the best barrier properties, but cannot be used for thin-film applications. Moreover, the cost of flexible glass is higher than other materials and it requires high-temperature processing, which can affect device fabrication. Polymer materials, such as polyethylene terephthalate (PET) and polyethylene naphthalate (PEN) are normally used as the base substrate.

Organic and inorganic materials are also being used for effective barrier properties. Silicon oxide and aluminium oxide are the top choices for utilization in electronic applications. Mixed oxides and nitrides, such as silicon oxynitride, are also gaining popularity. To achieve better barrier properties, multiple layers of organic and inorganic materials have shown promise. Impurities, such as desiccant, can also be introduced in the barrier layers for absorbing water molecules in the vicinity, which enhances the barrier capability. During barrier film fabrication, pin-hole defects can arise, which affect the barrier performance. This challenge can be solved using nanomaterials that force water molecules to traverse a difficult path inside the inorganic layers. Thin-films are formed using deposition techniques that include physical vapor deposition, sputtering, plasma-enhanced chemical vapor deposition, surface plasma treatment and atomic layer deposition. ALD enables atomic scale precision, which makes it highly attractive for high performance barrier films. Plasma-enhanced chemical vapor deposition (PECVD) is another promising manufacturing process as it requires low deposition temperatures and is normally used medium barrier films.

The Road Ahead

Printed electronics signals a new era of electronics as the choicest material silicon takes a back step after dominating the electronics industry for decades. The promise of mass scale low-cost manufacturing without the need of stringent requirements of clean rooms and complex multi-step processes makes printed electronics a very lucrative industry segment. Printed electronics is a very good example of convergence, in which traditional printing technology merges with material technology and electronics to enable new product development and new markets. Printed sensors, RFID tags, flexible OLED displays and lighting, and organic photovoltaics are expected to be lucrative markets in the future. But in order to realize the true potential of printed electronics, concerted efforts are required to develop end-to-end manufacturing processes and a strong value chain. **SMT**

Sumit Kumar Pal is Technical Insights' senior research analyst for the global growth consulting firm Frost & Sullivan. He focuses on market and technology analysis within the automation and electronics domain. For more information on this research, please contact Jeannette Garcia by clicking here.

Conversations with...
Integrated Micro-Electronics Inc

Challenges Remain in Printed Electronics

I-Connect007 editor Richard Ayes recently interviewed Rafael Nestor Mantaring, vice president for design and development at Philippines-based EMS firm Integrated Micro-Electronics Inc. (IMI), who discusses the benefits and impact of printed electronics for the electronics manufacturing industry and the current challenges the technology faces.

I-Connect007: Printed electronics has been around for a long time, but during the past few years, it has become of the hottest topics in the industry. What can you say about the developments in this space?

Mantaring: While the past few years have seen rapid developments in this field, the applications are still limited or very niche. That is because active circuits produced using printed electronics suffer in performance and require a larger area when compared to circuits fabricated using conventional substrates. But it has its space: in displays, thin batteries, solar panels—although still at a very low efficiency—wearable electronics, and sensors.

I-Connect007: From your perspective, what is the impact of printed electronics in the EMS/PCBA industry?

Mantaring: I don't expect it to have any significant impact in the short to medium term. Because the applications are very niche, EMS companies may not find the target markets or applications attractive. Furthermore, suppliers will likely do their own manufacturing. After

all, one of the attractions of printed electronics is that it supposedly can be done with relatively inexpensive equipment.

I-Connect007: What are the benefits of PE in electronics manufacturing?

Mantaring: One of the promises of printed electronics is being able to prototype circuits inexpensively and by yourself. This could accelerate the development of electronic products in the future. On the other hand, printed electronics has the potential of supplying components with special requirements to EMS companies. For example, very thin batteries and very flexible assemblies.

I-Connect007: What about the challenges in this space?

Mantaring: The challenges are producing faster, more efficient, and smaller circuits. This requires developing the right materials: that is, the inks that are "printed" on the chosen substrate and the high-resolution printing equipment.

I-Connect007: Do you see any opportunities for PE for your company?

Mantaring: Not for the products we currently manufacture and the markets we currently serve.

I-Connect007: How do you think printed electronics will be integrated in the PCBA process?

Mantaring: Print technology is already being employed in PCB assembly. In lines where flexibility and quick changeover is a requirement, solder paste is deposited on the PCB using printing techniques rather than through a stencil.

It is not farfetched that in the future certain components, instead of being mounted on the PCB, will be printed on the PCB. For example, different antenna designs can be printed on the PCB when switching production from one transceiver frequency to another in a low-volume, high-mix scenario. Or a computed resistor value can be printed on a PCB after a calibration procedure for highly sensitive electronic assemblies.

I-Connect007: On which industry domains (automotive, consumer electronics, medical, etc.) will printed electronics have a significant effect, and in what way?

Mantaring: All of these markets have opportunities for printed electronics, but because of the existing limitations, early products will likely be in the consumer space where performance is not critical.

I-Connect007: Finally, where do you see the printed electronics industry headed? Will it be an important part in electronics manufacturing?

Mantaring: Yes, for special components and for niche requirements. **SMT**

Quarks Behave Like Electrons in Superconductors

The protons and neutrons that make up the nucleus of an atom are themselves made up of fundamental particles known as quarks. Arata Yamamoto from the RIKEN Nishina Center for Accelerator-Based Science has used supercomputer simulations to show that quarks can behave like electrons in a superconductor.

The existence of quarks in a semifree state under extreme conditions raises the fascinating question of whether quarks can behave like other free particles such as electrons. The interaction between quarks is described by a complex theory known as quantum chromodynamics (QCD).

"This is the first implementation of such a model with a population imbalance between flavors," explains Yamamoto.

SMTonline Market News Highlights

Conference Board ETI Up 6.3% in June

"The rapid increase in the Employment Trends Index in recent months suggests that strong job growth is likely to continue through the summer," said Gad Levanon with The Conference Board. "While the strong labor market signals an improvement in economic growth, the key factor is that the average productivity of workers will need to rise as well."

Global LCD TV Shipments to Gain 3% This Year

WitsView Research Director Burrell Liu noted, "TV panel pricing is expected to remain flat or increase throughout August into September but this is still yet to be fully determined, as end sales performance and whether vendors' inventories are piling up will still all make a difference. The same will apply to notebook and monitor panels."

Consumer Confidence Index on the Rise

The Conference Board Consumer Confidence Index, which had increased in May, improved again in June. The Index now stands at 85.2 (1985=100), up from 82.2 in May. The Present Situation Index increased to 85.1 from 80.3, while the Expectations Index rose to 85.2 from 83.5 in May.

Consumer Healthcare Sensor Market at $47.40B by 2020

The sensor market in Consumer Healthcare is expected to reach $47.40 billion by 2020, growing at an estimated CAGR of 5.56% from 2014–2020. The developments in sensing technologies can help to increase the trend of continuous patient monitoring, which can result in reduced healthcare costs and improved treatment outcomes.

Solar Makers Seen to Boost Production Capacity

Solar PV supply chains are starting to see demand in China wither, while demand in the United States and Japan remain stable, according to EnergyTrend. As such trends occur, solar supply chains are expected to increase production capacity in the second half of 2014.

Global 3D Printing Forecast to 2019

The 3D printing market has seen rapid growth in recent years due to its increasing applications across different sectors such as consumer products and electronics, automotive, medical, industrial, and aerospace. Decreasing cost of 3D printers and its increasing adoption across the government and education sectors is further expected to spur the demand in the coming years.

Tablets to Bridge the Gap with Smartphones

New analysis from Frost & Sullivan finds that by 2016, the use of smartphones is expected to decrease from the current levels of 66% to 58%, while tablets are expected to increase from 49 percent to 56%.

PC Monitor Market Sees Sluggish Q12014

"Despite the overall decline, the shipment totals were stronger than the forecast of 31 million units," said Phuong Hang, program director, Worldwide Trackers at IDC. "Geographically, Japan and the Middle East and Africa (MEA) regions delivered the largest gains during the first quarter while Dell and HP both experienced solid shipment growth."

Health Monitoring Market to Reach $2.50B by 2020

The machine health monitoring market is expected to reach $2.50 at a CAGR of 7.16% from 2014 to 2020. Machine health monitoring is an uninterrupted assessment of the equipment and machinery. Machine health monitoring system can be implemented to reduce plant operating costs by optimizing maintenance activities and lowering the instances of unscheduled outages. Thus it helps in reducing the overall maintenance costs and improving the lifetime of equipment.

Digital Signage Revenue Falls Flat

The digital signage industry is facing a formidable challenge from cheaper, conventional TV panels that replace specialized custom products that long have differentiated the professional displays market.

Introduction to Inline AXI Technology

by Ondrej Simecek
TEST RESEARCH INC.

Since the initial discovery of X-rays on the eve of 20th century, the technology has become an important tool for non-destructive inspection of internal structure in non-transparent objects. Among the many applications that have been developed, by far the most common is simple transmission imaging, or radiography, which allows operators to view a shadow image of the inspected object's internal structure from various angles by manipulating the position of the object.

Individual components of the inspected object absorb different portions of the emitted X-rays, forming a shadow image on the X-ray detector. Selective absorption of X-rays by different materials allows us to differentiate between solid bodies in an object. Dense items composed of heavier atoms—such as metals—can block a significant portion of incident X-rays and form clear shadow images. The amount of absorbed X-rays also depends on the thickness of the blocking objects, allowing us to determine the physical structure of the inspected target from its X-ray shadow.

Photographic film was initially used as a media to record X-ray images, but this is impractical in industrial settings. With the advance of scin-

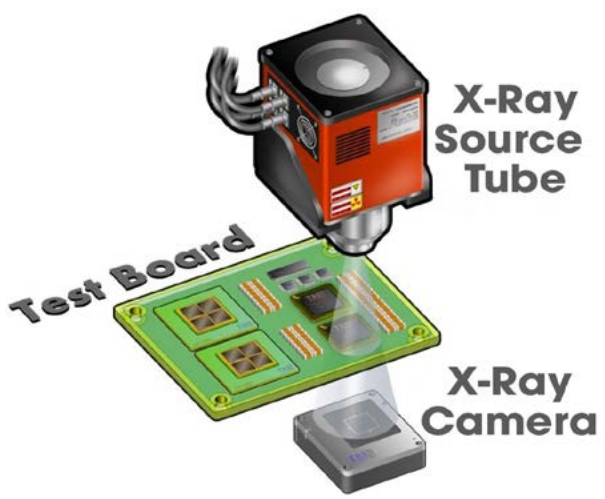


Figure 1: In AXI Inspection, X-rays emitted from a source tube pass through the inspected object and the resulting X-ray image is captured by the imaging sensor.

