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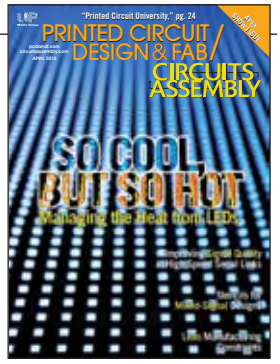

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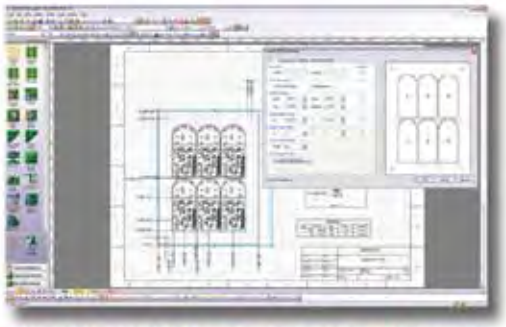

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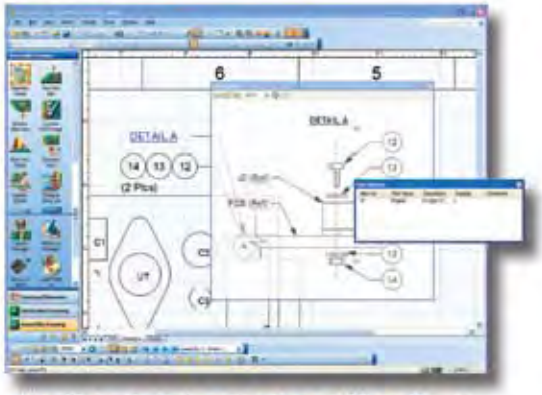

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MIKE BUETOW, EDITOR-IN-CHIEF

Toyota's Troubles Ours Too

THE sudden unintended acceleration problems in Toyota's vehicles have touched off a firestorm of controversy over the cause(s). Accusations of problems with the electronics throttle system were quickly followed by emphatic denials by the automaker. Then on Feb. 23, Toyota's top US executive testified under oath before US Congress that the automaker had not ruled out electronics as a source of the problems plaguing the company's vehicles. Subsequently, other company officials denied that was true.

To confuse matters more, a professor of automotive technology claims to have found a flaw in the electronics system of no fewer than four Toyota models that "would allow abnormalities to occur." Testifying before Congress, David W. Gilbert, a Ph.D. with almost 30 years' experience in automotive diagnostics and troubleshooting, said the trouble locating the problem's source could stem from a missing defect code in the affected fleet's diagnostic computer.

Prof. Gilbert said his initial investigation found problems with the "integrity and consistency" of Toyota's electronic control modules to detect potential throttle malfunctions. Specifically, Prof. Gilbert disputed the notion that every defect would necessarily have an associated code. The "absence of a stored diagnostic trouble code in the vehicle's computer is no guarantee that a problem does not exist." Finding the flaw took about 3.5 hours, he added. (A video of Prof. Gilbert's test at his university test track is at www.snotr.com/video/4009.)

It took two weeks for the company to strike back. In early March, Toyota claimed Prof. Gilbert's testimony (http://circuitsassembly.com/blog/wp-content/uploads/2010/03/Gilbert.Testimony.pdf) on sudden unintended acceleration wasn't representative of real world situations. In doing so however – and this is important – Toyota made no mention (at least in its report) about Prof. Gilbert's more important finding: the absence of the defect code. Was Toyota's failure to address that an oversight? Or misdirection?

Second in concern only to the rising death toll is Toyota's disingenuous approach to its detractors. Those who follow my blog realize I've been harping on this for several weeks. But why, some readers have asked.

The reason is subtle. Electronics manufacturing rarely makes international headlines, and when it does, it's almost always for the wrong reasons: alleged worker abuses, product failures, (mis)handling of potentially toxic materials, and so on. The unfolding Toyota story is no different.

Yet it's important the industry get ahead of this one. Planes go down over oceans and their black boxes lost to the sea. Were the failures brought about by conflicts between the cockpit navigational gear and on-board satellite entertainment systems? When cars suddenly accelerate, imperiling their occupants, was it a short caused by tin whiskers that left the driver helpless? It's vital we find out.

In the past four years, NASA's Goddard Space Flight Center, perhaps the world's premiere investigator of tin whiskers, has been contacted by no fewer than seven major automotive electronics suppliers inquiring about failures in their products caused by tin whiskers. (Toyota reportedly is not one of them, but word is NASA will investigate the incidents on behalf of the US government.) These are difficult, painful questions, but they must be examined, answered, and the results disseminated. Stonewalling and misdirection only heighten the anxiety and fuel accusations of a cover-up.

We as an industry so rarely get the opportunity to define just how exceedingly difficult it is to build a device that works, out of the box, as intended, every time. A Toyota Highlander owner has a satellite TV monitor installed into his dash, then finds certain controls no longer work as designed. A Prius driver's car doesn't start when he's using his Blackberry. It's impossible for an automotive company to predict and design for every single potential environmental conflict their models may encounter.

The transition to lead-free electronics has been expensive and painful for everyone – even for those exempt by law, because of the massive infiltration of unleaded parts in the supply chain. And despite no legal impetus to do so, some auto OEMs have switched to lead-free. Moreover, to save development time costs, automakers are quickly moving to common platforms for entire fleets of vehicles, dramatically exacerbating the breadth of a defect. We do not yet know if lead-free electronics is playing a role in these catastrophic failures. But if tin whiskers or some other electronics-related defect are the cause, or even a cause, of these problems, we need to know. If we are inadvertently designing EMC in, we need to know.

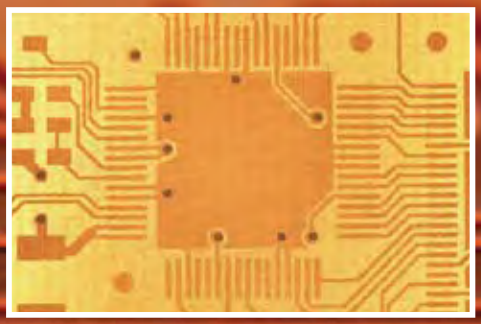
Toyota's PR disaster could be a once-in-a-lifetime chance for the electronics industry to reposition itself. What we build is important and life-changing. This is a chance to take back our supply chains from those whose single purpose is cost reduction, and to redefine high-reliability electronics as a product worth its premium. And it's a chance to explore whether wholesale industry changes are conducted for the good of the consumer, or for short-term political gain. It's a tragic reminder that science, not opinion, must always win, and that moving slowly but surely is the only acceptable pace when designing and building life-critical product.

'Virtually' great. A big "thank you" to the 2,600-plus registrants of this year's Virtual PCB conference and exhibition. It was the best year yet for the three-year-old show, confirming once again that there's more than one way for the industry to get together. The show is available on-demand through May 4; be sure to check it out at virtual-pcb.com.

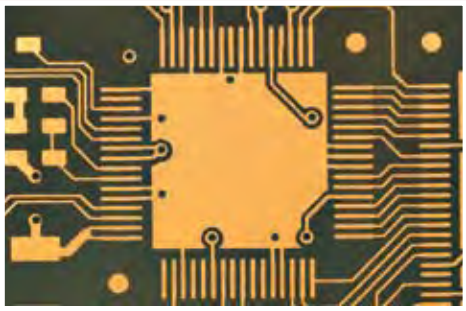
Mike Buetow

mbuetow@upmediagroup.com

Revolutionary Digital Fabrication Process



Panel printed with LithoJet 210 Etch Resist



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PCD&F Briefs

PCB fabricator **Sierra Circuits** (protoexpress.com) has ceased production at its mid-volume plant in Chanute, KS, and is transitioning the site into a sales office. Sierra Proto acquired the site, the former **PC Boards,** from Dennis Steinman in 2007, as part of growth run that took the firm to a reported $40 million in annual sales.

Mysore City Corp. (mysorecity.gov.in) officials reportedly locked their PCB factory in Krishnaraja Mohalla, India, following complaints by local residents over foul odors.

PWB fabricator **Electro Plate Circuitry** (eplate.com) has achieved NADCAP accreditation.

Dow Epoxy (epoxy.dow.com) will increase prices of its standard brominated epoxy resins, and other epoxy products by $200 per metric ton in Asia Pacific, excluding Japan.

Atotech (atotech.com) in February opened a tech center in Jablonec nad Nisou, Czech Republic.

Automatic Lamination Technologies (dynachem.eu) finalized its purchase of Dow Chemicals' Electronic Materials Equipment division. The Castronno, Italy-based unit is a provider of dry-film imaging equipment.

Mentor Graphics (mentor.com) will move some 450 jobs from San Jose to Fremont, where it has acquired three buildings.

ICM Controls (icmcontrols.com) purchased an **IPS** (ips-vcm.com) HCM Model 21 copper chloride etching system.

PCD&F People

Lenthor Engineering named **Michael Newman** applications engineer. He has 30 years' PCB engineering and management experience at TTM, DDI and Hadco.

Isola Group named **David Luttrull** director of development – emerging technologies. He was president and chief scientist for MG Lab Services.

Polar Instruments promoted **Martyn Gaudion** to chief executive, replacing **Martyn Mann,** who has been named chairman.

Milplex Circuit (Canada) named **Davinder Dhanoa** regional sales manager.

Mentor Graphics promoted **Serge Leef** to vice president of new ventures.

Circuits Assembly Briefs

University of California – Berkeley (berkeley.edu) engineers have created energy-scavenging nanofibers that could be woven into clothing and textiles. The nanofibers can convert

ECHA Targets 8 More Substances for Restriction

HELSINKI – The European Chemicals Agency in March published proposals to identify eight chemicals as Substances of Very High Concern (SVHC) and possible candidates for authorization.

The substances, which include trichloroethylene; boric acid; disodium tetraborate, anhydrous; tetraboron disodium heptaoxide, hydrate; sodium chromate; potassium chromate; ammonium dichromate; and potassium dichromate, are proposed because of their potentially serious effects on human health.

The deadline to comment on the proposals is April 22. The proposals are available on the ECHA website: http://echa.europa.eu/doc/press/pr_10_03_svhc_consultation_20100308.pdf.

Industry reaction was quick. On a popular industry email forum, it was pointed out that boric acid is listed as an ingredient in E-glass fabrics, a base material for laminate. "The loss of E-glass in laminate would probably be worse than the lead-free issue," said Denny Fritz, a materials expert with SAIC (saic.com). Fluoroborate plating also was noted as a substance once used in circuit board fabrication, and possibly not yet completely eliminated.

The recommended substances are now on a list for discussion on whether they should be classified as a SVHC. Inclusion on that list for discussion is not the same as being banned. Nevertheless, it raises the odds that use of the substances could be severely restricted or banned in the future. As Julia Lietzmann, an attorney at the Levinson Environmental Law Firm in Haifa, Israel, noted on the email forum, "The ban is not the immediate effect. However, a ban has become more likely…. The ultimate goal is, in fact, to eliminate the substances from the community market as far as possible."

In a press release, ECHA said comments should focus primarily on the hazardous properties that qualify the chemicals as SVHCs. In addition, interested parties can provide comments and further information on the uses, exposures and availability of safer alternative substances or techniques. They should be aware that these aspects will mainly be considered at the next stage of the process (i.e., selection of substances for authorization), which includes a new round of public consultation.

The Member State Committee will review these comments when seeking an agreement on the identification as SVHC before ECHA includes these substances on the Candidate List, from which substances are selected for authorization. Substances that appear on the Authorization List can, after a transition period, only be used if a specific authorization is granted.

According to the ECHA, three EU Member States – Denmark, France and Germany – were responsible for the proposals.

There are already 29 substances on the Candidate List. Inclusion on that list means new information requirements for suppliers of preparations and articles containing the substances.

Some of the Member States are seeking to extend national limits on the proposed SVHC. Trichloroethylene, for example, is banned in Germany, except in totally emissions-free equipment. – *MB*

Virtual PCB Now 'On-Demand'

SMYRNA, GA – Following record-breaking attendee registration, Virtual PCB, the industry's only virtual trade show and conference is now offered on-demand for the next month.

More than 2,800 PCB designers, fabricators and assemblers registered for Virtual PCB (virtual-pcb.com), which took place March 2-4.

This year's event has drawn nearly 1,500 attendees from all over the world. The show is now available on-demand until May 4.

Exhibitors include several leading suppliers of assembly process equipment, design software, and bare boards. The technical conference includes webinars on design, signal integrity, lead-free soldering, tin whiskers, and other issues from well-known industry experts.

"This year's Virtual PCB was the best event yet," said Mike Buetow, Editor in Chief of Circuits Assembly, which co-sponsored Virtual PCB. "The technical conference is clearly a huge draw, and the lively chats on tin whiskers and board reliability showed again that engineers don't need to be face-to-face in order to engage in productive discussion and debate."

A fully interactive, Web-based event, Virtual PCB incorporates all the critical

features of a live event, while allowing PCB design, fabrication and assembly equipment and materials buyers and sellers to interact online.

Virtual PCB is produced by UP Media Group, the industry's leading publisher of technical magazines. – *CD*

Banner Year: Altium Adds 500 US Customers

SYDNEY – Altium's (altium.com) North American operation has acquired more than 500 new US customers over the past year, the company said in February.

During the past 12 months, the PCB EDA firm's flagship tool, Altium Designer, has picked up hundreds of customers across a variety of segments, including industrial, medical, and other growing markets.

An Altium survey conducted in December found 84% of new users had experienced improvements of more than 200%.

Altium Designer provides a system development platform for FPGA, PCB and embedded software development. – *CD*

Isola, ITEQ Settle Litigation

CHANDLER, ARIZONA – Isola USA (isola-group.com) and ITEQ (iteq.com.tw) have settled all outstanding litigation between the two firms. As part of the settlement, ITEQ will pay Isola an undisclosed sum and withdraw all of its litigation against Isola in the US and Taiwan.

Isola will also drop its counterclaims against ITEQ in the US.

Although Isola will not grant a license for a US patent to ITEQ, Isola did grant ITEQ a covenant not to sue, provided ITEQ's chemical formulations conform to specific confidential restrictions.

ITEQ also agreed to pay a royalty to Isola on the global sales of ITEQ's low-loss products through the life of the patent. – *CD*

Advanced Circuits Acquires Circuit Express

WESTPORT, CT – PCB fabricator Advanced Circuits (4pcb.com) in March acquired Circuit Express Inc. (circuitexpress.com) for $15.6 million.

Tempe, AZ-based CEI is a provider of quickturn prototype and low-volume rigid PCBs, primarily for aerospace and defense customers. It had 2009 revenue of approximately $16.4 million. The combined company will have estimated sales of more than $55 million.

Advanced Circuits is a subsidiary of Compass Diversified Holdings, formed to acquire and manage middle market businesses headquartered in North America. – *CD*

Mentor Acquires Zeland, Virtual Garage

WILSONVILLE, OR – Mentor Graphics (mentor.com) made a pair of acquisitions in the past two months, acquiring a software package and a company.

The EDA firm in February acquired the Virtual Garage automotive electrical and electronic systems design and management software from Freescale (freescale.com). Terms were not disclosed.

Virtual Garage addresses tradeoffs between value-of-variety and cost-of-complexity caused by optional electronic content, and provision of vehicle-specific design data, such as dynamic electrical schematics, on-demand to service networks. The deal includes relevant intellectual assets, key personnel, and one key commercial contract.

Mentor also acquired Zeland Software, a provider of 3-D EM simulation and modeling tools. As part of the deal, Zeland's development, customer support, and marketing/sales team, including Zeland founder and CEO Dr. Jian-X Zheng, have joined Mentor Graphics.

No financial terms were disclosed for the deal, which closed Feb. 1.

Zeland's full-wave 3D EM simulation and modeling technology will be available

energy from mechanical stresses and into electricity, and could one day be used to create clothing that can power small electronics.

Top 40 EMS company **Hana Microelectronics** is considering capital expenditures of up to $35 million to expand its production facilities and may hire up to 1,000 more workers this year.

C-Tech Electronics has ordered a **Blakell Europlacer** (europlacer.com) Speedprint SP210AVi stencil printer.

Vitronics Soltec (vitronics-soltec.com) named **JT Technologies** (jttech.net) as its representative in upstate New York.

Celestica (celestica.com) plans to close its facility outside Nashville, TN, on April 15, and lay off 43 staff.

EMS firm **LSH** (lewien-verbindungstechnik.de) is building a 32,500 sq. ft. production facility in Jaklovce, Slovakia.

Does **Ford's** use of an electronics manufacturing services provider portend a wider opening of the automotive market to EMS providers and ODMs? (www.tradingmarkets.com/news/press-release/f_isuppli-ford-opens-the-door-for-contract-manufacturing-in-automotive-774061.html)

A new **Commerce Department** study of contractors, subcontractors and Defense Department agencies found the number of counterfeit electronics entering the system has risen from 3,868 incidents in 2005 to 9,356 in 2009.

Hon Hai (Foxconn) (fih-holdings.com) is shooting for 30% sales growth in 2010, and to cope with possible labor shortages, will set up some unmanned factories in Taiwan this year.

An equity group led by Gary Tanel has purchased **Circuitronics** (circuitronics.com), an EMS firm in Ft. Worth, TX. Terms were not disclosed. Former owner Jeff Frobus reportedly will stay with the company to run its sales team.

Honeywell Sensing and Control cited **Digi-Key** (digikey.com) with its 2009 Authorized Distributor Performance award.

CyberOptics (cyberoptics.com) appointed **Maxim** SMT Technologies (maximsmt.com) as representative in India.

Nigerian Communications Satellite (nigcomsat.com) plans to start producing handsets and computer hardware in the country in less than two years, having commissioned a local PCB Micro Electronics Centre.

The European Commission's Directorate-General for Trade has issued a report on the seventh round of negotiations on an Anti-Counterfeiting Trade Agreement, held

Jan. 26-29 in Mexico. (strtrade.com/wti/wti.asp?pub=0&story=33923&date=2%2F19%2F2010&company=)

Zhejiang Hongchen (hongchensolar.com) has purchased several **DEK Solar** (deksolar.com) PV1200 photovoltaic metallization lines.

Northrop Grumman's (ng.com) Navigation Systems Division will expand its Salt Lake City site by 50,000 sq. ft. to increase factory output.

Infineon Technologies (infineon.com) has filed a complaint with the US International Trade Commission, seeking to stop **Elpida Memory** from importing and selling certain DRAMs in the US.

CirTran Corp. (citran.com) has transferred its open and active purchase orders relating to its contract electronics manufacturing business to a new ownership group led by its former COO. The new owners will lease equipment and 19,000 sq. ft. of manufacturing space, and will retain the company's EMS employees. The group, **Katana Electronics,** is headed by Shaher Hawatmeh, who had been CirTran's COO since 1995.

Philips' (philips.com) lighting division has awarded a manufacturing deal to **Elcoteq** (elcoteq.com).

Seoul Semiconductor (seoulsemicon.com) named **Digi-Key** (digikey.com) a global distributor of its full range of LEDs. Also, Digi-Key, Transim and NXP have integrated NXP SimPort Design Center with Digi-Key's e-commerce software.

Compal Electronics (compal.com) will restart construction of a production base in Vietnam.

Preh GmbH has purchased a pair of **Siemens** (siplace.com) Siplace SX placement lines.

EMS provider **NBS** (nbscorp.com) has installed four **VI Technology** SPI systems at its manufacturing facility in Santa Clara, CA.

Electrolube (electrolube.com) is moving to a new 62,000 sq. ft. campus in Swadlincote, Derbyshire, UK.

DEK (dek.com), **Senju** (senju-m.co.jp) and **Asymtek** (asymtek.com) are among the winners of **Intel's** (intel.com) Preferred Quality Supplier and Supplier Continuous Quality Improvement awards.

Electronics manufacturer **Ionics EMS** (ionics-ems.com) seeks a voluntary delisting from Singapore Exchange.

MicroScreen (microscreen.org) named **MicroProduct Sales** (microproductsales.com) as its exclusive agent in Indiana, Michigan and Ohio.

with Mentor's HyperLynx signal integrity and power integrity tools.

All existing Zeland products and development roadmaps will remain intact, Mentor said. – *CD*

And Then There Were 329: N.A. PWB Shop Numbers Dwindle

PALO ALTO, CA – North America, once home to a reported 1,000 printed circuit board shops, now has 329.

That's the latest sum as totaled by industry analyst Harvey Miller. Miller, who publishes Fab-File, a directory tracking the domestic PWB industry, finds the 10 largest North American-based fabricators account for half the region's revenue. The North American PWB market is estimated at $3 billion, Miller wrote.

The number of shops as of March 1 was 329 in the US and Canada, Miller found, down 4.9% from a year ago. In the US, the number of shops dropped by 16, to 293, over the past year. California, with 101 shops, remains the principal place of manufacture.

Given the number of recent acquisitions, including DDi's purchase of Coretec, and the overlap of locations (both companies have shops in Toronto, for example), more closures are likely on the way. – *MB*

iNEMI Calls for Carbon Footprint Standard

HERNDON, VA – iNEMI (inemi.org) says the electronics manufacturing industry must work collectively at all levels of the supply chain to mitigate greenhouse gas emissions affecting climate change.

Integral is development of a product carbon footprint methodology that will enable companies to quantify environmental impact of their products and easily assess tradeoffs to make improvements, says the consortium.

iNEMI members supporting the call for an industry-standard PCF methodology are Alcatel-Lucent; ASSET InterTech; Cookson Electronics; Cisco; Dell; Dyconex; Elite Material Co. Ltd.; Guangdong Shengyi Sci. Tech Co.; Henkel; HP; Intel; Integrated Service Technology; Industrial Technology Research Institute; Lenovo; Micro Systems Engineering Inc.; Purdue University; Quanta Computer; Stats ChipPac; TI; Tyco Electronics, and Universal Instruments.

iNEMI's position on product carbon footprinting is at http://thor.inemi.org/webdownload/projects/ELSC/Position_Statement/iNEMI_PCF_Feb2010.pdf. – *CD*

Input Sought for PCB IP Standard

BANNOCKBURN, IL – The first draft of a proposed standard covering protection of IP designed into PCBs will be released this month during Apex.

The Intellectual Property Committee will release the draft during its scheduled meeting on April 6.

The draft, Best Industry Practices for Intellectual Property Protection, is intended to assist printed board manufacturers in the protection of IP for their customers in commercial, industrial and military/high reliability markets. Members from all segments of electronics manufacturing are invited to attend to review the draft standard and provide input.

Developed as a high-level roadmap to best industry practices for printed board manufacturers, the draft IP standard addresses issues such physical and information security, employee data access, computer networks, destruction of scrap material, and more.

Also, under direction from Congress, the Department of Defense's new executive agent for PCBs will develop a trusted source program for PCB manufacturers supplying the DoD. Similarly, many leading OEMs in the commercial sector are auditing their supply chain to ensure protection of their IP, says IPC (ipc.org), under whose auspices the standard is being written. – *CD*

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STI to Update '610,' '001' Training Programs

MADISON, AL – STI Electronics Inc. (stielectronics.com) has been awarded an IPC contract to update the existing IPC-A-610 and J-STD-001 training and certification programs to the E revisions.

The two updates are being developed concurrently with betas to be conducted from April to June.

STI has previously developed or updated curricula for IPC-A-610, J-STD-001, IPC-A-620 and IPC-7711/7721.

Terms of the deal were not disclosed. STI is also a training center for the standards. – *CD*

CA People

Nordson Dage named **Aram Kardjian** (pictured, top) bond tester national sales manager for the Americas. The company also promoted **Keith Bryant** (pictured, bottom) to global sales director, x-ray products. Bryant was European sales manager for six years, and is chairman of the SMART Group.

Creation Technologies named **Andy Hyatt** executive vice president – business development. He has 20 years' EMS experience in operations, program management and business development.

LSH named **Michael Mühlnickel** facility manager of its EMS sites in Hamburg and Halstenbek, Germany, and Jaklovce, Slovakia.

EMS and solar provider Worldwide Energy and Manufacturing USA named **Gerald DeCiccio** CFO.

Martin, a FineTech Co., appointed **Scott Rushia** sales manager for the US, Canada and Mexico, responsible for sales and service for rework and dispensing products. He has experience in customer support and application engineering with Dynapert and Philips.

Solar cell materials company Innovalight named **Boris Mathiszik** vice president of worldwide sales. He was managing director, Asia, at BTU.

Nu Horizons Electronics promoted **Kent Smith** to president of the company's global distribution division.

JJS Electronics named **Alf Bates** principal test engineer.

EMS firm Victron Inc. named **Jim Williams** vice president of North America sales, responsible for new business growth. He has 15 years' of executive leadership in the EMS industry, and is a former vice president and general manager at Celestica.

Techcon appointed **Karl Fischbeck** Eastern Territory sales manager for the Americas.

Visit PCD&F and CIRCUITS ASSEMBLY on Facebook, and follow us on Twitter (twitter.com/mikebuetow).

Correction: The CIRCUITS ASSEMBLY Top 50 EMS Companies should have included **UMC Electronics** at no. 14.

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STORAGE BURSTS

Trends in the U.S. electronics equipment market (shipments only).

	% CHANGE			
	NOV.	DEC.[r]	JAN.*	YTD
Computers/electronics products	-1.0	-1.6	8.3	15.7
Computers	6.6	5.3	1.2	3.1
Storage devices	-9.9	-14.0	44.6	92.0
Other peripheral equipment	1.9	4.1	5.9	21.0
Nondefense communications equipment	-2.2	-3.0	0.2	3.5
Defense communications equipment	-8.2	-9.7	-0.3	-21.6
A/V equipment	1.0	-3.4	0.9	19.3
Semiconductors	-8.3	-0.4	32.1	39.0
Components[1]	-0.3	3.8	4.0	11.0
Nondefense search and navigation equipment	0.6	-5.6	4.9	-0.6
Defense search and navigation equipment	3.0	-3.9	4.0	20.5
Medical, measurement and control	0.4	-3.5	6.0	14.2

[r]Revised. *Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: U.S. Department of Commerce Census Bureau, Mar. 4, 2010

US Mfg. Orders, Employment Growing

TEMPE, AZ – US manufacturing continued to grow in February, but the rate of growth decelerated, as the PMI fell 1.9 points sequentially to 56.5%, the Institute for Supply Management (ism.ws) said.

Still, businesses have started hiring, as the Employment Index was up 2.8 percentage points to 56.1%, the third consecutive month of growth.

A reading above 50% indicates the manufacturing economy is generally expanding.

New Orders registered 59.5%, down 6.4 percentage points. Production was 58.4%, down 7.8 points. Inventories contracted at a slower rate in February, as the index registered 47.3%, up 0.8 points. Customer Inventories grew 5 points to 37%, and Backlogs hit 61%, also up 5 points.

"The manufacturing sector grew for the seventh consecutive month during February. While New Orders and Production were not as strong as in January, they still show significant month-over-month growth," said ISM spokesperson Norbert J. Ore in a press release.

The overall economy grew for the 10th consecutive month, says ISM.