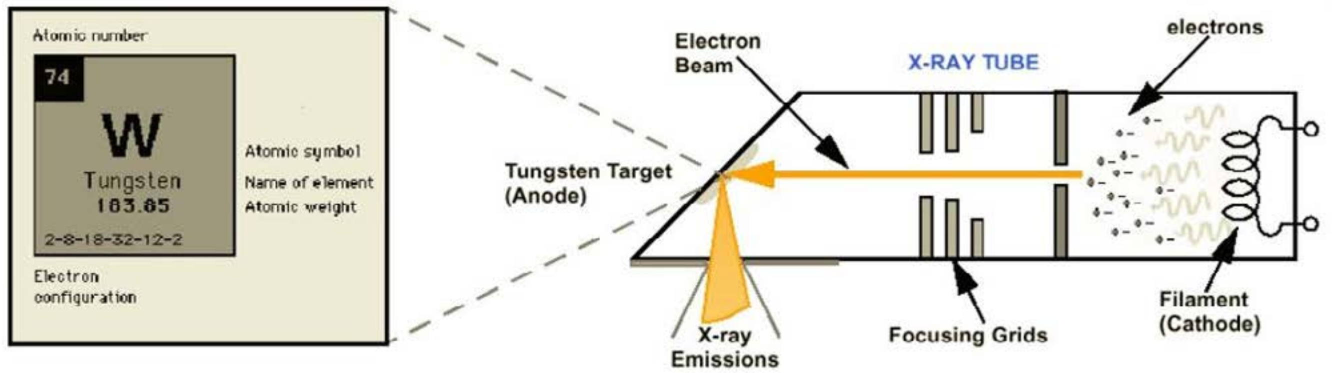


Figure 2: In a typical microfocus X-ray source tube, the cathode filament is heated up by passing current to emit electrons, which are then accelerated towards the tungsten target and focused by electromagnetic focusing grids. The impacting electrons then cause the Tungsten atoms in the target to emit X-rays.

tillating materials that emit light when struck by ionizing radiation, it has become much easier to obtain instant high-resolution digital X-ray images using specialized CCD cameras that remove the need for additional photo-chemical processing.

The single obvious limitation of X-ray images is the inability to distinguish the spatial structure of overlapping objects. This shortcoming has been initially addressed by changing the orientation of the target object, but this requirement placed additional stress on the operator and may be completely impossible for large objects.

Fortunately, modern computers have allowed us to overcome this limitation by calculating 3D cross-sections of the target objects from a series of 2D X-ray images captured from different angles. In the next section, we will describe the three distinct 3D technologies that have found practical applications in industrial PCB production.

Technical X-ray Applications

2D X-ray

Modern industrial applications depend on digital X-ray imaging, using an X-ray camera to capture images. A typical example is manual X-ray Inspection (MXI), which allows the operator to manipulate the inspected object to look for defects from different angles.

2D AXI

An evolution of manual 2D X-ray is automated X-ray inspection (AXI), which uses customizable inspection programs to scan and review transmission X-ray images to find parts that do not conform to preset manufacturing parameters. This reduces operator workload and allows for much higher inspection speed with a lower number of false calls. Despite its advantages, 2D AXI is still limited by overlap-

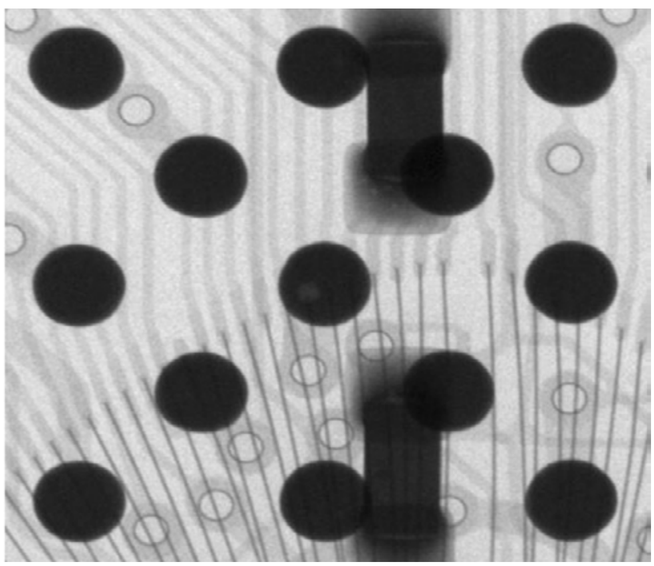


Figure 3: 2D X-ray offers very high resolution and speed, but cannot separate overlapping components on dual sided PCBs.

ping structures which occur on dual sided PCBs. These may not be easily inspectable even using a different angle of view.

3D X-ray

Designed to overcome the deficiencies of 2D X-ray technology, 3D X-ray is the inspection tool required when all other methods fail. With increasing board complexity and density, both visual and electrical inspection technologies (AOI, ICT, 2D X-ray) are faced with limited to no-testing and inspection access. 3D X-ray is the only non-destructive inspection technology capable of inspecting high-density dual-sided PCB assemblies.

Computer processing of a series of 2D X-ray images enabled inspection of virtual cross-sections at different slice height, minimizing problems with overlapping structures on dual-sided PCBs and multi-layer components. There are three main 3D X-ray technologies, each of which has its own advantages and shortcomings. In the next section, we will go over their individual differences and applications.

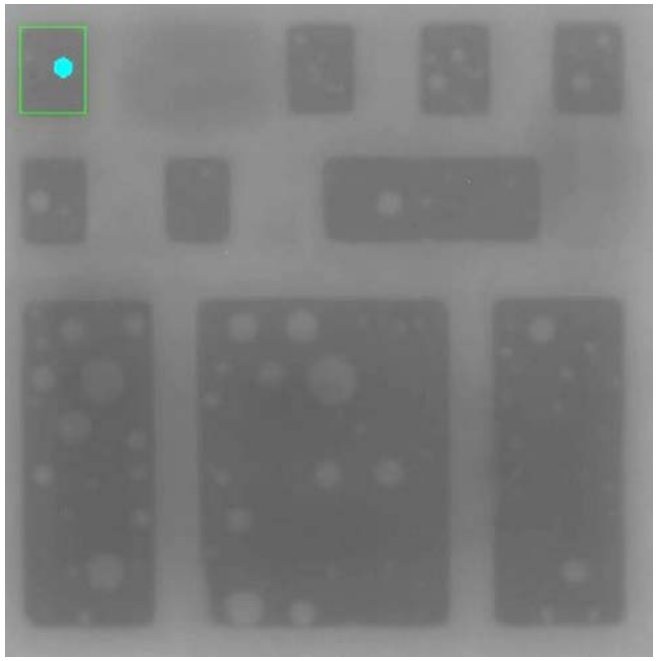


Figure 4: Laminographic slice images have low contrast, but retain sharp edges. Each slice needs to be scanned separately, requiring additional time.

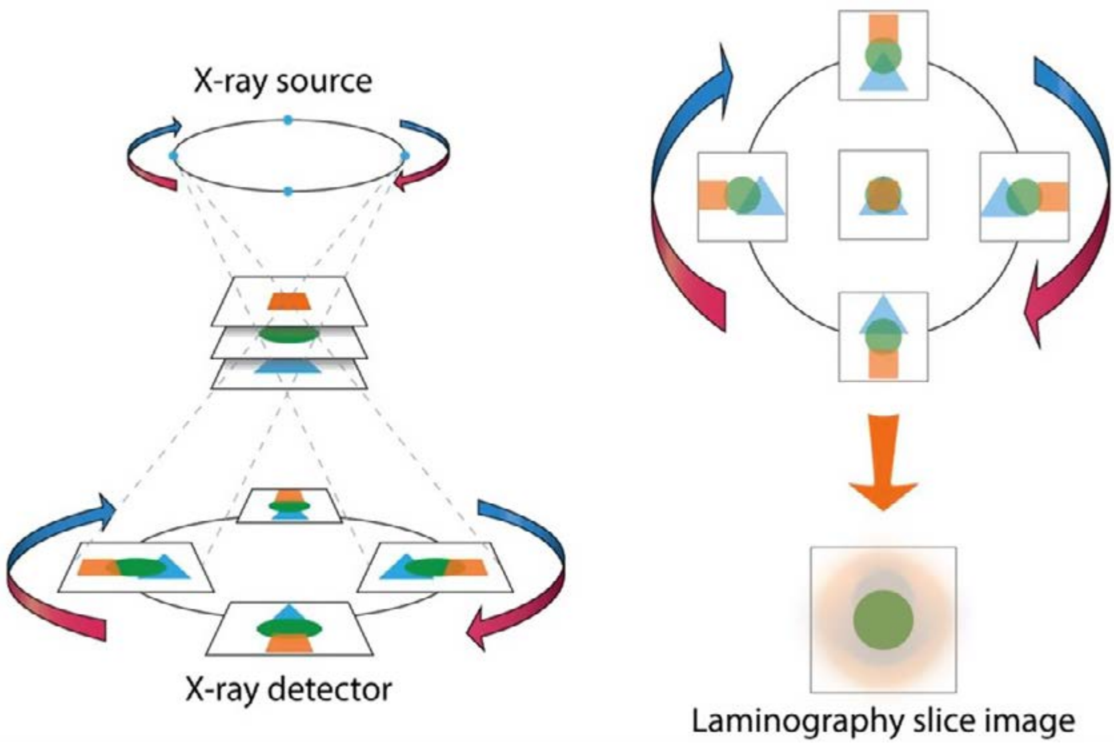


Figure 5: Laminography utilizes a steerable X-ray source and a rotating detector to blur out objects that are not on the focal plane.