	OCT.	NOV.	DEC.	JAN.	FEB.
PMI	55.7	53.6	54.9	58.4	56.5
New orders	58.5	60.3	64.8	65.9	59.5
Production	63.3	59.9	59.7	66.2	58.4
Inventories	46.9	41.3	43.0	46.5	47.3
Customer inventories	38.5	37.0	35.0	32.0	37.0
Backlogs	53.5	52.0	50.0	56.0	61.0

Source: Institute for Supply Management, Mar. 1, 2010

METALS INDEX

DATE	3/2/09	11/30/09	1/4/10	2/1/10	3/1/10
LME Cash Seller and Settlement for Tin	$5.01	$6.81	$7.89	$7.99	$7.63
LME Cash Seller and Settlement for Lead	$0.46	$1.06	$1.11	$0.95	$0.97
Handy and Harman Silver (COMEX Silver)	$188.29	$267.00	$257.20	$236.86	$241.25
LME Cash Seller and Settlement for Copper	$1.51	$3.13	$3.39	$3.19	$3.20

Smartphones Hogging Memory

EL SEGUNDO, CA – Apple's (apple.com) iPhone is expected to generate insatiable demand for NAND-type flash in 2010, straining supplies for the year, says iSuppli (isuppli.com). The device is a NAND hog, consuming an average of 35.2 Gb of NAND, the research firm estimates.

Exacerbated by demand forecasts – shipments are set to rise to 33 million in 2010, up 31.5% compared to 2009 – periods of undersupply are ahead, the firm says. iSuppli forecasts that mobile handsets with embedded flash units will grow to 732 million units in 2010, up 13.8% year-over-year.

Other products pushing NAND consumption include eBooks, smartphones and tablet PCs.

Chip Sales to Spike 20% in 2010

STAMFORD, CT – Worldwide semiconductor revenue will increase by nearly 20% this year on higher average selling prices and PC demand, says research firm Gartner (gartner.com).

Semiconductor revenue will rise 19.5% year-over-year to $276 billion in 2010, the research firm said.

Chip sales fell 9.6% year-over-year in 2009, although demand picked up in each of the last three quarters. Gartner said higher demand for PCs – some forecasts call for 20% growth this year – will drive a semiconductor recovery. Also, capacity shortage will push DRAM prices higher, leading to 55% revenue growth in 2010.

Jan. Japanese Semi Gear Up 237% YoY

TOKYO – Japan-based semiconductor equipment manufacturers posted 85.1 billion in orders in January on a three-month average basis, up a staggering 237.4% year-over-year, and 9.9% sequentially. The book-to-bill was 1.36, says the Semiconductor Equipment Association of Japan (seaj.or.jp/english).

INDUSTRY MARKET SNAPSHOT

Book-to-bills of various components/equipment.

	SEPT.	OCT.	NOV.	DEC.	JAN.
Semiconductor equipment[1]	1.17	1.09	1.06	1.03[r]	1.20[p]
Semiconductors[2]	-10.1%	-2.94%	8.83%	2.89%[r]	4.72%[p]
Rigid PCBs[3] (North America)	1.09	1.10	1.07	1.05	1.06
Flexible PCBs[3] (North America)	0.95	1.00	1.02	0.95	1.03
Computers/electronic products[4]	5.56	5.36	5.31	5.41[r]	5.21[p]

Sources: [1]SEMI, [2]SIA (3-month moving average growth), [3]IPC, [4]Census Bureau, [p]Preliminary, [r]Revised

IC a Chip Recovery

Shipments and revenues should skyrocket in 2010, leaving the spectres of 2009 behind.

IC revenue will stage a comeback this year, growing 18.8%, with unit growth a tick lower at 18%. Both figures are considerably better than the 8.8% decline in revenue and 6.9% decline in shipments in 2009.

DRAMs are anticipated to be the largest growth area for ICs, with revenues up 40% in 2010. Numerous analog chips, including regulators and references, computer, communications, automotive, and industrial applications; special purpose logic chips, including consumer, computer, communications, and automotive; flash, EEPROM, 32-bit MCU, and standard cell and PLD chips will see revenue growth rates in excess of 15%.

Shipments should continue to climb at least through 2013, according to NVR data. Unit growth should top 100 billion over the four-year span of 2009 to 2013 (**FIGURE 1**).

What's driving the recovery? Low interest rates, low oil prices, and the stimulus packages instituted around the world are all contributing to a stabilizing economy and upturn. Purchases were less than the replacement market in 2009, and pent-up demand is pulling the market in a positive direction.

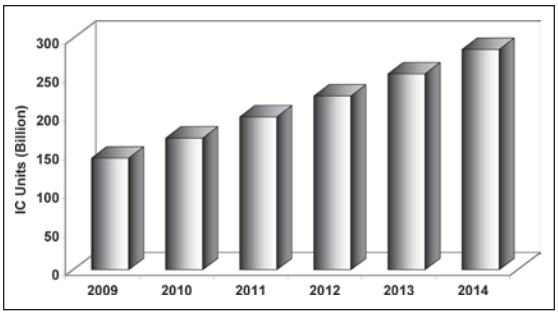

FIGURE 1. IC unit shipments in billions, 2009-2013.

Cellphones, particularly high-end smartphones, will see high growth rates. Smartphones are gaining in popularity and becoming a larger piece of the cellphone pie. Anything handheld and somewhat affordable that keeps us connected to the rest of the world seems to be doing well. New product introductions such as Apple's latest iPhone are hot topics; the iPad is expected to do well, and Research in Motion's Blackberry has been doing well for some time.

Netbook computers, with prices as low as $200 during holiday sales, and notebook computers are driving up IC demand. Other high growth areas include 3-D and digital TVs, DSL/cable modems, flash drives, memory cards, set-top boxes, digital cameras, automotive, and an assortment of audio applications.

The economy is stabilizing, which is easing fears of spending on consumer goods. The housing market, which took down the economy by taking the credit markets with it, is stabilizing, and the ratio of income-to-housing expenditures is more balanced than it was previously.

The automotive market, host for numerous ICs, fell substantially during the downturn. This market did benefit from the cash-for-clunkers program, although automotive sales receded again after the program ended. But it became a booster to spending, which helped. And automotive is expected to turn up in 2010 and beyond, particularly in areas such as China. Overall, spending is higher now than it was in the depths of 2009, and that is what is pulling us up and out of the sloth of 2009 and will carry us to a more positive future. CA

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Managing 'Process Management'

When personality enters the equation, process management seems to vanish.

SOME THINGS JUST seem to get to me, and one is the concept of "process management." It's not that I don't like or believe in it. Over the years I have spent tons of money successfully working to improve processes, and have seen firsthand the benefit improved process management can yield. There really is a solid return on investment when improvements are made and productivity improves.

But what gets me is that process management seems to only matter when applied to "things" vs. "people."

Everyone – regardless of industry or job function – loves to tout improvements derived from applying a process improvement to a "thing." This may include manufacturing equipment – hardware or software – end-products – newly developed or long-standing favorites – and even bricks and mortar (or elimination of same). However, when the process that needs improvement exclusively involves personnel, and someone's name is identified with said "process improvement," watch everyone shy away.

By identifying names, I am referring to when the process improvement involves people who work with people (versus equipment), and when the processes that those people should be developing or following are associated with a small number of colleagues, which means those involved are easily identified. Usually, those people work in externally focused departments (sales, purchasing, administrative functions such as HR and accounts payable and receivable). The process management challenge is to improve the level of service, support or value-add that would create a solid relationship in processes that have heavy interpersonal versus machine-driven interaction. And it is not just the supplier/customer relationship. In any situation that involves people – supplier, customer, consultant, employee – friend or foe – when personality enters the equation, process management seems to vanish.

Some examples: When someone evaluates a plating process and comes up with an optimal chemistry, preferred timing and sequence, or improved equipment or configuration, they tout their process management skills and the resulting improvement as a major victory. However, when dealing with the timing and sequence of involving people in, say, periodic capability updates with customers, or the frequency and "configuration" of communication between key suppliers and purchasing, or even just being more visible with key decision-makers at specific customers or suppliers, those involved often shy away from dealing with the situation. Far worse is if there is a problem, almost everyone will assume the ostrich position: put their head in the sand and hope no one notices the deafening silence caused by a lack of process or management.

This is not to say initiatives don't take place in people-driven processes. But too often these efforts manifest themselves as software-focused "interfaces" or "portals" – to create a cyber impression of involvement and progressive process management so to improve how people are dealt with – without actually helping the managers tasked with dealing with those people. Others will periodically take momentary actions of heroic brilliance led by an employee who tries to assist. Yet, if the action is not embraced with appropriate reward and recognition, and then adopted and implemented as a true process improvement, then it is not truly process management.

When process improvement exclusively involves people, rather than focusing on process improvement, we tend to deal with only the most serious problems, and even then not in the context of process improvement, but in a superficial, expeditious way.

Using the most basic definition, we are all job shops that cannot create demand or inventory product for future customers, but must react to customers' specific technological as well as volume needs, responding only when they want it. What differentiates us all – for better or worse – is the level of support and service we offer; the relationships we have with our suppliers, and our abilities to pull together diverse subcontract capabilities to satisfy a pressing customer need. In short, what differentiates us is our ability to interact with … people.

And yet, we tend to not focus as much on process improvement in the very areas that could and will best differentiate us. Yes, cutting-edge software or web portals may help, but do they really address what customers want? We might have the most technologically savvy staffs, but if they don't want – or know how – to interact with customers consistently and effectively, what is their use? We may be able to identify customers' or suppliers' problems, but if we explicitly or implicitly cop an attitude that communicates that we are not the ones who should help, how can our role be viewed as value-add?

While most companies have undergone extraordinary measures to improve internal design and manufacturing process management, I would bet that if the folks at ISO really focused on processes that involve suppliers and customers, most companies would not qualify for certification. Which brings me to the importance of embracing all the processes that link your company with the people to which you are most trying to provide value: customers. Only by making sure you apply the best available processes and

(continued on p. 47)

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Investing in Employees is Still in Vogue

Despite the downturn, several EMS companies found ways to improve workers' lives both in and outside the plant.

With organizations tightly watching costs and a steady stream of headlines on (high) unemployment rates, it would be easy to assume that companies are no longer willing to invest in their employees. When I surveyed several EMS providers in February, however, I found nothing could be further from the truth. While programs varied, the common link was that all these companies saw investments in improving employee quality of life and skills as a practice that contributed to the bottom line. I selected some program highlights from operations in the US, Mexico, Singapore and Poland to provide a broader look at variations between countries and cultures.

MEC. According to Rick McClain, general manager of MEC NW's Canby, OR facility, MEC chose to invest in employee development during the downturn by keeping a trainer on staff and enhancing internal capabilities. Training focused on a mix of IPC-A-610 certification training and in-house systems training. One result is that the company recently added IPC-A-610 Class III assembly capability.

There also is a strong focus on continuous improvement (CI). Employees are encouraged to submit CI suggestions that improve one or more of eight identified areas of waste: waiting, rework, overprocessing, transportation, inventory, overproduction, unused employee creativity or motion. At a facility level, MEC has a game similar to the TV show *Amazing Race*. In this "race," employees pick a spot on a world map and then earn "miles" based on tracked company improvements. Metrics tracked are revenue, on-time shipments, warranty returns, employee improvements implemented, parts per million (PPM) defect rates and employee fitness (i.e., miles walked, swam or biked). A conversion chart is used to assign miles to each category. If the target mileage is hit, there is a luncheon and prizes that reflect the country originally targeted on the map.

As the metrics example indicates, there is also a wellness program. The company hosts an annual Wellness Fair featuring 10 to 20 vendors and benefits specialists who offer advice on fitness options. Biometric screenings for employees are free, and results are translated to recommendations for a healthier lifestyle. Fitness activities such as walking are encouraged and there is monthly recognition for employees living healthy lifestyles. Fitness club discounts have been negotiated as well.

EPIC Technologies. EPIC Technologies maintains a strong focus on worker training and quality of life in its US and Mexico operations. Here, we focus strictly on its programs in Juarez, Mexico. Mexican law mandates a wide range of employee benefits related to onsite health care, bonuses, vacation and sick leave. EPIC's programs exceed these minimums. According to Salvador Baca, EPIC's Mexico human resources manager, good benefits are one way to reduce absenteeism, tardiness and turnover.

Although Mexican law only requires infirmaries be staffed by nurses, EPIC has an onsite doctor too. Nurses are present on all shifts and the doctor during the day. The facility provides prescription medicine and immunizations. Employee families are also treated. According to Baca, the benefit of this extra health care option is improved health for employees and less lost time, since the government's health care system typically has long waiting times.

The company also has invested in training. A teacher conducts classes within the facility to help employees who haven't completed high school study for their degree. After six months on the job, employees are eligible for an annual $400 scholarship for special training. In special cases, tuition reimbursement is provided for programs toward a job-related degree. Employees are also sent to schools around the country for special programs related to IPC, ISO/TS-16949, or customer-required training.

While emphasis is on CI initiatives throughout the year, EPIC drives an extra focus on quality once a year with its Race for Quality event. The race adds a competitive element to Lean projects and kaizen events for three consecutive months. Goals are set for projects for each month. If the goals are met, employees get a prize and the best-performing shift gets a double prize. Each monthly goal is more difficult, but prizes are improved as difficulty increases.

Also, focus is on social activities, as Mexico has a very family-centered culture. For example, a special Mother's Day celebration in May includes mariachis, a special lunch and raffles for all employees who are mothers. Families are invited to an annual picnic in July. A Christmas party for employees in December includes a special dinner and gift for each employee. Sports teams also have been organized. There are internal tournaments for soccer, and the teams also play in a city league with other factories. Basketball and volleyball tournaments are held.

"These types of activities improve the company by encouraging better communications and working environment," says Baca. "This type of teamwork and communications creates more ownership." It is not unusual to see companies without such activities experience 25% more turnover than those that invest in expanded benefits, he adds.

Unique at EPIC is its Values Program targeted at employees' families. Employees who sign up to participate are given monthly homework assignments to take to their children. The assignments are focused

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on core values such as justice and responsibility. "We want to invest in the community and send strong values messages out to families," said Baca.

Employees who work with their children in this program are recognized by EPIC with a small gift. At the end of the year, EPIC has a party with the families that participate.

CEI Contract Manufacturing. During the downturn, when asked if layoffs would help create better shareholder value, CEI contract manufacturing managing director Ka Huat Tan replied, "Do you want to create shareholder value for the next three months or the next 10 years?" Not only did the Singapore-based EMS company have no layoffs, it continued to pay small bonuses.

"When times are hard, people become uncertain and edgy," Tan said. "It is important to make sure people feel valued. CEI is very sensitive to that. We had our HR department informally communicate that there would be no layoffs. During the worst of the downturn, we kept our staff busy with additional training, funded in part through Singapore Economic Development Board incentives. We also bought a new factory with gross space of 40,000 sq. ft. and continued to invest in new technology, which signaled employees we were committed to long-term growth."

That decision also had positive impact on the bottom line. In 2009, the company received nearly S$600,000 in job credit incentives because it maintained its employment levels.

Tan believes people are a company's most important asset, but cautions that simply stating that is meaningless if not backed by actions. For example, Tan asked his managers to watch for employees who might be experiencing financial difficulties. While the company didn't provide cash in those cases, it did provide informal assistance, including suggestions on contacts or resources that could help. "The goal wasn't to give employees in financial trouble a handout, but instead create a supportive environment that made it easier for them to fix the issues themselves," said Tan.

CEI has a Work Life Balance committee that consists of a safety committee, a sports committee, a special interest group committee and an HR committee.

The company's Wellness Program is quite comprehensive. HR organizes a 1.5 to 2 hr. quarterly seminar that focuses on health-related topics such as stress management.

Sports teams have been organized for bowling, table tennis and badminton. The company also holds a Sports Day at a local stadium and gets almost 100% employee attendance at the event. There is a recreation room in the facility used for table tennis and yoga classes. A gym with a treadmill, cross trainers and a fitness instructor were recently added.

CEI funded 80% of a 2009 medical checkup to encourage all staff to have diagnostic testing. This testing program provides them with a measure of the general health of the company's employees that can be compared to Singapore averages. "The statistics show there is room for improvement. Part of showing you care about employees is identifying areas for personal improvement and encouraging them to improve. By studying overall health trends and tracking sick leave, we can tell who abuses sick leave and who truly has health issues that need to be accommodated," said Tan.

At the last dinner dance, the organizing committee invited staff members who have been exercising to talk about what they've learned in the process. Participation in extracurricular wellness activities is part of the equation in determining the size of an employee's bonus. But CEI's program also has punitive measures. A pattern of sick leave abuse can impact annual bonuses.

Tan sums it up simply: "We try to encourage the best in our employees, but also have checks and balances to address issues such as sick leave abuse."

Kimball Electronics Group. Kimball has strong programs for sharing corporate values and incenting individual employee development. According to Julie Dutchess, Kimball Electronics Group's global HR director, the company has been administering Vision and Guiding Principles Surveys in its Poznan, Poland, facility since 2004. In 2007, the Poland group included an additional step in the survey process to provide group and production unit leaders with 360° feedback on softer management skills. Employees' comments for improvement in previous guiding principle surveys were used as criteria in the feedback process.

"Polish culture always placed high value on work ethic and accomplishing goals, and when they added focus on the softer interpersonal relationship management skills, they could see the positive impact," Dutchess said. "The survey allows us to measure how supervisors and managers are improving in terms of the way they manage. Tracking rating trends the same way we track metrics for on-time delivery or quality has helped the staff to realize the importance of this area of management skills, and we have seen visible improvement over time."

Another area of improvement has been in worker skills. Originally, employees' jobs were focused fairly narrowly. As the company's customer base has grown in size and diversity, so has the need for greater flexibility on the floor. Keeping headcount the same meant training operators for several job stations.

"Originally people didn't like this. They were used to doing the same job. We told them that if they were willing to develop themselves and gain new knowledge through training, their promotion ability and earning potential would grow. Some embrace this; others do not," said Magdalena Okon, the Poland facility's HR manager.

The new program created a core group of employees called multi-operators. When demand varies, Kimball can very quickly shift employees between production lines. To qualify as a multi-operator, the operator must be trained and certified for 60% of the job stations within the production area.

Multi-operators are paid more and are prioritized for promotion to higher levels, such as group leader or transfer to other departments. Okon points out that this has helped to create a clear path for career advancement on the production floor. Currently 80% of internal promotions come from the pool of production operators.

One other path for career advancement is Kimball's Individual Development Program. "People development is everyone's responsibility. HR supports by providing engagement, tools and

knowledge. Participants must have a vision for their career. Kimball can help, but the employee is the owner of their own development," said Okon.

IDP has several goals:

- Development and retention of key employees.
- Assurance of successors for key management positions in the organization.
- Improved employees' satisfaction as the result of advancement potential.

A class of candidates are selected every two years. Candidates must fill out an application that outlines long-term career aspirations and a plan to achieve them. There is a a follow-up interview with HR and their immediate supervisor. Managers in each department then nominate the employees they feel have the most development potential.

An IDP Council composed of the managers of the facility, quality, production, HR and an HR specialist reviews the nominees and chooses final participants. It is interesting to note the selection process looks at organizational resources in terms of availability of mentors and the availability of career path advancement, in addition to the relative merit of each candidate. No more than seven candidates are selected per IDP class.

Once selected, the candidate, HR and the candidate's immediate supervisor identify the key skills that need to be developed to perform well in the final position and create a detailed plan that lists skills, development activities, responsibilities, timeline, risks, cost and status of execution. External consultants verify the level of competencies while the candidate is in development. Every six months, HR checks plan status and collects feedback from participants. The information also is discussed with the IDP Council.

"Not everyone stays," Okon said. "In some cases, there is no path for further progression, and a candidate opts to leave the program to pursue other opportunities. We do debrief candidates who leave to determine what went well and what could be done better. It is definitely worth the risk of investing in training. In the end, even when we lose someone because the organization is not ready to utilize his or her full potential because a desired advancement opportunity isn't available, we still have the opportunity to get some benefit from his or her talent while the candidate is growing. We would probably lose the candidate much sooner if we did no development. The program has helped fill some key slots."

One key measure of the success of Kimball's program is turnover. According to Okon, while voluntary turnover in the Poznan region averages 8% per year, Kimball's Poland facility's annual turnover rate is 2%.

Each of these companies has taken basic good management practices and used them creatively to increase motivation and productivity, reduce turnover and improve employee quality of life. Given that employees are often the key differentiators between one EMS provider and another, it appears money well spent. CA

About DECs and PCUs

Bringing tutorial-level instruction to designers' desktops.

LAST MONTH UP Media Group produced our third Virtual PCB trade show and conference for PCB design, fabrication and assembly professionals. Every year the event has grown and shown more promise as a format for bringing together the industry.

We originally started researching virtual trade shows in the late 1990s, but the technology was just not ready. There just was no platform for doing a virtual show in a way that we felt would appeal to our audience.

About four years ago, things changed. Editor-in-chief Mike Buetow called our attention to a company that had a good grasp of what we needed. For those of you who don't know Mike, he is a thorough and hard-charging editor, with a good handle on most areas of the fabrication and assembly sides of the printed circuit board market. Once Mike set us on the path, UPMG's Frances Stewart and Alyson Skarbek turned the concept of Virtual PCB into a must-attend event. This year we had a record registration of over 2,600 people from literally every corner of the globe. Those who missed the two-day live event can view the on-demand version, available through May 4.

I take this as another indicator of the power of the Internet. And though we at UPMG are, at heart, print kind of people, we realize the Internet has a huge and still-evolving role to play in how we interact with our readers and advertisers.

This leads me to our latest project. The PCB Design Conferences have always been one of my favorite projects. As an old PCB designer at heart, I realized from my own experience how much we need to learn about every aspect of design, and to stay in touch with technology that sometimes changes almost daily. A couple months ago, a friend turned me on to a software platform that allows us to take the virtual experience to a new level. This new project is called Printed Circuit University. PCU's primary mission is to help PCB designers, engineers and management stay abreast of technology and techniques. We'll accomplish this through short flash presentations, webinars, white papers, resource links and blogs by some of the most interesting people in the industry. You'll be able to post questions for peers to comment, and share experiences and opinions on just about any subject that has to do with circuit boards.

Then there is the Design Excellence Curriculum. The DEC is a program we developed around 15 years ago for the PCB Design Conference. Over the years, thousands of PCB designers and engineers have taken the courses and furthered their knowledge of specific areas of PCB design. Today, the Web allows us to reach a greater number of people than ever, so we've decided to bring the DEC to Printed Circuit University.

How does it work? Think of a college curriculum where to get a degree in a specific subject you complete core classes like English and math that round out your general knowledge, and then follow a field of study that builds knowledge in the area you want to pursue. Core classes are on subjects that build the foundation for what every good designer should know: PCB fabrication, assembly and test; dimensioning and tolerances; laminates and substrates; electrical concepts of PCBs.

Printed Circuit University
RESEMBLES A COLLEGE CURRICULUM, with classes based on basic and advanced PCB concepts.

After passing the core courses, you'll be able to choose from a series of classes on specific subjects such as flex design, signal integrity, RF design, advanced manufacturing, packaging and a host of others designed to build your knowledge in that area. After the core classes, a person can study as many fields as they want, to gain more and more knowledge of all types of PCB design.

The platform we've settled on for PCU is the same used by universities and online learning institutions such as Penn State, Tennessee Tech, University of Iowa and many more. The platform establishes a real-time, online classroom where you can see the instructor and ask questions. You'll be able to view presentation materials, and the instructor can even switch to a white board view to illustrate a point. Sessions will be archived for review at any time, and when you have completed a course of study, you'll take an exam to demonstrate that you were listening in "class."

We expect to launch Printed Circuit University at the end of June, so stay tuned. If you have comments or questions, please email me. In the meantime, stay in touch and we'll do the same. PCD&F

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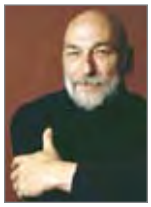

Passing EMC Certification

Radiated emissions must be designed out at the beginning.

If your last product passed FCC certification and shipped on time, pat yourself, your EMC engineer and your design team on the back. You accomplished something that is really hard and doesn't usually happen by accident.

Of the various EMC certification tests, FCC Part 15 Class B, which applies to consumer products, is one of the most stringent. In the roughly 100 MHz range, the maximum allowed radiated emissions from a fully functioning product, when measured 3 meters away, within a 120 kHz bandwidth, must be less than about 100 µV/m.

To put this in perspective, what do you think is the maximum power a radio station could transmit, into a 120 kHz bandwidth, and still pass this FCC test? Is it 1 W? One mWatt? One microwatt?

The answer is shocking. A radio station would have to radiate less than 10 nW of power into a 120 kHz bandwidth in order to pass certification. That is hard.

The most common reason for products to fail this test is due to radiation from common currents on external cables. For a cable 1 meter long, it only takes a common current of 3 µA to radiate enough to fail a certification test.

When you consider that a 1 V signal, driving into a 50 Ω line, is a current of 20 mA, you see that the common currents must be less than 0.01% of the signal currents. This is why passing EMC tests is difficult.

I have yet to encounter a single large system company that does not have a horror story to tell about a product that worked great, passed all the functional tests, but either was never able to pass FCC certification or took so long to fix an EMI problem that its release was late and it missed the market window.

One doesn't pass an FCC test by accident. It is by designing radiated emissions out of the product right from the beginning, and, in instances where they can't be designed out, adding filters and shielding to minimize their impact on the certification test.

Don't expect to learn how to design a product to pass an EMC certification test by following a list of 10 habits. But, if you want a list of topics to use as a guide to begin the discussions in your design team, here are my recommendations for the Top 10 Habits to increase the probability of passing an EMC certification test:

1. Ground bounce drives common currents on external cables. Minimize ground bounce in all the components of the system.
2. Use shielded cables. The cable shield should be an extension of the enclosure, not connected to the ground planes of circuit boards. Cable connectors should make a 360° connection between the shield and enclosure.
3. All control wires and cables that leave the board, even if just routed inside the enclosure, should be routed with an adjacent return conductor. Use as long a rise time as can be afforded for all signals that leave the board. Increase rise times with filters.
4. Use ferrites around the outside of external cables to suppress common currents.
5. Minimize mode conversion in all differential channels that leave the enclosure.
6. Add common signal chokes to all differential signals that leave the enclosure.
7. The largest source of noise, above 50 MHz, that gets into the power and ground network is from signals passing through the power and ground cavity. Manage this noise with return vias, differential signaling and decoupling capacitors adjacent to signal vias. Smart stack design up can enable the use of return vias.
8. Design the stackup so that power and ground planes are on adjacent layers, with as thin a dielectric as possible, and preferably close to the board surfaces.
9. Plan on using a spread spectrum clock generator to smear the first harmonic of all signals into a wider bandwidth. The FCC receiver has a 120 kHz bandwidth. Spreading the spectrum of each harmonic over 1.2 MHz reduces the average power detected in the FCC test by 10 dB.
10. Enclosure design is not about designing enclosures; it is about designing apertures and seams.

If you weren't aware of these guidelines when you designed and built your last product, you may have been lucky and dodged a bullet. Don't rely on luck for your next design. Bring up these topics in the next design review. Have SI engineers and EMC engineers explain what they mean. If still not clear on the concepts, or how to implement them, read a book, find an expert or take a class. PCD&F

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The Second Nature of Process Control

Our newest columnist seeks to expose the synergy of fabrication, assembly and end-use.

Hello! I'd like to take a few moments to introduce myself, though I feel like I have known most of you for years. I have the opportunity to write this column as a result of my predecessor, John Swanson, moving on to smaller and more expensive things. John has taken the task of expanding our business to include electronic packaging. After 10 fast-paced years in the industry, I now find myself managing a business unit.