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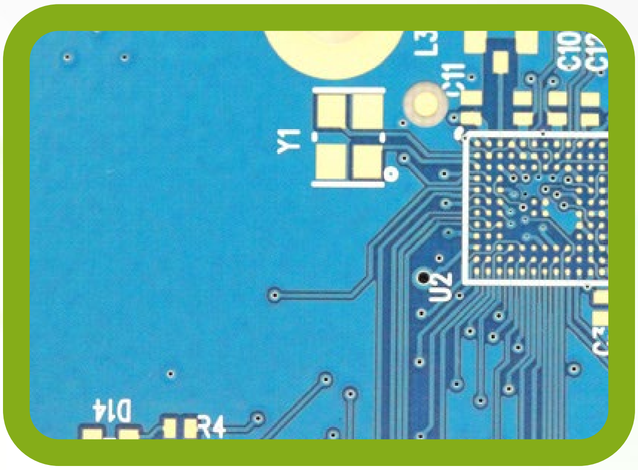

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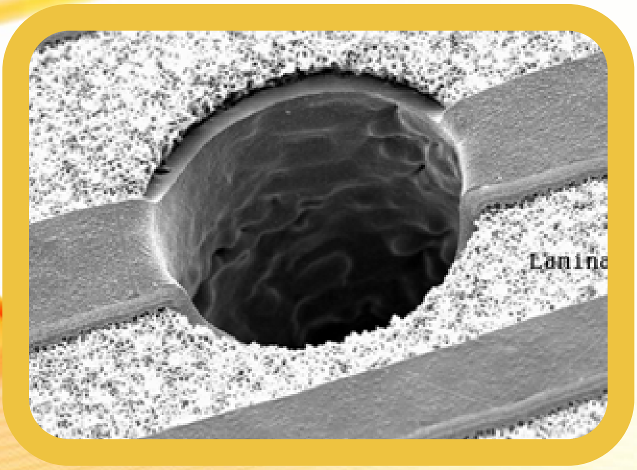

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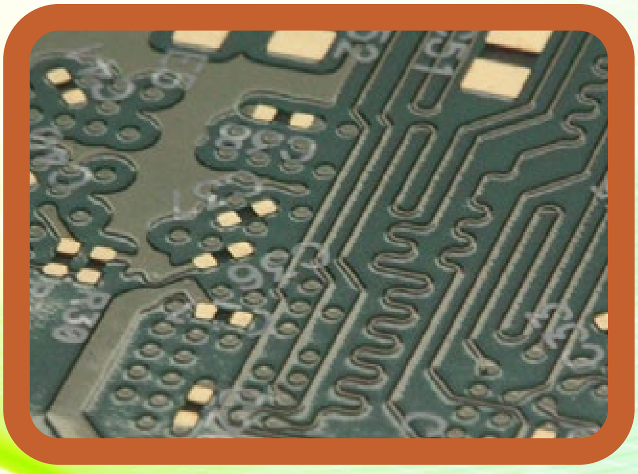

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Laminography

One of the first practical 3D X-ray technologies, laminography has been developed to provide layer-based imaging of three-dimensional bodies. The objective is achieved through synchronized rotating movement of the X-ray source and detector, which ensures that objects on the chosen focal plane are projected onto the same spot on the detector, while all out-of-focus objects get blurred out. Each full scan generates a single focused layer slice, requiring additional scans to acquire slices at other height. Since objects which are out of the focal plane are blurred out, they contribute to a relatively low-contrast image with comparatively sharp edges.

All out-of-focus objects are automatically blurred by the physical rotation of the X-ray beam and the detector when each slice image is captured, which makes laminography computationally less demanding than other 3D AXI technologies.

Computed Tomography

Computed tomography (CT) is a solution designed for accurate imaging of complex 3-dimensional internal structures using volumetric reconstruction from a large number of source images taken from a very wide range of viewing angles. The main disadvantages of CT are very slow imaging rate (dozens of minutes) and a high radiation dose, but it can offer the highest available detail resolution. These limitations make CT ideal for detailed inspection of complex individual components (e.g., µBGAs, PoPs) on prototype boards, QA and sampling during new product introduction (NPI), but unsuitable during volume production when inspection time is critical.

Digital Tomosynthesis

A more practical approach to computed tomography, digital tomosynthesis, uses a limited number of source radiographs from a limited range of angles to reconstruct virtual cross-section images at arbitrary height. This approach requires significantly shorter imaging time, limiting the radiation dose and approaching production line speeds.

A significant advantage of tomosynthesis over laminography is the ability to reconstruct virtual cross-sections of the inspected subject at any arbitrary height using only the images captured in the initial scan, avoiding additional scanning and radiation exposure of the subject.

Since objects at the same height will project to known locations on the camera array, we can use a simple shift-and-add operation to align the captured set of images with the in-focus parts overlapping to blur out all other objects.

Figure 6: CT reconstruction of a BGA package using micro CT reconstruction from a very large number of images.

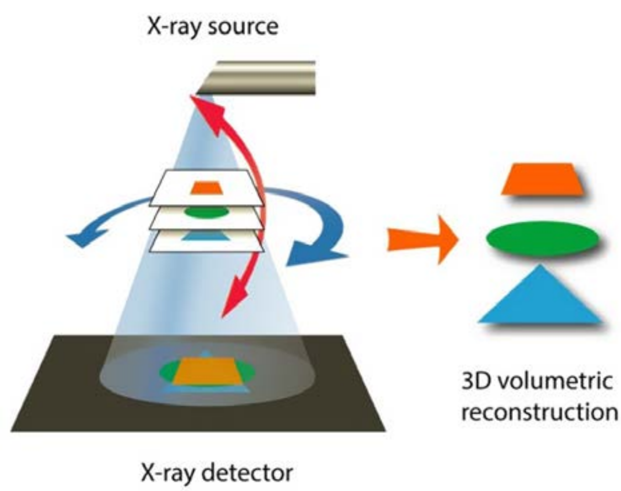


Figure 7: Computed tomography uses circular motion around the subject to gather shadow images from a very wide range of angles.

While the slice projections obtained through digital tomosynthesis have lower resolution due to the lower number of source images, they exhibit higher contrast than laminography and are captured at significantly faster speed than a full CT scan. These qualities make digital tomosynthesis the dominant AXI technology for live production runs, allowing reliable near-real-time inspection while optimizing image quality as necessary by acquiring additional source images.

Which X-ray Inspection to Use?

3D AXI

- Double-sided boards and multilayer components (PoP)
- High-density shielded connectors
- High-speed, high-resolution inspection

2D AXI

- Single-sided boards
- High speed, very high-resolution inspection

2.5D AXI

- Detector/board tilt for virtual 3D
- Small overlap of components

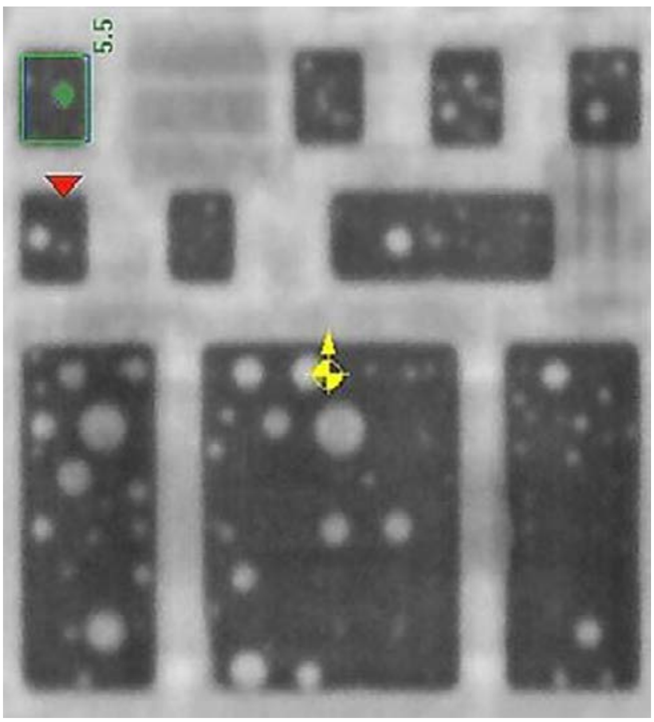


Figure 8: Reconstruction using Tomosynthesis induces some blurring, but offers much higher contrast than comparable laminographic images.

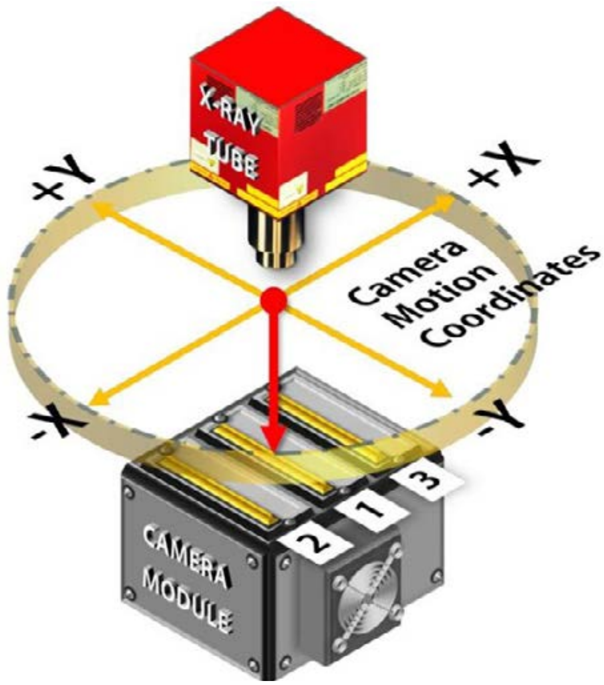


Figure 9: Tomosynthesis X-ray systems use a source tube paired with an array of cameras to capture each location of the inspected object under a predefined set of angles.

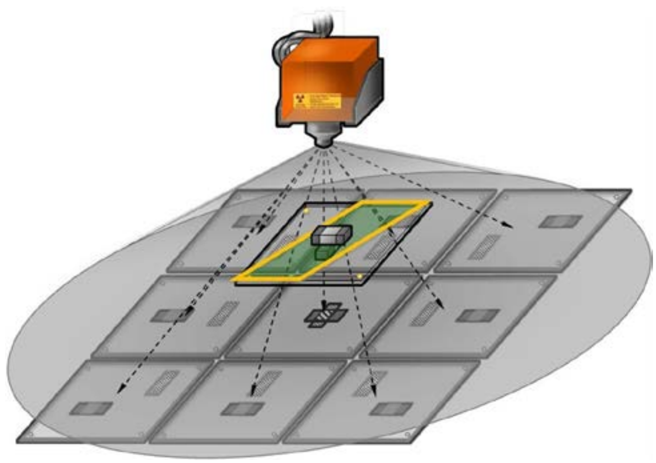


Figure 10: Objects at different slice height project to different locations. By aligning the projections on the images from each camera, we can get clear 3D slice images at the desired height while blurring out all other parts at different levels.

Manual (MXI)
- X-ray microscope
- QA, human/manual calls
- Very low volume; time-consuming

Computed Tomography (CT, micro CT)
- X-ray microscope
- Quality assurance, research
- Very high 3D quality imaging, very low speed

AXI Market Drivers

Ever since the first through-hole components were hand-placed on PCBs, methods have been needed to test the resulting product for manufacturing defects. The initial use of manual visual inspection yielded uneven results, as operators would get tired and bored of repetitive tasks.

While functional testing verified that the product was operational at the moment it left the factory, it didn't reveal any structural solder joint defects which might cause early failure due to shocks received during transport, or as a part of deployment. Weak solder joints would break, resulting in the whole product being returned from the field for repairs. The traditional inspection method for structural defects was cross section, an expensive approach which requires destruction of the inspected board.

As the electronics market moved to high volume production, automated inspection equipment became indispensable to maintain high yields and stable production quality, SPI (solder paste inspection), AOI and AXI. X-ray proved to be the most suitable non-destructive inspection technology for high-density boards with hidden joints.

Mobile Electronics

The growing success of mobile electronics with limited PCB space has forced a transition towards higher density packages with bottom-facing solder joints (BTCs) and multiple layers

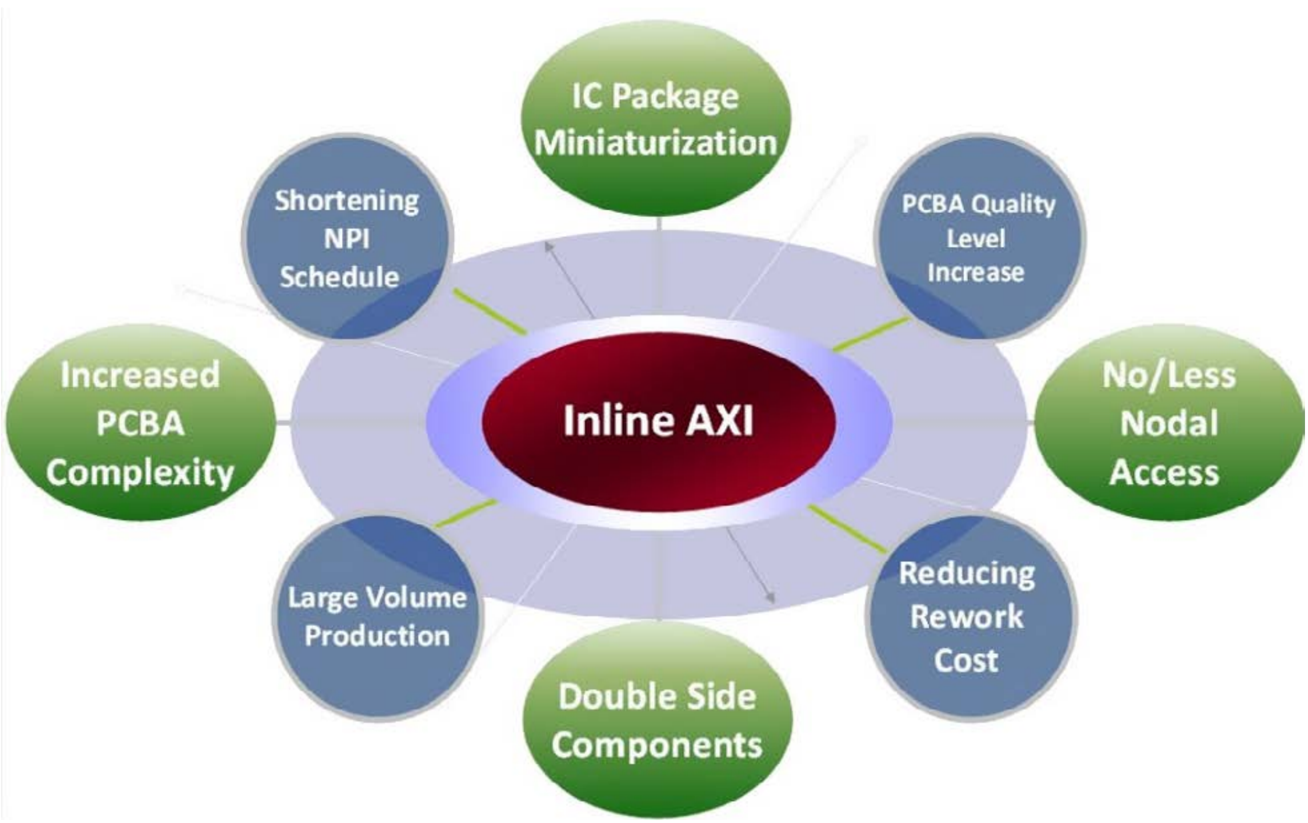


Figure 11: Inline AXI adoption drivers in electronics manufacturing include cost-cutting measures as well as technological developments.

(PoP, stacked dies). These high-density packages do not have visible solder joints and cannot be reliably inspected using AOI, making AXI the only reliable method to inspect for structural defects incurred during assembly and solder reflow. The increased use of wireless technologies in mobile devices also brings metal shielding mounted onto the PCBA, which prevents standard visual inspection. These components can be only inspected using X-ray imaging.

Cost-reduction through Integration

Cost-reduction measures in electronics manufacturing are driving the adoption of highly integrated IC packages and more complex dual-sided PCB assemblies with reduced test access. This further reduces the utility of traditional optical inspection and electrical testing. AXI has therefore become an important element in reducing rework costs, by verifying actual defects and eliminating unnecessary repairs.

Process Quality Management

Extended inspection coverage offered by Inline Automated X-ray Inspection provides real-time solder joint quality information which can be used to statistically monitor and adjust the manufacturing process and maintain stable production quality.

Increasing demands on high production yields and process miniaturization stress inspection capabilities of optical and electrical inspection systems, which are becoming unable to test the quality of many solder joints. X-ray inspection is therefore becoming a key component for maintaining stable quality and eliminating process variation.

AXI in PCB Assembly Manufacture

Defect Detectability Matrix

Based on different principles, the three dominant inspection and testing technologies each

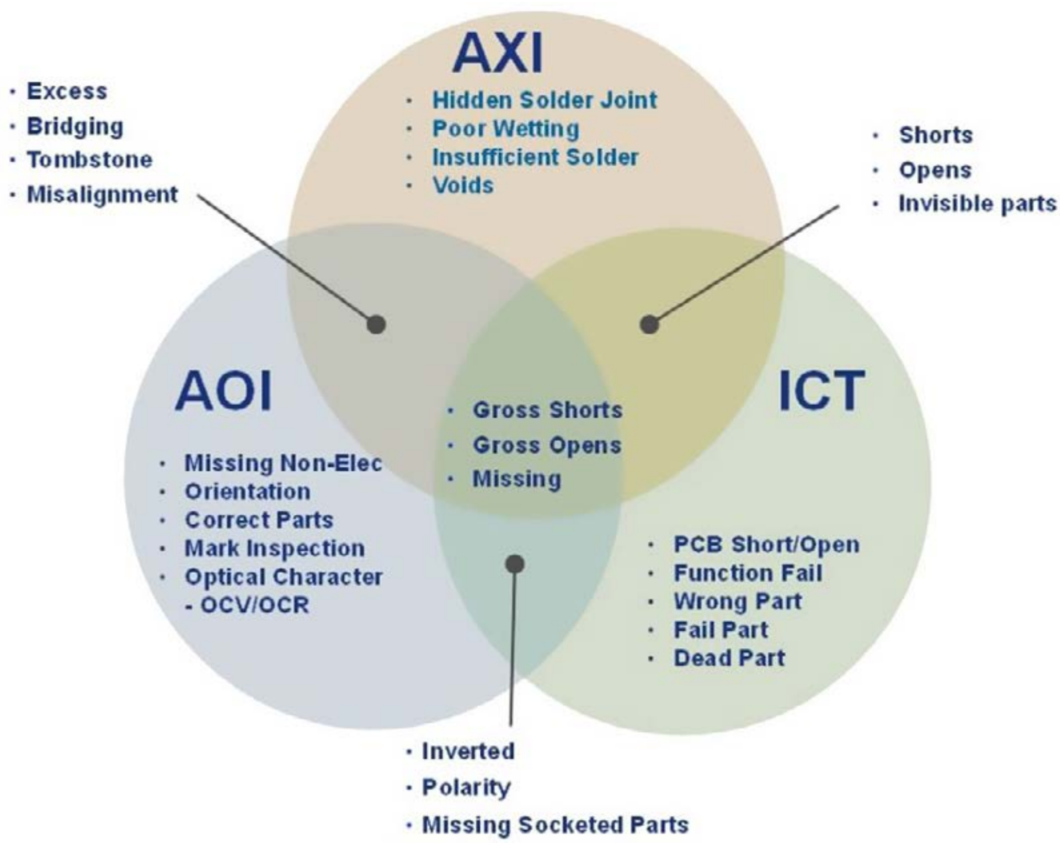


Figure 12: Optical, X-ray and Electrical testing each cover a different segment of manufacturing defects that affect typical electronics production.

cover a different segment of manufacturing defects. While all three can detect gross faults such as opens, shorts and missing components.

AXI specializes in solder joint integrity inspection, revealing voids, non-wetting and poor wetting joints. Its unique capability to reveal hidden solder joints, their deformities and faults makes AXI an indispensable component in maintaining a modern high yield electronics production.

Image Quality and Enhancement

Base X-ray imaging quality depends on key system components and their settings: namely the X-ray source tube, system resolution, power settings and magnification ratio.

X-ray Magnification

The wavelength of X-rays is about 100x shorter than of visible light. This enables the rays to penetrate through matter and explains why X-rays cannot be focused by lenses as visible light and the image resolution depends solely on the resolution of the system X-ray detector. In order to reveal more detail, X-ray systems employ geometric magnification by moving the source tube closer to the subject, which results in a larger shadow image that is projected onto the detector.

As magnification of the radiographic "shadow" is increased geometrically (that is, by moving the specimen toward the radiation source), the physical size of the source, or focal spot induces a penumbra, or blurry edge, in the X-ray shadow.

Therefore, to increase magnification without increasing the image blur, manufacturers are compelled to reduce focal spot size, as seen in the figure below.