A little about me. I love yoga. It never allows my mind to travel to the pressures or issues encountered in life. But what I enjoy most is that I usually feel like a superhero after the class is completed. This last time, though, there was a new instructor, who began the class by saying, "Tonight we are going to concentrate on the basics." Great, I thought. How can I reach superhero strength if we are going back to the beginning?

Yet, I left an extremely sore and beaten woman. Not only was I a better person than the one who entered, but I had my idea for this column: How can we expect greatness if we do not pay attention to the basics?

It's cliché, but building a strong foundation paves the way for success in everything we do. Consider process control. Again, I know part of you is cringing, but there is another side that remembers the last three product issues experienced came down to poor process control. Ensuring good control will result in the best possible products we can make.

Did you know that when the board goes through the reflow oven, if vias are not properly plugged with soldermask, the mask cracks, leaving exposed copper? As in **FIGURE 1**, the copper found through the crack has not seen any protective coating and becomes a breeding ground for corrosion. If soldermask registration is off on a pad, and the solder cannot collapse properly, the resultant joint is more susceptible to thermal fatigue.

Imagine a BGA pad that has one side soldermask-defined, as a result of misalignment, and the other metal-defined. The solder collapse will not be uniform. During reflow, the soldermask will expand on the one side, creating pressure on the sphere, which acts as a lever. This can promote joint cracking.

Inadequate copper preparation will result in nonuniform coverage of an OSP coating. This is true for all surface finishes, though shortcuts often are taken at the cleaner and microetch steps of a process. If the copper surface has contaminants, the finish will not properly bond to the copper. This can manifest itself as nonuniform coverage, poor surface coating adhesion, insufficient thickness, solder joint voiding, and even premature tarnishing.

FIGURE 1. Improper via plugging can crack the copper.

Also true for any surface finish is the importance of coating thickness. Believe it or not, thickness specifications were put on the technical datasheets for a reason. The specified thickness is critical to the coating's performance. Everyone has experienced an insufficiently plated tin deposit. After one reflow, all the pure tin had been quenched by intermetallic that laughed at you on the second assembly pass.

Focusing on process flow and routine analysis can eliminate many future quality issues. Did you know sending a board twice through Pb-free HASL can embrittle the soldermask to the point where the resultant product will have much worse creep corrosion than any thin immersion silver deposit? Did you know the first instance of soldermask interface attack on an immersion silver board was found as a result of a customer continuously dragging microetch into the following rinse, which did not have a sufficiently strong turnover? Basically, the PCBs were being double-etched, and then put directly into the pre-dip bath.

On a positive note, running the right process controls can make a better product. Choosing the proper equipment for immersion tin can minimize solution air exposure and extend bath life. Premature tin oxidation and thiourea decomposition can be greatly reduced. Using the right pre-clean, including a well-maintained microetch, can enhance the OSP and immersion silver coating quality, which in both cases enhances solderability.

Maybe you do realize all this. But did you realize how much research at a chemical supplier goes into widening an operating window to accommodate the "what ifs" in fabrication? It is amazing what is asked of the surface finish on a day-to-day basis.

I don't want this to be a finger-pointing exercise. I want to provoke thoughts on how to make process control second nature. I want to expose the synergy of the fabrication, assembly and end use performance. Every detail affects the next step and ultimately the final product.

When I started on this journey, I learned quickly that there was an application for each surface finish. They all have strengths and weaknesses. If processes are run according to specifications provided, and the same can be said for the processes around them, the resultant product will be superior. There are many instances where a coating outperforms the expectations of the chemical supplier, fabricator assembler and end-user. Imagine a surface finish produced as a result of everything run under optimal conditions: superhero status. PCD&F

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5 Competitive Advantages

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23 YEARS IN BUSINESS...AND STILL GOING STRONG

The DfM Continuum

Setting up the proper feedback loop saves time and cost in re-spins. by JOHN ISAAC and BRUCE ISBELL

When considering electronics product development, design and manufacturing often are thought of as separate processes, with some interdependencies. The processes seldom are considered as a continuum, and rarely as a single process with a feedback loop. But the latter is how development should be considered for the purposes of making competitive, fast-to-market, and lowest cost product.

FIGURE 1 shows the product development process from design through manufacturing to product delivery. This often is a segmented process, with data exchange and technical barriers between the various steps. These barriers are being eliminated and the process made more productive by software that provides for better consideration of manufacturing in the design step, more complete and consistent transfer of data from design to manufacturing, manufacturing floor optimization, and the ability to capture failure causes and correct the line to achieve maximum yields. The goal is to relay the failure causes as improved, best-practice DfM rules and prevent failures from happening.

The process starts with a change in thinking about when to consider manufacturing. Design for manufacturability should start at the beginning of the design (schematic entry) and continue through the entire design process. The first step is to have a library of proven parts, both schematic symbols and component geometries. This forms the base for quality schematic and physical design.

Then, during schematic entry, DfM requires communication between the designer and the rest of the supply chain, including procurement, assembly, and test through a bill of materials (BoM). Supply chain members can determine if the parts can be procured in the volumes necessary and at target costs. Can the parts be automatically assembled or would additional costs and time be required for manual operations? Can these parts be tested using the manufacturer's test equipment? After these reviews, feedback to the designer can prevent either a redesign or additional product cost in manufacturing.

The next DfM is to ensure the layout can be fabricated, assembled and tested. Board fabricators do not just accept designer data and go straight to manufacturing. Instead, fabricators always run their "golden" software and fabrication rules against the data to ensure they will produce boards that are not hard failures, and to determine adjustments to

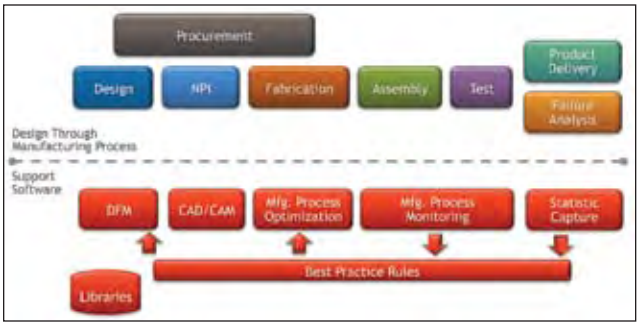

FIGURE 1. The electronic product development process should be a continuum supported with software, and with feedback to previous steps for continuous improvement.

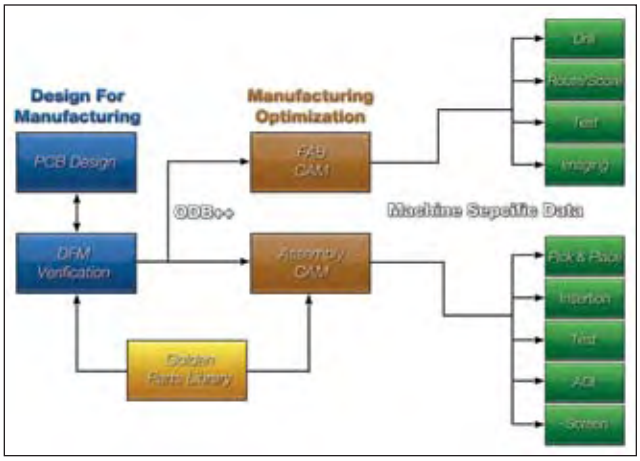

FIGURE 2. NPI has improved significantly with the use of standards such as ODB++ and manufacturing optimization software that generates machine-specific data.

avoid soft failures that could decrease production yields.

So, for the PCB designer, part of the DfM is to use this same set of golden software and rules often throughout the design process. This practice not only could prevent design data from being returned from the fabricator or assembler, but, if used throughout the process, could ensure that design progress is always forward, with no redesign necessary.

A second element in this DfM process is the use of a golden parts library to facilitate the software checks. This library contains information typically not found in a company's central component libraries, but rather additional information specifically targeted at improving a PCB's manufacturability. (More on this later.)

When manufacturing is considered during the design process, progress already has been made toward accelerating new product introduction and optimizing line processes. Design for fabrication, assembly and test, when considered throughout the design function, helps prevent the manufacturer from having to drastically change the design data or send it back to the designer for re-spin. Next, a smooth transition from design to manufacturing is needed.

As seen in **FIGURE 2**, ODB++ is an industry standard for transferring data from design to manufacturing. This standard, coupled with specialized software in the manufacturing environment, serves to replace the need for every PCB design system to directly produce data in the formats of the target manufacturing machines.

Time was, design systems had to deliver Gerber, machine-specific data for drill, pick-and-place, test, etc. Through standard data formats such ODB++ (and other standards such as GenCAM), and available fab and assembly optimization software, the manufacturing engineers' expertise can be capitalized on. One area is bare board fabrication. If the designer has run the same set of golden rules against the design, there is a good chance no changes would be required, except ones that might increase yields. This might involve the manufacturer spreading traces, or adjusting stencils or pad sizes. But the risk here is the manufacturer does not understand tight tolerance rules and affects product performance. For example, with the emerging SERDES interconnect routing that supports data speeds up to 10 Gbs, matching trace lengths can be down to 0.001˝ tolerance. Spreading traces might violate these tolerances. It is important the OEM communicate these restrictions to the manufacturer.

From an assembly point of view, the manufacturer will compare received data (pad data and BoM) to a golden component library. Production engineers rely on this golden library to help identity BoM errors and footprint, or land pattern mismatches prior to first run. For example, the actual component geometries taken from manufacturer part numbers in the BoM are compared to the CAD footprints to validate correct pin-to-pad placement. Pin-to-pad errors could be due to a component selection error in the customer BoM. Although subtle pin-to-pad errors may not prevent parts from soldering, they could lead to long-term reliability problems.

Designers have DfT software that runs within the design environment and can place test points to accommodate target testers and fixture rules. Final test of the assembled board often creates a more complex challenge and usually requires a manufacturing test engineer to define and implement the test strategy. Methods such as in-circuit or flying probe testing require knowledge of test probes, an accurate physical model of the assembly (to avoid probe/component collisions), and the required test patterns for the devices.

Manufacturing Process Optimization

Even as a new assembly line is configured in preparation for future cost-efficient production, for high-mix, high-volume or both, simulation software can aid in this process. Many manufacturers are utilizing this software to simulate various line configurations combined with different product volumes and/or product mixes. The result is an accurate "what if?" simulation that allows process engineers to try various machine types, feeder capacities and line configurations to find the best machine mix and layout. Using line configuration tools, line balancers, and cycle time-simulators, a variety of machine platforms can be reviewed. Once the line is set up, this same software maintains an internal model of each line for future design-specific or process-specific assembly operations.

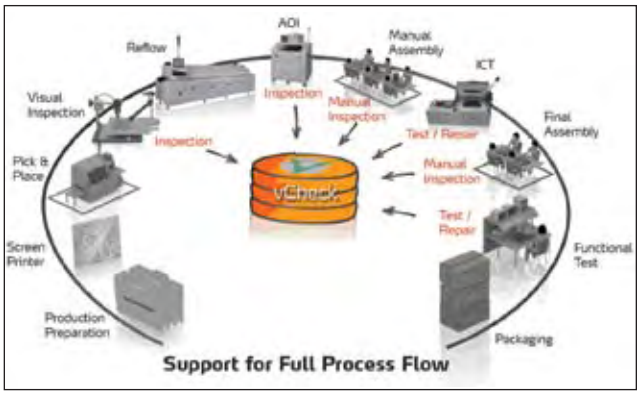

FIGURE 3. Capturing and analyzing failure data can improve manufacturing line efficiency and create new DfM rules for designers.

This has immediate benefits. When the product design data are received, creating optimized machine-ready programs for any of the line configurations in the factory, including mixed platforms, can be streamlined. A key to making this possible lies in receiving accurate component shape geometries, which have been checked and imported from the golden parts library. Using these accurate shapes, in concert with a fine-tuned rule set for each machine, the software auto-generates the complete machine-ready library of parts data offline, for all machines in the line capable of placing the part. This permits optimal line balancing, since any missing part data on this or that machine – which can severely limit an attempt to balance – are eliminated. The process makes it possible to run new products quickly because missing machine library data are no longer an issue. Auto-generating part data capability also makes it possible to quickly move a product from one line to another, offering production flexibility.

Programming the automated optical inspection equipment can be time-consuming. If the complete product data model – including all fiducials, component rotations, component shape, pin centroids, body centroids, part numbers (including internal, customer and manufacturer part numbers), pin one locations, and polarity status – is prepared by assembly engineering, the product data model is sufficiently neutralized so that each different AOI platform can be programmed from a single standardized output file. This creates efficiency since a single centralized product data model is available to support assembly, inspection and test.

Managing the assembly line. Setting up and monitoring the running assembly line is a complex process, but can be greatly improved with the right software support. Below is a list of just a few elements to this complex process:

- Registering and labeling materials to capture data such as reel quantity, PN, date code and MSD status.
- Streamlining material preparation and kitting area per schedule requirements, plus real-time shop floor demand, including dropped parts, scrap and MSD constraints.
- Feeder trolley setup (correct materials on trolleys).
- Assembly machine feeder setup, verification and splicing.
- Manual assembly, and correct parts on workstations.
- Station monitoring, capture runtime statistics, efficiency, feeder and placement errors and OEE calculations.
- Call for materials to avoid downtimes.
- Tracking and controlling production work orders to ensure visibility throughout the process.
- Enforcing the correct process sequence is followed, and any test or inspection failure is corrected to "passed" status before product proceeds.

Collecting failure data. It is inevitable some parts will fail. By capturing and analyzing these data, causes can be determined and corrected. **FIGURE 3** shows certain areas where failures are diagnosed and collected using software. One benefit of software is the ability to relate, in real-time, test or inspection failures with the specific machine and process parameters used in assembly and the specific material vendors and lot codes used in the exact failure locations on the PCB.