Image Processing and Auto Focus Imaging

Successful inspection of 3D X-ray data depends on accurate layer separation. Using laser height measurement to set up source and camera offset, laminography systems are therefore very sensitive to height measurement errors. Tomosynthesis allows automatic focusing of

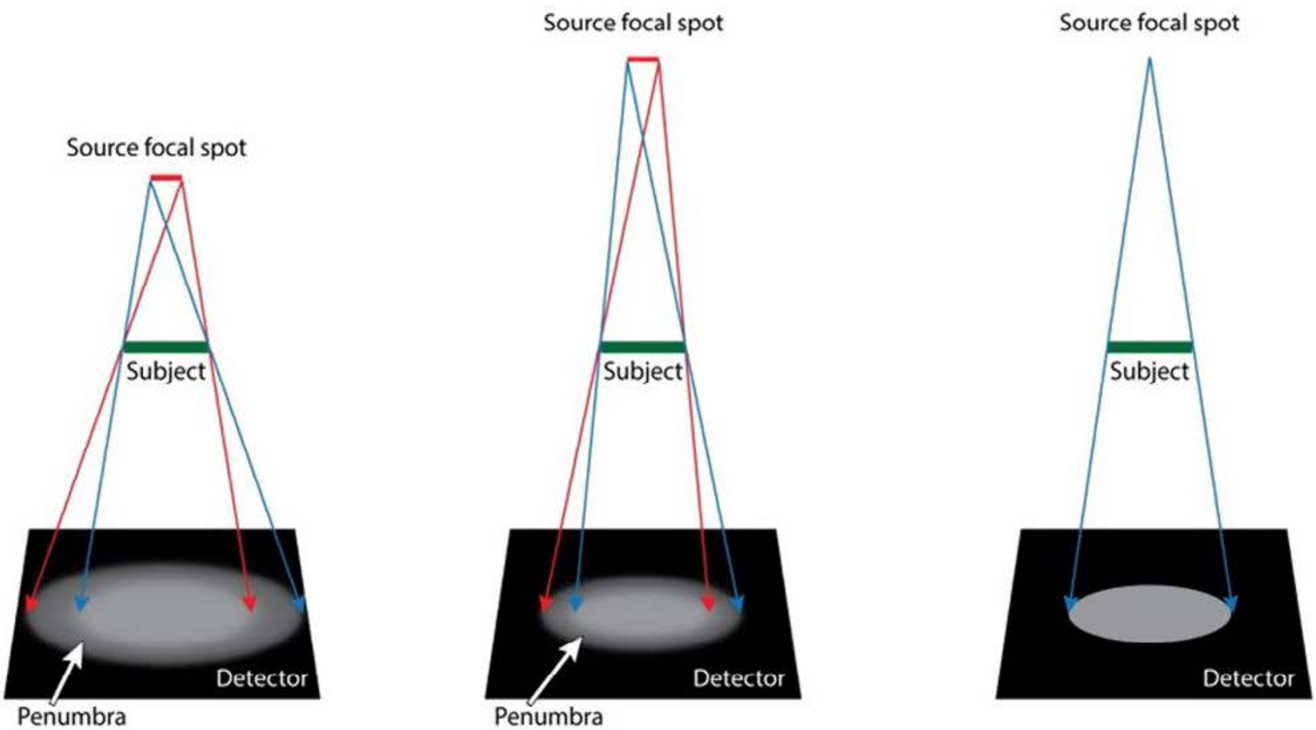


Figure 13: The size of the focal spot directly impacts final image sharpness, but it also depends on the X-ray source power used for imaging.

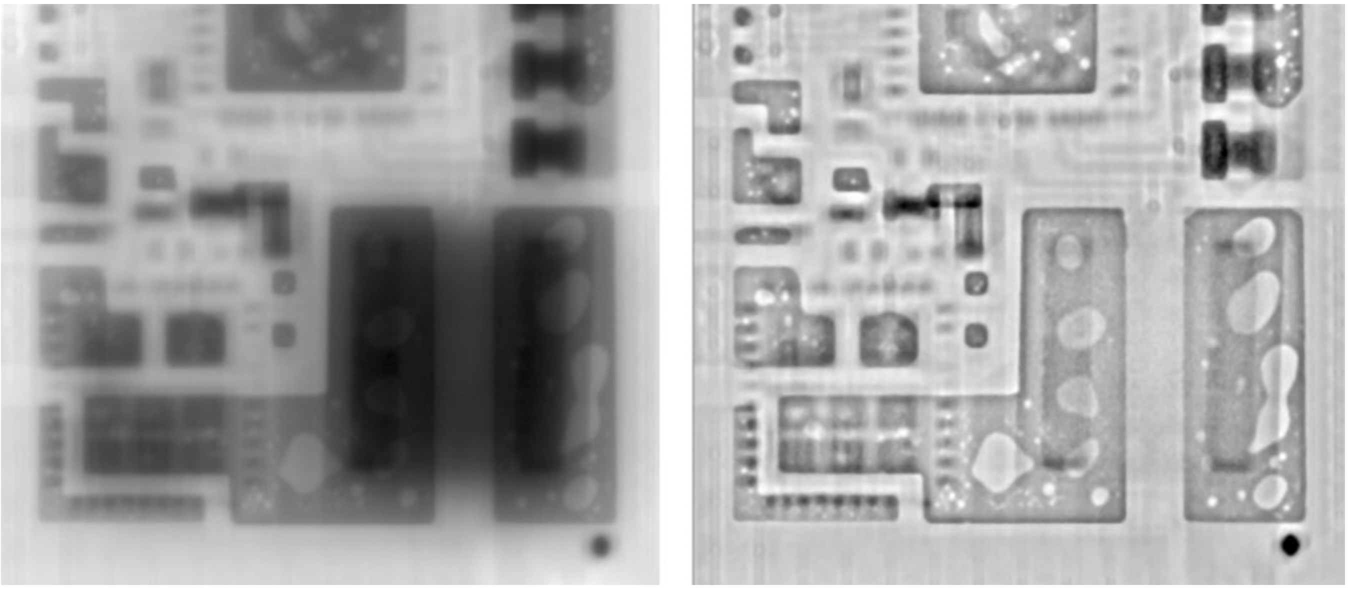


Figure 14: Image Processing is a vital component for accurate AXI inspection. Unprocessed X-ray image (left); with TRI's patented IPI image processing (right).

each layer by detecting the image signal with strongest contrast; all layers can be reconstructed from one original set of images.

Basic Algorithms

Basic inspection capability for AXI systems includes component and solder joint-level defects.

Component defects: Missing, misalignment, tombstone, billboard, tantalum polarity, skew

Solder Joint defects: Insufficient/excess solder, short, open, solder ball, non-wetting, void, lifted lead

BGA

Ball grid array inspection focuses on the quality of solder joints under a BGA package. The typical problems which may be encountered are opens, shorts, voiding, and head-in-pillow defects (incomplete reflow) of solder balls.

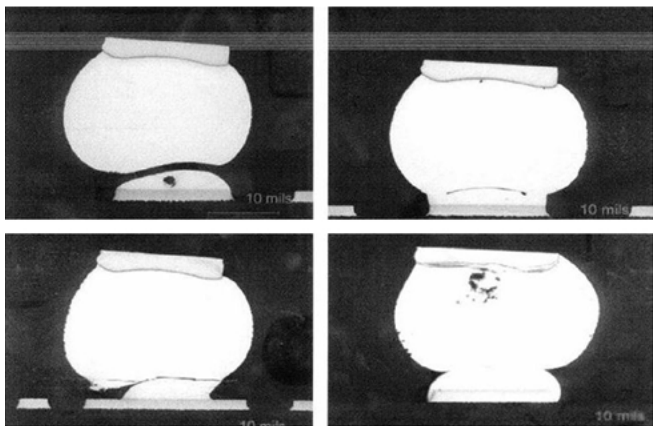


Figure 15: BGA HIP defects are signs of incomplete solder reflow, where the solder ball failed to bond with the printed solder paste. These defects show up as shape deformities on slice images and can lead to premature product failure, although they pass electrical testing without problems.

BGA Defect Causes

Reflow issues

• Low temperature: insufficient temperature to completely reflow solder balls and solder paste prevents formation of stable solder joints

• High temperature: excessive heat during reflow phase can damage BGA substrate, cause solder sputtering and exhaust solder paste flux or cause solder oxidation which will result in poor solder joints

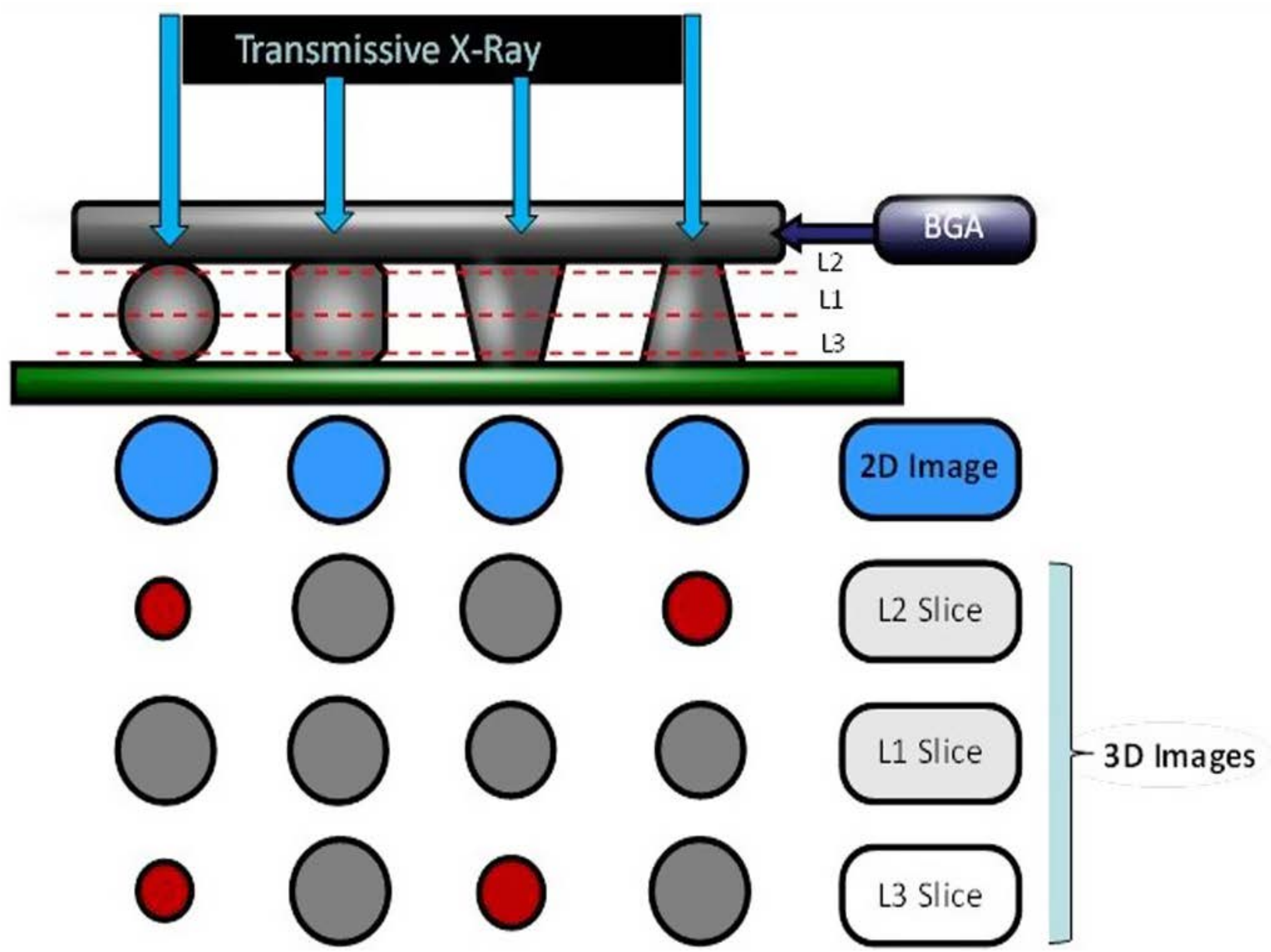


Figure 16: BGA inspection using 3D slice images reveals reflow problems. No reflow (1); normal (2); non-wetting at PCB (3); non-wetting at BGA (4).

• BGA warping: incorrect reflow profile settings may cause the BGA substrate to change shape, bringing the attached solder balls out of contact with solder paste

• Contamination: any foreign matter or oxidation of solder paste may cause solder joint defects which are likely to cause early failure and require field repairs. These defects include head-in-pillow and voiding

Stencil Print/Placement Issues

• Misalignment, bridging, incorrect solder paste volume

Automated solder ball inspection typically requires three slices through the solder joint to determine if the connection is complete or a reflow defect occurred near the PCB or BGA device.

PTH Barrel Fill

Through-hole components have leads soldered to metal-plated holes (vias) through the PCB. The IPC-A-610 standard defines that the amount of solder in the via barrel must cover at least 75% of the board thickness to be acceptable for Class 3 high performance products.

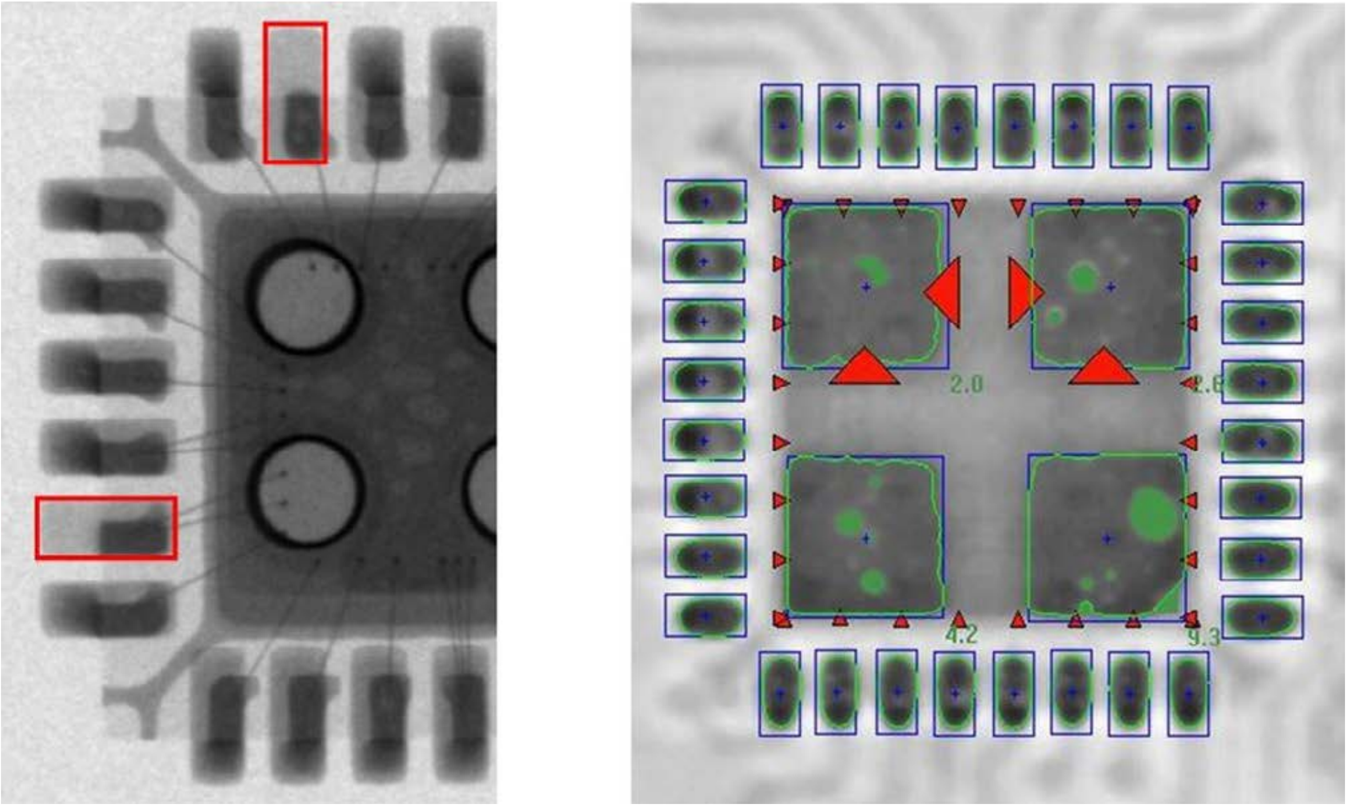


Figure 17: Large ground pads on QFN packages often exhibit voiding, which may cause reliability problems with outer solder joints.

3D AXI inspection uses slices through the PTH joint to determine if the required amount of solder is present at the solder joint.

QFN Package Inspection

QFN is a leadless package where electrical contact is made by soldering the pads on the bottom of the package rather than on the perimeter. In most cases, this type of package cannot be inspected using optical inspection (AOI) and has to rely on X-ray imaging.

Most common QFN defects involve voiding and non-wetting of leads around the package perimeter. The large ground pads on the bottom of QFN packages can be a frequent source of voiding defects, and as a result the entire package may begin to float on the liquid solder and fail to form proper solder joints around the perimeter.

AXI systems search for large discontinuities in the solder pad area to locate voids and calculate if the proportion of voiding is above the tolerable limit.

Conclusion

Selection of an AXI system is a complex process which depends on many variables, including customer's manufacturing process, inspected product complexity, production volume, required inspection coverage and cost, among many others. It is important for manufacturers to choose inspection solutions providers that can offer an extensive portfolio of AOI solutions suitable for various environments, from small desktop products to high performance integrated in-line systems capable of inspecting even very large and complex boards while connected to a high volume production line. **SMT**

Ondrej Simecek is a technical specialist, global marketing, at Test Research Inc. (TRI).

SMTonline Supplier/New Product News Highlights

Ellsworth Europe Now Offers Dow Corning's Latest Product

Ellsworth Adhesives Europe, the leading distributor of adhesives and specialty chemicals, has just announced availability of Dow Corning's latest product range—a series of dispensable thermal pads that have been specially designed for the electronics market, where high performance materials are required.

EasyBraid Unveils Latest Soldering Iron Handpiece

EasyBraid, a manufacturer of soldering systems using the unique "Curie Point" technology have announced the introduction of the SHP-K & SHP-KM soldering iron handpiece which can be used in competitive OKI/Metcal soldering systems, designated PS-800, PS-900, MFR-PS1100, MFR-PS2200.

AIM Appoints Denney NE Regional Sales Manager

Ed Denney has been appointed to the position of Northeast regional sales manager. Based in New Hampshire, Denney will be responsible for providing support to AIM customers in the northeast region of the United States.

MYDATA Changes Name to Mycronic Technologies

MYDATA automation AB has changed its name to Mycronic Technologies AB. The new name will unify the operations of MYDATA and parent company Mycronic AB, former Micronic Mydata AB, under a single brand. Across the globe, Mycronic's high-tech solutions are vital for development of many of the technologies changing the world today: from state-of-the-art satellites, industrial electronics to everyday products like smartphones, computers and flat-screen TVs.

Photo Stencil Research: Electroform vs. Laser-Cut Stencils

Photo Stencil, LLC, a leading full-service provider of high-performance stencils and tooling, announces a new research paper, "Print Performance Studies Comparing Electroform and Laser-cut Stencils."

GOEPEL electronics Boosts Testing Speed of TurboLine

Earlier this year, GOEPEL electronics announced a significant increase in testing speed for the high-end AOI system TurboLine. Innovative solutions of image capturing technology and test program execution in combination with massive use of angled-view inspection could reduce the test time up to 50%.

Manncorp Debuts Three-axis Dispensing Systems

The company's new multi-purpose, off-the-shelf dispensing solutions combine high-precision, three-axis robots with integrated digital dispense controllers for a variety of SMT assembly tasks. These compact, benchtop units weigh less than 100 pounds and can store up to 10,000 dispensing routines created through the use of a hand-held teach pendant and simple, intuitive programming.

Nordson ASYMTEK Intros Spectrum II Cleanroom Series

Nordson ASYMTEK, a Nordson company, a leader in fluid dispensing and jetting technologies, introduces high-speed, high-accuracy, scalable fluid dispensing systems with new Class 100 (ISO 5) compatible configurations.

MatriX Technologies Marks 10th Anniversary

Eckhard Sperschneider, CEO and founder of MatriX, speaking at the celebration event, said, "This is a significant milestone for our company and we can proudly look back on this dynamic development that would never have been possible without the outstanding commitment and motivation of our staff."

Essemtec Benelux Expands, Relocates to Aarschot

Strong growth and an increased number of inquiries have made it necessary for Essemtec Benelux to move to a new office location. Effective June 2, 2014, Essemtec Benelux moved to Aarschot where the new site offers a far superior space with offices, warehouse, a demo room, and a larger spare parts stock.

Reshoring Made Simple

by Michael Ford
MENTOR GRAPHICS VALOR DIVISION

For many years, manufacturing has sought to increase competitiveness by moving offshore to countries with lower labor costs. The simultaneous rise of EMS manufacturing was an essential element to allow the offshore transfer to happen more quickly, with further cost reduction opportunities from load balancing. Initiatives are in place to reverse that trend—to bring manufacturing back, closer to the market it serves, notably in the United States. Throughout the off-shoring process, fierce arguments were put forward to protect the loss of local jobs, even though the result was, in almost all cases, inevitable.

Today, however, the whole market of PCB-based electronics products has changed significantly. Companies are waking up to the fact that the pros of offshoring are no longer what once they were, and that the cons are becoming more significant. The key question is whether reshoring is really commercially viable or is government trying to push water uphill once again? Reshoring could turn around the local labor markets and resolve balance of payment issues. This reshoring opportunity, coordinated with the seemingly unstoppable current market trends, can either be taken advantage of now, or if delayed, could represent the final loss of onshore manufacturing opportunity.