Earlier, a set of DfM rules in the PCB design environment that reflects the hard and soft constraints to be followed by the designer was discussed. If these rules were followed, we could ensure that once design data reached manufacturing, they would be correct and not require a redesign. What we did not anticipate was that producing a product at the lowest cost and with the most efficiency is a learning process. We can learn by actually manufacturing this or similar designs, and determine what additional practices might be applied to DfM to incrementally improve the processes.

This is where the first feedback loop might help. If we capture data during the manufacturing process and during product failure analysis, this information can be used to improve DfM rule effectiveness. Continuous improvement of the DfM rule set based on actual results can positively influence future designs or even current product yields.

The second opportunity for feedback is in the manufacturing process. As failures are captured and analyzed (**FIGURE 3**), immediate feedback and change suggestions can be sent to the processing line or original process data models. Highly automated software support can reconfigure the line to adjust to the changes. For example, software can identity which unique machine feeder is causing dropped parts during placement. In addition, an increase in placement offsets detected by AOI can be immediately correlated to the machine that placed the part, or the stencil that applied the paste, to determine which tool or machine is in need of calibration or replacement. Without software, it would be impossible to detect and correlate this type of data early enough to prevent yield loss, rework or scrapped material.

Design through manufacturing should be treated as a continuum. One starts with the manufacturer's DfM rules, followed and checked by the designer's software, the complete transfer of data to the manufacturer using industry-recognized standards, the automated setup and optimization of the production line, the real-time monitoring and visibility of equipment, process and material performance, and finally the capture, analysis and correlation of all failure data. But the process does not end with product delivery, or even after the sale support. The idea of continuum is that there is no end. By capturing information from the shop floor, we can feed that to previous steps (including design) to cut unnecessary costs and produce more competitive products. **PCD&F**

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Ed.: At press time, Mentor Graphics had just completed its acquisition of Valor.

Open 'Eyes' in the FREQUENCY DOMAIN

Although final performance is measured in the time domain, a detour may be the faster route to a signal integrity solution.

by DR. ERIC BOGATIN

Do you speak frequency domain? Especially if you are a digital designer, you should consider learning the language of the frequency domain. The time domain has special significance because it is the real world. This is the domain in which we live our lives, where we build our intuition, and where we measure digital performance. If the time domain is the real world, why would we ever want to leave to enter the frequency domain?

For signal integrity problems related to lossy transmission lines, working in the frequency domain can often help us find solutions to eye closure problems. Sometimes, taking a detour through the frequency domain can bring an acceptable answer more quickly than staying in the time domain.

In this brief introduction to solving problems in the frequency domain, we will look at how to improve signal quality in high-speed serial links like PCI Express (PCIe) by speaking the language of the frequency domain.

Rise time in the frequency domain. If the time domain is the real world, what does this make the frequency domain? The frequency domain is not the real world; it's a mathematical construct. As such, it has certain very special rules that must be followed. One rule is that only sine waves can be used to describe signals.

Each sine wave is described by a frequency, an amplitude and a phase. While the phase of a sine wave is important, we usually focus attention on the amplitude of the sine wave.

Any waveform in the time domain can be translated into the frequency domain using the Fourier Transform. While it is important to have done a Fourier Transform by hand at least once in your life, after that, it's usually more important to get the answer as quickly as possible. Every version of SPICE can perform a Fourier Transform of any arbitrary time domain waveform.

The hidden assumption with these translations, typically called a Discrete Fourier Transform, or DFT, is that the waveform in the time domain is repetitive. The repeat frequency is either the clock frequency or the total simulation time. The repeat frequency has special significance. It is the lowest frequency that will appear in the spectrum and is called the fundamental frequency.

Every frequency component that appears in the frequency domain is a multiple of this fundamental and is called a harmonic. The collection of all the harmonic components is called the spectrum.

A very important waveform in the time domain and the frequency domain, to which most other waveforms are compared, is an ideal square wave. In the time domain, an ideal square wave has a zero psec rise time and a 50% duty cycle.

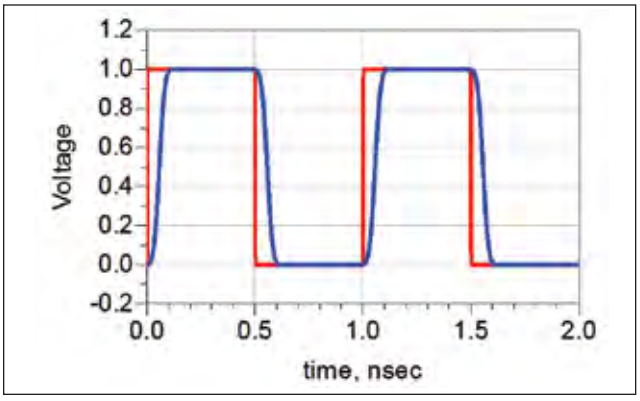

FIGURE 1. Ideal square wave and finite rise time clock in the time domain and the frequency domain, simulated with Agilent's ADS.

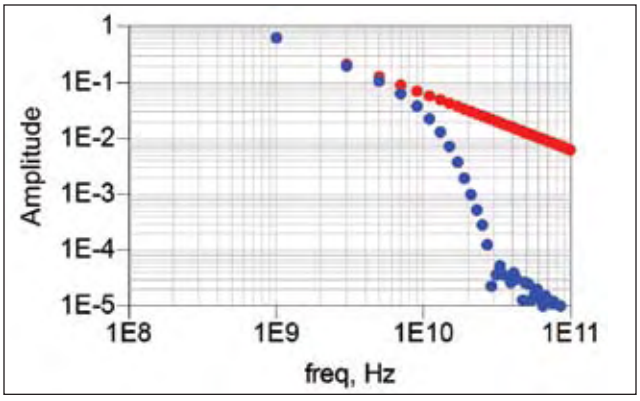

FIGURE 2. A single bit as it propagates down a real interconnect spreads out due to the frequency-dependent losses. The rise time increases, simulated with Agilent's ADS.

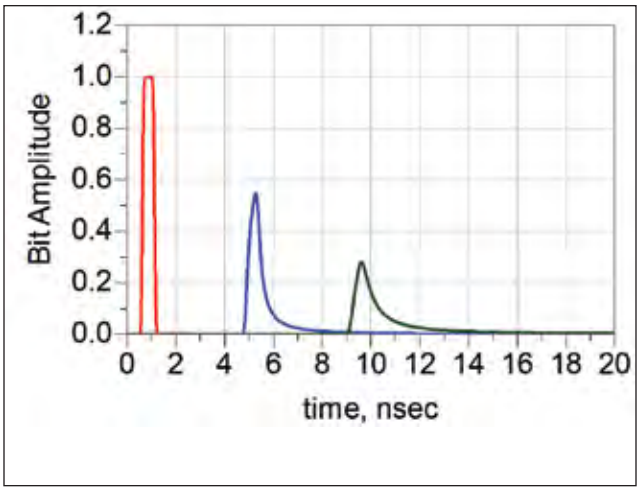

FIGURE 3. Received eye PRBS signals at the locations in Figure 2. As rise time increases, ISI increases and the eye collapses. Simulated with Agilent's ADS.

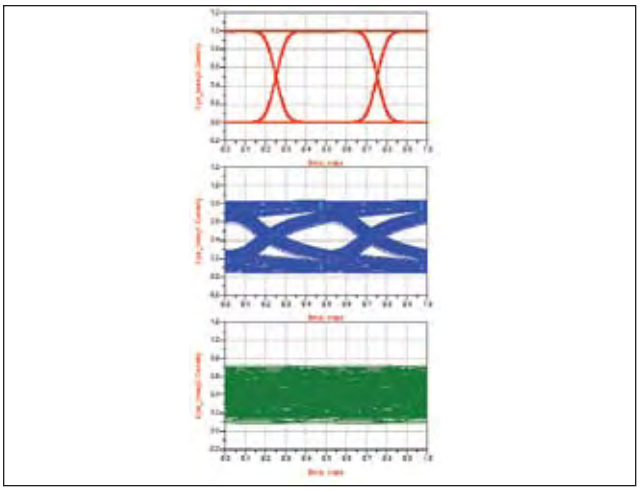

FIGURE 4. Differential insertion loss for the interconnect lengths described in Figure 2. Simulated with Agilent's ADS.

Its spectrum has three important features:

- Only multiples of the fundamental appear.
- The harmonic of each component drops off like 1/n, the harmonic number.
- The even harmonics, i.e., 2d, 4th, 6th, etc., have zero amplitude.

For an ideal square wave, the frequency components continue with their pattern to infinite frequency, always dropping off inversely with frequency or harmonic number. But, if the rise time is finite, this is not the case. After some frequency, which we call the bandwidth, the amplitudes of the frequency components drop off much more quickly than 1/f for an ideal square wave.

FIGURE 1 shows a 1 GHz ideal clock square wave spectrum and the spectrum of a clock with a rise time that is 5% the clock period. The relationship between the 10-90 rise time, RT, and the bandwidth, BW, is roughly approximated as BW = 0.35/RT. For this example, we would expect the bandwidth to be about 0.35/0.05 = 7 GHz. This is about where the amplitude begins to drop off below the ideal square wave spectrum.

Every frequency component of an ideal square wave is significant in contributing to that 0 psec rise time. However small the amplitude may be at very high frequency, it is still important. Remove any and you won't get the 0 psec rise time.

When the frequency component of a real waveform has an amplitude significantly smaller than the equivalent ideal square wave, it won't be large enough to contribute to the rise time and can be ignored. The bandwidth of a real waveform is the highest sine wave frequency component that is significant. Decrease its bandwidth in the frequency and its rise time in the time domain will increase.

A fundamental measure of the rise time of a signal in the time domain is the frequency at which the harmonics begin to drop off more quickly than 1/f. For this reason, the bandwidth is often referred to as the knee frequency. The lower the knee frequency in the frequency-domain, the longer the rise time of the signal in the time-domain.

Signal propagation on real interconnects. How do real interconnects like traces on a circuit board, or coax or twin-ax cables, affect signals? In the time domain, we can evaluate the behavior of a single bit as it propagates down a transmission line. **FIGURE 2** shows what a single 1 bit would look like traveling down a 0.003″ wide FR-4 transmission line for a 1 Gbps signal, initially, after 30″ and after 60″.

The single 1 bit starts out with a 1 nsec unit interval, and a very fast rise time. As it propagates down the transmission line, the wave form is dramatically affected. That single bit spreads out into adjoining bits. This cross talk between one bit and other bits is called inter-symbol interference or ISI. It contributes to the collapse of the eye. **FIGURE 3** shows the received eye of a pseudo random bit stream (PRBS) signal at the three locations above.

How the single bit spreads out is a very important metric of the behavior of the interconnect. Yet, as viewed in the time domain, the exact shape of the pulse is complicated and difficult to describe in a simple way.

Here is where the frequency domain description offers a simpler description. The term that describes how a sine wave differential signal is affected by an interconnect when it exits is the differential insertion loss, sometimes referred to by its S-parameter designation, SDD21. This is also called the transfer function of the interconnect. This measureable property describes what a sine wave with amplitude of 1 looks like when it comes out the transmission line. The differential insertion loss for these interconnect paths is shown in **FIGURE 4**.

Every single interconnect has a similar SDD21 response. The amplitude coming out is always less than the amplitude going in, and the amplitude of SDD21 drops off with increasing frequency. On a log scale of amplitude, measured in dB, the differential insertion loss generally drops off nearly linearly with frequency. A metric of the dB/inch per GHz is one single number that characterizes most interconnects.

If we send an ideal square wave signal into a real interconnect, its spectrum will be multiplied by this transfer function. The SDD21 tells us how each frequency component will be attenuated. Higher frequencies get attenuated more than lower frequencies. This pushes the knee frequency of

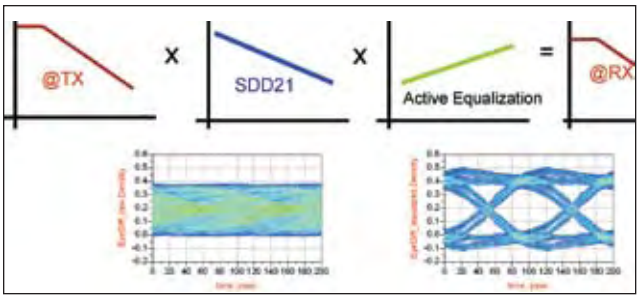

FIGURE 5. Flatten an interconnect's SDD21 response with frequency-dependent gain with an equalizer. Example of the received eye with and without equalization, simulated with Agilent's ADS.

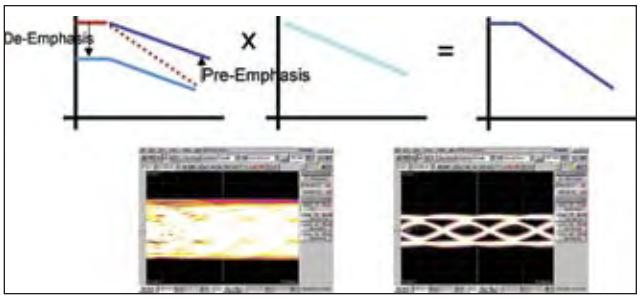

FIGURE 6. Pre-distorting the spectrum of the transmitted signal will enable it to end up at the receiver with a 1/f frequency response. Example of the measured received eye, with and without pre-emphasis (courtesy Altera).

the signal's spectrum to lower frequency, and increases the rise time of the signal.

This frequency-dependent attenuation of typical interconnects will cause rise time degradation, which will smear one bit into adjacent bits, result in ISI and cause collapse of the eye.

It's not the attenuation of the interconnect that degrades the rise time; it is the frequency dependence of the attenuation. After all, if we take all the frequency components and just attenuate each of them the same amount, we will still have the same spectral shape of the bit sequence coming out. The frequency at which the knee occurs will be unchanged; the rise time of the signal will be unchanged, and there will be no ISI and no collapse of the eye.