Changing Market Demands

Demand patterns for electronic products in the market continue to change and evolve. As technology-based products become fashionable, the demand from customers becomes more volatile, more heavily influenced by endorsements and trends. It is more important than ever before to get the latest technologies out into the market as fast as possible, with a range of product options to match people's individual tastes. The trend of direct shipping of products, driven by Internet shopping and direct ordering, means that this variation in demand pattern is now felt directly at the door of the factory.

Putting these factors together would seem to spell very bad news for offshore manufacturers, who require longer shipping times with higher costs. Their trade-offs are delays in delivery versus the cost of shipment by air and the

cost of holding local stock around the world, which simply reintroduces issues of price depreciation and product obsolescence. Manufacturers of key products in China, such as mobile handsets, have chosen direct shipping to the customer by air to avoid this issue.

The Changing Face of Distributors

It is not only big manufacturing companies who are direct shipping from China, however. Take a look at the seller profiles of many companies in the Amazon marketplace. Many of these are people based in China or Hong Kong, often with a haphazard website and what looks like their home apartment as a postal address. These guys have a deal with local manufacturers and distributors, buying in China to order and shipping directly to customers all over the world. This business model is becoming more popular because the prices are much more competitive this way compared to the traditional distribution chain, such as a U.S.-based company ordering products in bulk from China and distributing around the country by conventional means.

The cost of the whole distribution chain is still surprising for many people today. If you consider a product that retails for $100 in the United States, think about the actual cost of manufacturing the product. It is likely to be around $20. This gives the Chinese guys incredible opportunity to undercut other forms of distribution, offering what seems like a huge discount through their portal on Amazon. Their weakness is the perceived risk, cost, and delay associated with offshore purchasing. With the savings created by the internet shopping model, and the shorter lead-times and/or costs of shipping, on-shore manufacturing using the same distribution model as the Chinese manufacturers would have the advantage, being competitive to deliver what the customer wants, at

Figure 1: Reshoring can bring manufacturing closer to market, improve demand response and delivery, take advantage of site capability and capacity, support differentiation between prototype sites and volume sites, reduce costs through better design and manufacturing agility, and cut down on geographical and geopolitical risks.

a compelling price, and much faster, being so much closer to the market.

The continued demise of the traditional product distribution chain is also putting intense pressure on labor markets. Shopkeepers, in fact, any physical outlets of products, are under threat as direct shipping of Internet orders takes hold.

The Changing Costs of Labor

Reshoring would bring work opportunities back to the United States and Europe, with a focus on higher value and more interesting job roles within manufacturing than in the past, for example jobs as technology process managers rather than just people who "stuff boards." The increased degree of production and information technology raises the profile of the manufacturing job market.

The principle for reshoring exists, although the old offshore argument of labor costs is still what people will focus on. The significance of the labor cost differential is often thought of as being greater than it actually is. Take our $100 product, for example, with an actual manufacturing cost of $20. Probably, at least 80% of that cost is for materials, which leaves about $4 to the manufacturing operation itself. That $4 can be divided up between the cost of machinery, operational overheads, labor, and profit margin. Many of these costs scale with the labor cost but global items such as SMT and test machines are not affected as much.

The first challenge for onshoring is to understand what effect the increased cost of labor will really have on competitiveness. Manufacturing operations have also been through a big change in recent years. It no longer requires a team of specialist engineers to prepare product data and perform the necessary SMT and test programming, the process preparation, for manufacturing. Whereas years ago, a single new product introduction would consume several people for several days, current best practice has this completed by one person in a couple of hours. The SMT machines themselves are also a much more reliable technology today, controlled and monitored by software. This can be linked to live "just in time" automated logistics management of materials delivery. The requirement for machine operators and materials logistics operators is again, by today's best practice, less than half what it was just a few years ago.

> ***"The labor cost per person ratio has also changed significantly as labor rules in the United States have become more flexible and labor costs in places like China are increasing rapidly. The effect on the overall manufacturing cost of products, offshore as compared to on-shore, is far less compelling than it ever was."***

The labor cost per person ratio has also changed significantly as labor rules in the United States have become more flexible and labor costs in places like China are increasing rapidly. The effect on the overall manufacturing cost of products, offshore as compared to on-shore, is far less compelling than it ever was. In context with our $100 product break-down and the cost savings of direct shipping, the real impact of offshore manufacturing cost versus cost effectiveness of manufacturing close to the customer should be considered.

Localizing Raw Materials

The second challenge to reshoring is related to raw materials. Products manufactured in China are made predominantly with raw materials made in China. What would be the difference in shipping if, instead of the product being shipped from China, you have to ship all of the raw materials? The truth is that raw materials do continue to be manufactured locally, for example, in the United States, but at far lower amounts and often intended for use in more critical applications. Materials manufacturers also have gone through the same off-shoring process, following the example of most of their customers in manufacturing. Materials manufacturers are

RESHORING MADE SIMPLE *continues*

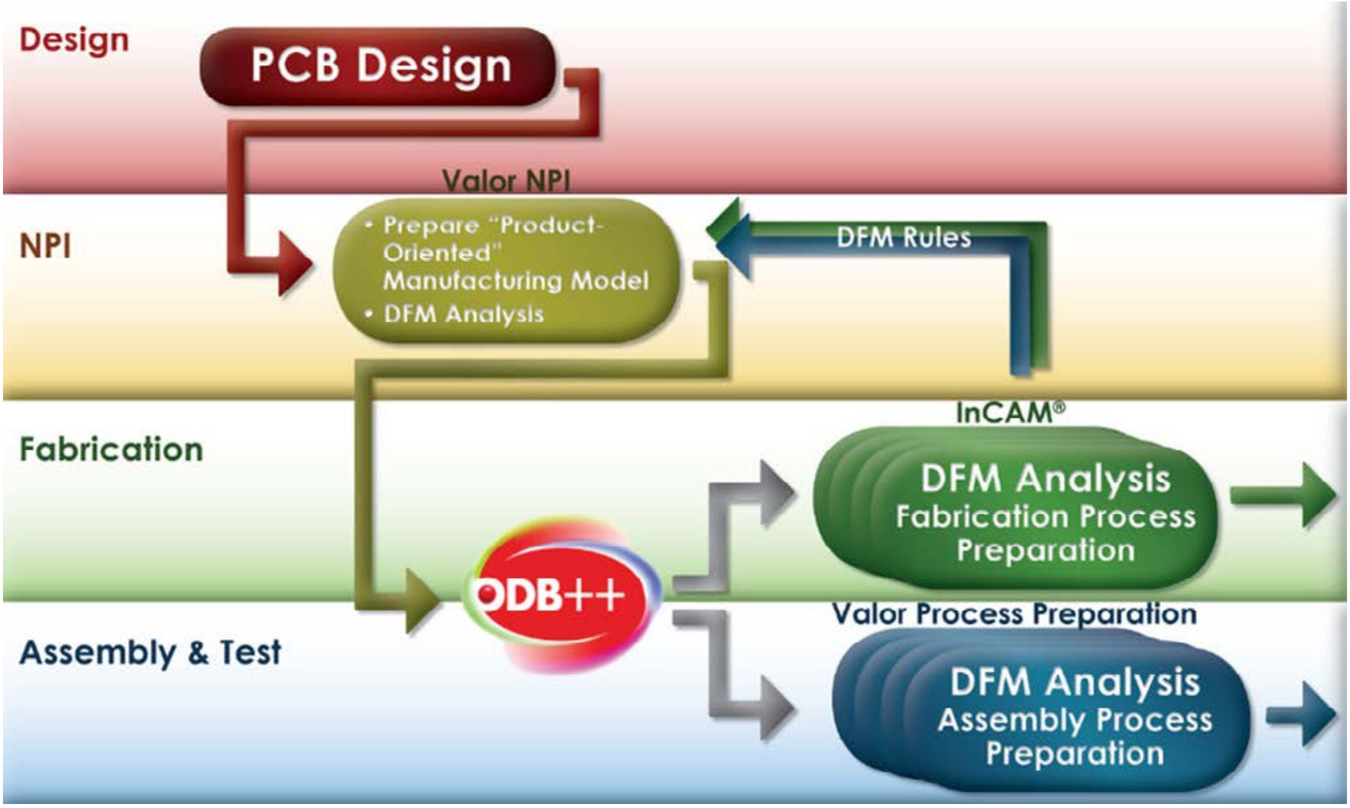


Figure 2: Best practices for Lean manufacturing bring the necessary enhancement to ERP to create a new manufacturing paradigm necessary to meet the changing demands of the market.

now also considering on-shoring issues, again when and where their customers are doing the same. There is a synergy for manufacturers and suppliers to work together in the reshoring process.

The challenge is then whether local manufacturing of raw materials can be as cost-effective as importing. The answer will again reflect the increased automation and technology of manufacturing processes, as well as the flexibility of manufacturing according to the customer's demand pattern. Raw material costs can also be avoided by having direct distribution links from the suppliers to manufacturing. This synergy of operation was achieved and proven by Toyota in Japan using their just in time system for delivery from their suppliers. The success of this strategy is ultimately dependant on whether suppliers actually follow the principles of flexibility and agility and so really achieve the cost savings, or whether they simply keep to their constrained legacy production practices, building to local stock to satisfy the customer's just-in-time demands. This is the juncture where the synergy of the whole process needs to work together.

Updating U.S. Manufacturing

Setting up new factories in the United States is going to require modern thinking. The legacy operational practices, driven by ERP technologies dating from the 1970s, need some enhancement. The design of the manufacturing operation must be based primarily on the ability to directly supply in accordance with the demands of the market. It may mean that the operation will have a large variety of products to make, with a high mix of each every day. The old adage that productivity is inversely proportional to product mix, which held true for many years, is no longer true.

Today's process preparation software can take a qualified product model, defined in a single file format such as ODB++, and make it

available for operation on any line configuration in the factory as needed. Live production planning software is actually the first stage in the production preparation now in best practice cases, putting together the combinations of products, optimizing feeder setups for zero-loss changeovers, and optimizing performance. Process preparation software delivers any needed programming for any line configuration, which creates product portability, the ability to produce any product on any line configuration at any time, without significant engineering cost or down-time. The execution of rapid planning decisions based on flexible customer demand also mandates Lean material delivery to machines to avoid needless physical shop-floor material WIP. Not only does this avoid the need to re-recount and move materials whenever a planning change is made, there is a significant cost saving of excess material investment.

Taking total control of materials across the shop-floor and warehouses provides very high accuracy of material inventory, which is critical for low-risk planning change execution and for good communication back to raw material suppliers. The Lean manufacturing engine, driven by live planning, brings the necessary enhancement to ERP to create a new manufacturing paradigm necessary to meet the demands of the market—performance and flexibility together, designed from the ground up. These innovations are, of course, not limited to new factories. Existing manufacturing operations can also implement these practices to move to the next level of competitiveness.