Fixing the eye collapse in the frequency domain. We can fix the ISI in real interconnects by either flattening the insertion loss curve of the interconnect, or by changing the spectrum of the signal going into the interconnect so that when it comes out, it preserves the 1/f shape.

Designing an interconnect with a flatter response is tough. The root cause of the frequency-dependent loss is the combination of the skin depth dominated copper series resistance and the laminate material dielectric loss. For example, certain Gore cable assemblies use a very thin signal conductor, which has a frequency-dependent resistance much flatter than a typical copper core cable.

Likewise, laminates such as Rogers' RO4350 have a lower dissipation factor and a flatter response dielectric loss curve. Both these interconnect design features reduce ISI with a flatter differential insertion loss response.

It is also possible to flatten an interconnect's transfer function by adding some extra frequency-dependent gain at the receiver. If the interconnect has more attenuation at higher frequency, why not add gain that increases at higher frequency to compensate and flatten the overall response? **FIGURE 5** shows how this works.

When we add frequency-dependent gain, we equalize the response of the interconnect across a wide frequency range. We call this process equalization. The ideal equalizer has a gain curve that is the exact inverse of the attenuation curve. With a flat response, the spectrum of the transmitter is preserved at the receiver; the knee frequency is the same as the transmitter; the rise time is the same, no additional ISI and no additional collapse of the eye.

Finally, the spectrum of the signal at the transmitter can be pre-distorted to add extra high-frequency components. The interconnect will attenuate the high-frequency components anyway. If we add extra high-frequency components at the transmitter, by the time they travel through the interconnect, they will be attenuated away, leaving the 1/f spectrum of a short rise time signal. The shorter the rise time, the less the ISI, and the lower the eye collapse.

One way of implementing adding high-frequency components is called pre-emphasis. Wherever a 1 bit begins, extra energy is added. Likewise, we could obtain the same pre-distorted spectrum by taking out low-frequency amplitudes. Whenever there is a string of more than one bit with the same value, reduce the signal level. This is called de-emphasis (**FIGURE 6**).

Both pre- and de-emphasis result in the same distorted shape in the transmitted signal spectrum. When either of these distorted signals travel through an interconnect, if optimized for the interconnect, the signal will come out the other end with a short rise time, less ISI and a more open eye.

By looking in the frequency domain, we can see how the techniques mentioned manipulate the frequency domain spectrum of the received signal. We engineer it to look more like an ideal square wave's spectrum and recreate the shortest rise time to minimize its ISI and keep the eye open so that each bit can be detected as its true 0 or 1 value.

Even though final performance is always measured in the time domain, sometimes detouring through the frequency domain may be a faster route to a signal integrity solution. **PCD&F**

Au: Many of the principles described in this paper are covered in great detail in papers that can be downloaded from bethesignal.com.

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Divining Value in SCREEN PRINTER OWNERSHIP

Companies return to market with new requirements, fresh capital, and new ways to evaluate cost-of-ownership.

by TREVOR WARREN

Value can be defined in many ways. In a financial sense, value is how much of what you need you actually get for your money. But measuring "how much you get" is not straightforward. It's easy to confuse cost with value. Low cost does not automatically translate to the best value. Likewise, the highest price isn't necessarily the best value. The purchase price of a capital item is only one element of value, but it can be one that is disproportionately influential in the purchase decision. A useful automotive analogy can be drawn here.

For most individuals, a car is among the largest capital purchases, or investments, they will make. Will the cheapest car represent the greatest value? The costs of running and maintaining a car need to be taken into consideration to determine a better measure of value. Then there's the issue of the value of the car when the owner has finished with it. Leasing companies know this because their long experience and amassed statistical data have turned whole-operational-life value into a science. It's why the monthly lease price of different vehicles is not directly proportional to their forecourt purchase price.

In principle, the same is true in industrial capital equipment. But all too often, the potential end-of-life value of a capital purchase is not taken into account. Could it be because it's more difficult to identify the use to which the equipment may subsequently be put? Or perhaps because there's no guide to look up the likely fiscal worth of used equipment? The experience of most electronics assembly capital equipment vendors is that investment in new equipment is typically justified on the basis of a single manufacturing requirement or contract, or at least an identifiable operational run lasting a few months to a couple years. Equipment needs to pay for itself easily within a percentage of that period to deliver a financial return. Understandably, the shorter the identified operational run, the more critical the initial purchase price of equipment seems to be to the purchase decision. But often this is a false economy.

A few years ago, one of the industry's leading surface mount pick-and-place equipment vendors ran studies into the equipment investment its larger EMS customers were making as a proportion of its total outlay to resource each new contract they secured. The result was usually around 2.5%. (The largest single portion of every contract investment was the procurement of components.) Within a typically conventional SMT assembly line comprising printer, placer and reflow oven, the placement machines invariably represent the largest part of the investment – accounting for around 1.5% of the 2.5%. Allowing for the oven, this means less than 1% of the total investment goes toward the screen printer. At less than one-hundredth of the overall investment funding, a few percent variation in the purchase price of a screen printer is relatively insignificant compared to what return the right equipment can deliver – or the horrors of what it may cost if it doesn't deliver. Which is why, for these large EMS companies, the value of the printer – measured in terms that include less tangible elements like on-time delivery, service support responsiveness, applications expertise, fast ramp to productivity, maximized uptime, etc. – is always more critical than the initial machine cost.

Not all screen-printer users are large EMS providers after lucrative new contracts. But all manufacturers can improve printer ownership value by considering a few strategic points when specifying the equipment.

'Flawless balance' challenges. Screen-printer productivity is a combination of throughput and yield. Conveying the maximum number of good printed boards from the print platform to keep downstream processes operating at peak efficiency is the productivity goal. But getting a flawless balance between throughput and yield is a challenge; there's no point in speeding the print process if yield suffers. Screen printing still has the most potential of any process in the assembly line to introduce catastrophic faults.[1,2] A single unprinted pad, if undetected, can render a subassembly useless or incur significant cost in diagnosis and rework. Or both.

The temptation to ramp throughput by, for instance, reducing cleaning cycle frequency or increasing squeegee excursion speed can lead to lower yields as the process moves out of control. So many variables influence the process that deploying expert knowledge is the best way to keep control. Dr. Ron Lasky of Dartmouth College, a leading Six Sigma process expert, illustrates aspects of process control in the screen-printing domain using a fictional process expert ("The Professor") who investigates manufacturing issues, and who

– as a profit sleuth – often focuses on COO as he helps electronics assemblers recover lost profit.

In one of The Professor's investigations,[3] Dr. Lasky cites the overall losses incurred by a manufacturer from switching to a cheaper solder paste. The production engineering manager's expectation is to save more than $30,000 per line per year by using paste costing only 5 cents per gram, as opposed to 8 cents per gram. But the paste has one property weakness in the form of lower on-screen open life, so each board printed after a stoppage must be cleaned and reprinted because the paste has "stiffened" – an exercise that costs 20 minutes in lost production per line per day, and which, with the production run figures in the example, results in a cost burden of over $340,000 per year. It's presented as fiction, but the impression is that it's not. In any event, it illustrates exactly the kind of process variable that requires specialized expertise to fully evaluate and manage.

Operational cost-of-ownership. Another obvious way to reduce, or at least contain, the cost associated with running a screen printer is to ensure the system is paying its way all the time – or as close to that as is practical. Downtime is the enemy of productivity. And productivity often relates directly to profitability. Downtime comes in many forms, most predictable and therefore manageable. Even unscheduled stoppages often result from operator oversight or error, or from a process or material issue, and in theory can be legislated against.

Scheduled stoppages for consumables replenishment and planned downtime for maintenance are both areas worthy of scrutiny. Choosing a printer that has fewer maintenance intervals, or that offers easier access to permit maintenance to take place faster, will render it offline for less time, which equates to better value when measured in terms of productive uptime. Solder paste replenishment is a frequent and necessary intervention, so rapid and easy access to the print area that lets this procedure take place more quickly has a true value that reduces COO by keeping the printer productive.

In addition, simple actions like selecting the optimum consumables for production needs can improve productivity.

FIGURE 1. Capital equipment can be expensive, but when considered and managed correctly, the value of feature-laden machines outweighs the higher price tags.

A recent study of understencil cleaning fabrics reveals not only measurable differences in the cleaning effectiveness of materials, but disparities in the length of the fabric rolls for a given price.[4] Naturally, the longer the roll, the less often the printer will need to halt for replenishment. Equipment manufacturers may offer a number of equipment options on printer platforms that mitigate stoppages, from effective cleaning fluids, fabric rolls and operator alerts to sophisticated tools such as paste height monitors and high throughput understencil cleaning.

The latter is a case in point on the issue of cost versus value. Newer generation systems have cleaning excursions that take half the time, use less than half the quantity of understencil cleaning fabric, and clean more effectively than comparable systems. They offer a choice: clean to the same standard as before, which means less frequently but more quickly to dramatically increase batch throughput by reducing the number of times the printer halts for a cleaning cycle and shortening the time it takes when it does; or clean as frequently as before, but twice as fast, to really safeguard yield and increment throughput. Clearly, both strategies have a tangible productivity value.

Another constraint on maintaining productivity is in high-mix assembly environments with high product changeover. Identifying ways to reduce the time it takes to set up the printer for a new board is key to productivity when measured over several batches, a more realistic snapshot of production. Using The Professor's technique of calculating potential earnings when the printer and line are running to capacity determines revenue lost for every minute of downtime. Again, tools exist to assist. Small EMS providers and OEMs that run several products in short batches should look at automated tooling for board support; at self-loading and aligning stencils to speed the operation and eliminate operator errors; and be aware of the time it takes to upload or initialize the software print file.

Looking at these stoppage types prompted Dr. Lasky to articulate how a simple cocktail of screen-print process considerations can reverse an expected financial outcome. The example is a manufacturer who contemplates deploying new screen printers with a purchase price $20,000 lower than those traditionally in use onsite; the intention being to save a total of $1 million over 50 lines. The Professor's investigations reveal how tiny time-based procedural issues that appear insignificant on their own can wipe out capital equipment purchase savings. In the example, factors such as 10% longer changeover due to more steps in setting up board support, computer programming and stencil installation, plus 15% more time to replenish solder paste, result in 3% less production, producing 3% less product, which equates to 6% less profit. On lines intended to average $4 million per year in profit, the small stoppages accumulate to lose around $240,000 per line per year, making the $20,000 saving on purchase price a gigantic false economy.

A final COO domain has traditionally remained unfulfilled. Arguably one of the greatest potential COO gains to be made is in the ability to redeploy a screen printer from production runs to other uses. Thanks to platform concepts, screen printers can be redeployed, often with no more than a modest investment in a module to reduce cycle time by two seconds, or an inspection system for traceability and higher yields. CA

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Why Mixed Signal Calls for PRECISE STENCILS

Taking a middle ground is verboten to avoid assembly problems. by ZULKI KHAN

Stencil design calls for three main criteria. One, the stencil should be completely flat because it needs to evenly distribute the amount of paste on all sides of the board. Two, it should be able to control solder paste spillage. If solder paste is spilled on an adjacent pad (or ball, in the case of a BGA), it could cause a short. Three, the stencil must provide optimum stability, meaning it can be repeatedly used without any issue. This could be achieved by using framed stencils versus unframed ones.

Stencil definition and design accuracy take on even greater significance when a high-count layer board is involved. In such instances, thicker boards are used for a load board application, for example, and unlike a standard six-to-12-layer commercial board, this thicker board has 20 or more layers, with more power and ground planes. This means a different thermal profile.

Stencil accuracy has a direct bearing on the thermal profile used on such a board. A thicker board, with a number of ground and power planes, requires considerably more heat for proper soldering. Also, for the same type board, a less accurate stencil design means too much or too little solder paste deposited, resulting in opens or shorts.

When a stencil is properly designed and solder paste is correctly deposited, the result is perfect printing. Put another way, this means few to no bridges or solder issues and little touchup and rework.

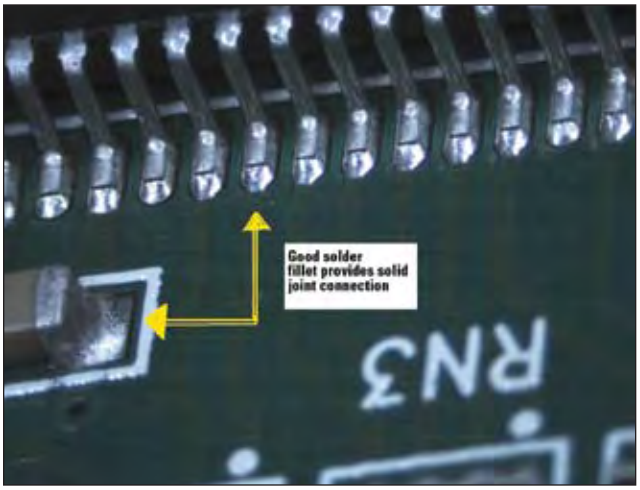

FIGURE 1. A fillet is the base of an IC or component. A good fillet means sufficient solder is deposited, but not so much as to create a short.

Special attention must be paid to devising apertures for surface mount pads on mixed signal PCB designs – in which one segment of the board is heavily analog laden, and the other digital. An analog segment requires a lot of heavy current and grounding. A thicker 0.006″ to 0.008″ stencil is recommended here. The thickest stencil would probably be 0.006″ with a ratio of 1.1:1. The ratio of 1.1:1 means 10% more paste deposited compared to the pad size, thus providing a good fillet. A good fillet means enough solder is deposited, but not so much as to create a short (FIGURE 1).