A More Favorable Environment for Reshoring

In terms of manufacturing costs then, the playing field has leveled off somewhat in recent years, most significantly for distribution and demand pattern satisfaction, also for labor and materials costs because of increased automation in machinery, and last but not least, enhancement to manufacturing engineering, planning, and supply chain. The arguments for offshore manufacturing are certainly now much weaker than they once were, so now let's explore the other positives for reshoring.

> *“Looking at the more serious side of the electronics manufacturing market, we see high reliability and safety critical products are more likely to have remained on-shore. The reasons include quality, control, and responsibility. The effect of poor quality or unreliable products is no longer exclusive to military, aerospace, medical, and automotive.”*

The environment is often put forward as a key positive for reshoring. The final shipping cost to the environment in terms of jet fuel or marine diesel comes easily to mind for most people; however, transportation throughout the whole product manufacturing cycle is a much more complex subject. Other factors, however, can be of stronger significance in a business context.

Looking at the more serious side of the electronics manufacturing market, we see high reliability and safety critical products are more likely to have remained on-shore. The reasons include quality, control, and responsibility. The effect of poor quality or unreliable products is no longer exclusive to military, aerospace, medical, and automotive. With consumers now making product reviews posted on Internet shopping sites and the popularity of social media, a single defect found in a popular product in the market can cause significant business opportunity loss and can be a threat to brand image. The media is also today keen to expose sensational stories of how products can fail.

Quality is Critical

Quality is more critical today than ever before, for competing in today's market. Quality in manufacturing comes from control, traceability, and assurance that work is performed correctly every single time, as well as insurance to know that if ever anything does go wrong, it can be resolved with minimum overall cost. Having manufacturing close to the customer provides a rapid feedback loop on market quality and a much tighter control on manufacturing execution. Having three months' worth of potentially faulty products in a container on a ship from China to the United States can be very frustrating. Delivery disruption and the cost of re-work and recall can quickly get out of control.

The weather, natural disasters, and political issues can also place a serious risk to manufacturing capability. If either the manufacturing of the finished product or any of the key components is dependent on a single location in an area that may be at risk, it can also significantly affect delivery of products. Keeping local control provides a far better chance of management and recovery.

Incentives are now in place for reshoring, driven by the knowledge that industry and technology has changed to make it viable. But how does one get started practically? As with the great race to go offshore, perhaps EMS companies will step up to promote on-shore services, built on modern manufacturing technologies to meet direct demand patterns. The load balancing that EMS companies can provide continues to be a benefit no matter where they are located. Off-shoring and out-sourcing are actually two completely different things.

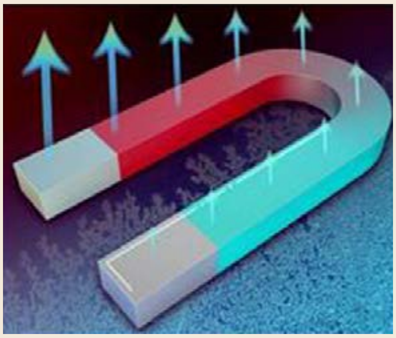
It's said that "You are what you eat." On an industrial level, I would say that you are what you make. Rather than fighting the trends in the way that products are sold and distributed, which have increasingly challenged manufacturing for some years, it is time now to let these changes work for manufacturing. Machine and information technology solutions are with us. The advantages are becoming much clearer if we understand the onshore and offshore arguments in context with today's market patterns and manufacturing technology capabilities. If we don't take this opportunity seriously right now, we may forever end up ordering our cool stuff from a guy in an apartment in China; that is at least, until all the gasoline is used up. **SMT**

Michael Ford is senior marketing development manager with Valor division of Mentor Graphics Corporation. To read past columns, or to contact the author, click here.

Magnets May Act as Wireless Cooling Agents

The magnets cluttering the face of your refrigerator may one day be used as cooling agents, according to a new theory formulated by MIT researchers.

The theory describes the motion of magnons — quasi-particles in magnets that are collective rotations of magnetic moments, or "spins." In addition to the magnetic moments, magnons also conduct heat.



"You can pump heat from one side to the other, so you can essentially use a magnet as a refrigerator," says Bolin Liao, a graduate student in MIT's Department of Mechanical Engineering. "You can envision wireless cooling where you apply a magnetic field to a magnet one or two meters away to, say, cool your laptop."

Liao and his colleagues recognized a similar "coupled" phenomenon in magnons, which move in response to two forces: a temperature gradient or a magnetic field. Because magnons behave much like electrons in this aspect, the researchers developed a theory of magnon transport based on a widely established equation for electron transport in thermoelectrics, called the Boltzmann transport equation.

"There's still a long way to go for thermoelectrics to compete with traditional technologies," Liao says. "Studying the magnetic degree of freedom could potentially help optimize existing systems and improve the thermoelectric efficiency."

TOP TEN

News Highlights from SMTonline this Month

① Flextronics Nets Contract from Aviage Systems

The company has been selected by Aviage Systems to manufacture Integrated Modular Avionics cabinet units to support commercial aircraft programs in China. Flextronics is providing supply chain solutions from its AS9100C aerospace-certified facility equipped with a world-class lab offering failure analysis, product qualification, test, and manufacturing design solutions.

② Saline Lectronics Boosts SMT Capacity

The company has dramatically increased its SMT capacity with the acquisition of new manufacturing equipment including two Juki FX-3RA high-speed modular mounters. Saline's equipment expansion will allow the manufacturing floor to increase both capacity and efficiency.

③ Jabil's Q3 Meets Expectations; EMS to See Drop in Q4

"Our third fiscal quarter performed largely as planned and is highlighted by a strong balance sheet performance, driven by significant cash flow from operations and a total cash position of $1.3 billion," said Forbes Alexander, chief financial officer. Management maintains its fiscal year 2015 outlook of $1.65 to $1.95 core earnings per share.

④ Dr. Bhartia Honored as NATEL EMS Fellow

The company's Board of Directors has bestowed the honor of NATEL EMS Fellow on Prakash Bhartia, Ph.D. The Fellowship Program was established to honor exceptional leaders who set technical direction for the electronics manufacturing company and use their knowledge, wisdom, and experience to provide guidance on crucial issues.

5 Creation's California Facility Earns FDA Approval

"Medical devices are at the core of our business growth in the region and indeed across the company," said Jeff Kuypers, regional leader. "Programs designed to encourage the growth of medical technology are becoming more prevalent, and some of the best medical device OEMs in the world are located in North America, and in California in particular."

6 Elecsys Enjoys 20% Sales Growth in FY 2014

"We are pleased to report a very successful year with continuing revenue growth, enhanced gross margins, and a substantial increase in earnings. Sales increased over 20% compared to the prior year driven by shipments of our proprietary M2M products and solutions," said Karl B. Gemperli, CEO.

7 Computrol Invests in ACE Selective Solder System

Now installed at Computrol's Meridian, Idaho facility, this marks the company's fifth KISS-103 system, with three at this facility and two at the Orem, Utah plant. Additionally, Computrol has upgraded the two existing KISS 103 systems at the Meridian facility and added a 3" wave capability to one of the machines.

8 LACROIX Tunisia Achieves ISO/TS 16949 Certification

The successful certification shows the investment of the entire LACROIX Electronics team in the quality process. "Actually, responding to or even anticipating our clients' expectations, is our mission's heart and a leitmotif running through our four plants and five R&D centers," explains General Manager François Beauxis.

9 STI Electronics Spins Off Sales & Distribution Division

Hisco Inc. expands its U.S. distribution footprint with the acquisition of the Sales and Distribution Division of STI Electronics, Inc. (STI), which provides assembly products and soldering supplies to the electronics manufacturing industry. Other services, including training services, failure analysis, prototyping, and small- to medium-volume PCB assembly, will remain with STI.

10 Despite Weak Market NOTE Posts 7% Growth in 1H

"Despite a relatively weak market we increased sales by 7% in the first half of the year. Further, the order book supports continued growth compared to previous year. In my eyes, a show of strength from NOTE," says Peter Laveson, president and CEO.

EVENTS

For the IPC's Calendar of Events, click here.

For the SMTA Calendar of Events, click here.

For the iNEMI Calendar, click here.

For a complete listing, check out *SMT Magazine's* full events calendar here.

Advancements in Thermal Management 2014
August 6–7, 2014
Denver, Colorado, USA

Philadelphia Expo & Tech Forum
August 12, 2014
Cherry Hill, New Jersey, USA

West Penn Expo & Tech Forum
August 14, 2014
Monroeville, Pennsylvania, USA

IPC Southeast Asia High Reliability Conference
August 20, 2014
Penang, Malaysia

NEPCON South China
August 26–28, 2014
Shenzhen, China

Vietnam Manufacturing Expo
August 27–29, 2014
Hanoi, Vietnam

Electronics Assembly
August 27–29, 2014
Hanoi, Vietnam

Assembly Technology Vietnam
August 27–29, 2014
Hanoi, Vietnam

World Engineering Expo (WEE)
September 1–3, 2014
Singapore

IDTechEX Business & Tech. Insight Forum
September 3-4, 2014
Tokyo, Japan

IMTS 2014
September 8–13, 2014
Chicago, Illinois

Capital Expo & Tech Forum
September 9, 2014
Laurel, Maryland, USA

Hybrid & Electric Vehicles Forum 2014
September 17–18, 2014
Munich, Germany

Medical Electronics Symposium 2014
September 18–19, 2014
Portland, Oregon, USA

FUTURA
September 18–21, 2014
Salzburg, Austria

MEDIX Osaka
September 24–26, 2014
Osaka, Japan

SMTA International 2014
September 28–October 2, 2014
Rosemont, Illinois, USA

Standards Development Meetings
September 28–October 2, 2014
Rosemont, Illinois, USA

CEA Innovate!
September 30–October 2, 2014
Phoenix, Arizona, USA

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INNOVATIVE TECHNOLOGY: **BRYSON MATTIES**
COVER PHOTO: **THIN FILM ELECTRONICS ASA**

SMT

SMT® (Surface Mount Technology) is published by BR Publishing, Inc., PO Box 50, Seaside, OR 97138

August 2014, Volume 29, Number 8 • SMT© (Surface Mount Technology©) is published monthly, by BR Publishing, Inc.

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Coming Soon to *SMT Magazine:*

SEPTEMBER:
Automation

OCTOBER:
Alternatives to Solder

NOVEMBER:
Rework & Repair