By its nature, the analog section is a heavily ground poured area. Since heavy current is characteristic of analog circuits, those components must have extremely solid connections, either through the component side or bottom side, or internally through the ground plane. In this instance, paste deposition is called a "solder brick" (FIGURE 2), which describes how efficiently paste is poured on the surface mount pad. Also, a stencil for a mixed signal board must have isolation islands created to segregate current and voltage between analog and digital circuitry.

The digital side of a board with fine-pitch devices such as BGAs, µBGAs and QFNs, for instance, is another story. This calls for a ratio for paste deposits compared to the pad size of less than 1:1: for instance, a ratio of 0.9:1, which means 90% paste is being deposited. Put another way, 10% less paste is being deposited compared to the pad because the pitch is so fine. Care must be applied here because the balls of a QFN or BGA are so close that too much paste can cause a short between them.

Step Stencils

A step stencil, characterized by its different depths, is used when the application has a considerable number of analog components on one side of the board and a lot of digital on the other side. In other words, it requires different amounts of paste dispensed on different segments of the board. It provides additional paste height in certain PCB areas, and in this case, it's called a "step-up" stencil. Conversely, sometimes, it provides lower paste height in certain PCB areas; thus, it's called a "step-down" stencil. In other instances, where the PCB has raised areas, a "relief step" stencil is used.

As an example of a step-down stencil, consider a board with a 0.020″ pitch QFP. A 0.007″-thick stencil is needed for resistors, capacitors, inductors and other passives. A step-down 0.005″-thick stencil is then used for fine-pitch technol-

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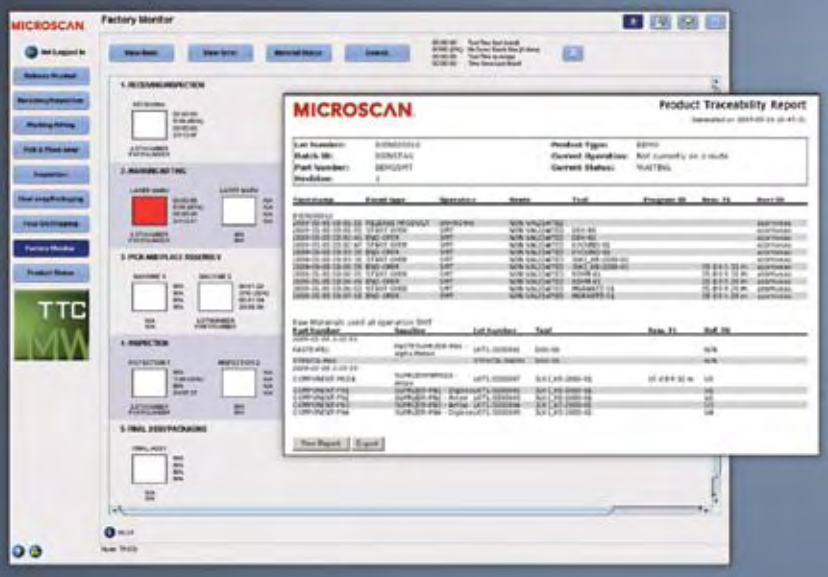

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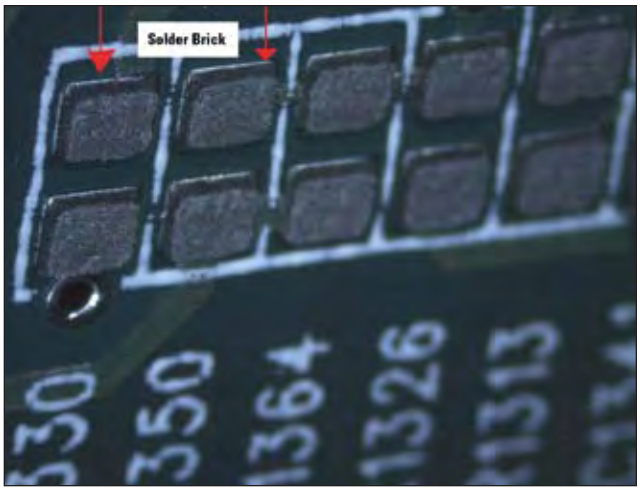

FIGURE 2. Solder brick paste deposition describes how efficiently paste is poured on the pad.

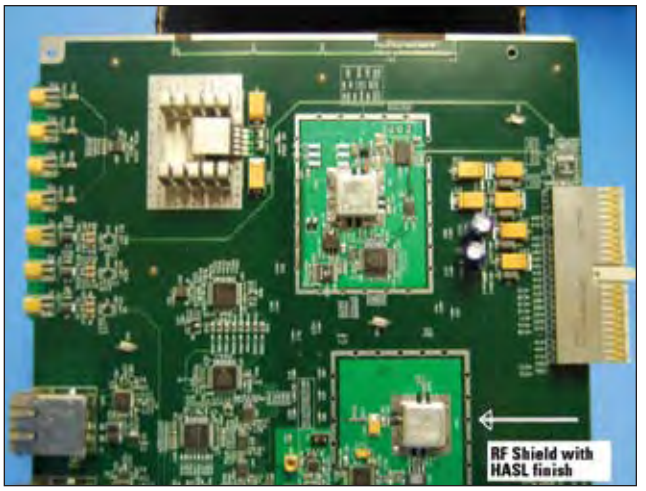

FIGURE 3. Coplanarity typically becomes an issue when an RF shield is created using HASL rather than gold as a PCB surface finish.

ogy (0.020″) SMT devices.

A step-up stencil is used not only for analog, but also for column grid areas (CGAs or CBGAs). For example, a 0.006″ stencil is used for capacitors and resistors. However, a step-up 0.008″ stencil is used for CGAs or CBGAs. The extra paste height is required to support those column grid areas because they require much more paste deposition, compared to the regular SMT components on the board.

Laser-cut step-up and step-down stencils provide ideal solutions for ceramic BGA and RF shield applications. In these cases, additional solder paste deposition is required, meaning solder paste brick height is higher. As a result, it deals extremely well with non-coplanarity issues. For instance, coplanarity typically becomes an issue when an RF shield is created using HASL, rather than gold, as a surface finish on the board (**FIGURE 3**). But it's not that much of an issue in analog or an RF board side, because the more paste deposited, the better the solder joint, especially when digital circuitry is minimal.

Thus, ceramic BGAs are one of the applications for step-up, step-down stencils. Electropolishing and then nickel plating are recommended for those stencils to achieve a good paste release for smaller aperture sizes. This stencil costs more because more processes are involved, and electropolishing or nickel plating can mean longer turnaround time.

First-article inspection is a next critical step to verify the stencil design after solder has been deposited. At this point, a determination needs to be made whether sufficient paste has been deposited for an ideal solder joint connection. Also, first-article verification step involves paste height inspection for component pre- and post-loading. Even when component placement is completed, first-article inspection should be deployed at post-placement of components. Component pre-placement inspection is performed when there's only solder paste on the pads to verify the correct amount of paste dispensed. However, post-placement is performed when SMT components have been placed to ensure correct placement and orientation.

In some instances, the EMS provider may take a middle ground for stencil design to minimize the probability of assembly problems. Issues arise in cases like this. Let's say the PCB layout engineer keeps the benchmark on the digital side. Based on this design, adequate paste will be deposited on pads on the digital side of the board. But it won't be enough on the analog side, thus creating voids.

Again, as mentioned, analog requires a 0.006″ to 0.008″-thick stencil, while digital needs a 0.004″ to 0.005″ stencil. Using the wrong-sized stencil negates the concept of step stencils – to deposit the precise amounts of paste on the analog side. Also, when taking the middle ground – for example, using a 0.006″-thick stencil for both types – the digital side may get too much paste deposition, thus creating shorts, especially when finer-pitch QFNs or µBGAs are used.

Misregistration Causes

Paste misregistration occurs for multiple reasons. The following are the most prevalent. First, the stencil aperture opening doesn't align with the PCB. This sometimes occurs during CAM, where the proper aperture openings are not created, resulting in paste misregistration.

Also, if a PCB layout engineer is not alert or careful, they may not view the component properly to see where paste needs to be dispensed. Therefore, a layout and design engineer has to be vigilant at reading the datasheets and reviewing the component specifications.

When special components are used, it's not always clear as to what goes on the board and what does not, or what is masked. To design proper stencils, the PCB designer has to look carefully at the physical component to ensure aperture openings are correctly defined.

Using an unframed stencil is another possible reason for misalignment. After an unframed stencil is placed on an adapter, but before it is mounted on the printer, is where damage can occur, and human interaction creates reliability issues. Also, a cleaning process must be extremely accurate during and after printing. If a stencil isn't properly cleaned before it is archived, paste residue may be left on the apertures. **PCD&F**

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Heat Transfer in LED ASSEMBLY

LED modules can offer significant benefits over filament and fluorescent lighting, but the right materials are crucial to proper heat dissipation. **by CHUCK NEVE**

LEDs (light-emitting diodes) may seem "cool" – at least to the touch – but they all produce heat. This is a particular design concern for high-brightness diodes, especially in LED clusters (**FIGURE 1**), and when they are contained within an airtight enclosure. Design challenges also occur in mounting LEDs on circuit boards along with other heat-generating devices. In such a case, insufficient thermal transfer with regard to one or more devices can impact the performance of LEDs and other components on the board.

For most applications, the answer in terms of dissipating heat within an LED assembly involves the selection and use of thermally conductive and (usually) electrically insulating materials. This process of thermal management is the sufficient transfer of heat generated by the LEDs to ensure optimum performance over time. Typical end-use products include automotive headlights, street lights, traffic signals, etc., all of which have a critical purpose and mandate both maximum brightness and longest possible life. And a key contributor in the selection, configuration, and application of materials is the materials converter.

LED diodes consist of a die of semiconductor material impregnated, or doped, with impurities to form a p-n junction (**FIGURE 2**). When the LED is switched on – in other words, when a forward bias is applied to the LED – current flows from the anode ("p" side) to the cathode ("n" side). At the junction, higher-energy electrons fill lower-energy "holes" in the atomic structure of the cathode material, due to the voltage difference across the electrodes.

The energy released by the electrons in filling the holes produces both light and heat. The light, in turn, is reflected upward by a cavity created for that purpose, while heat is transferred downward into the base of the LED, and ultimately through a torturous path to where it can be dissipated into the atmosphere by convection, usually with use of a heat sink (**FIGURE 3**).

The process of light emission is called electroluminescence, and the color of the light produced is determined by the energy gap of the semiconductor. Since a small change in voltage can cause a large change in the current, care must be taken to ensure both are within spec and are as constant as possible. Otherwise, the performance of the LED can become degraded over time, even to the point of failure.

Is heat really a problem with an LED? It definitely can be a problem, and sometimes a difficult one. As the temperature rises within the LED, the forward voltage drops and the current passing through the diode increases exponentially, thereby leading to even higher junction temperatures. (**FIGURE 4** shows how a small change in voltage can cause a significant change in current.) While catastrophic failures probably are rare, an LED module's light output will diminish over time (**FIGURE 5**); efficiency will drop, and the color of the light emitted may change, due to shifts in wavelength brought on by the temperature rise. Wavelengths typically rise from 0.3 to 0.13 nm per °C, depending on the die type. As a result, orange LEDs, for example, may appear to be red, and LEDs producing white light – such as automobile headlights and street lamps – may have a bluish tinge. Other effects include yellowing of the lens, breaking of the wire, and die-bond adhesive damage. Figure 5 also suggests why white light

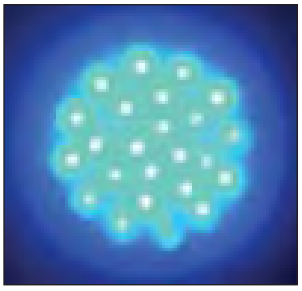

FIGURE 1. Clustering of LEDs mandates efficient transfer of heat to prevent possible failure of the LED assembly.

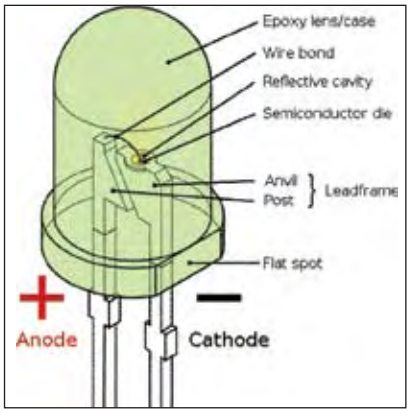

FIGURE 2. While light produced by high-energy electrons is reflected upward from the cavity, the heat is conducted downward, the epoxy lens being a poor conductor.

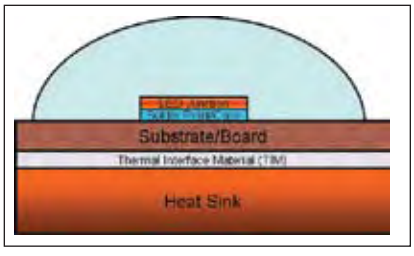

FIGURE 3. Heat is generated on the underside of the chip and travels through a metal block, known as a "slug" (not shown), to solder points on the board.

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created from RGB LEDs can appear to have a blue tinge as the junction temperature rises above its intended value. As the figure depicts, blue light falls off slightly less than green and much more so than red.

Proper thermal management in designing circuitry and modules containing LEDs is thus essential, and while various approaches are available, involving heat sinks, base plates, constant-current power supplies, and fans, the solution almost always encompasses the selection of materials for attachment, from thermally conductive adhesives to die cut pads, that are electrically isolating and thermally conductive (Figure 6). In most instances, a thermally-conductive/electrically-insulating pad will be the choice in transferring heat to either a heat spreader or a heat sink.

Designing an LED assembly – whether on a circuit board with other components or within an enclosure – first requires an assessment of the methods available for dissipating the heat to be generated by the assembly. Will the LEDs be through-hole or surface-mounted? Should a dielectric substrate be employed with thermal vias and a copper plate on the underside for absorbing and distributing the heat, or will the LEDs be mounted on a coated metal-core board that acts as a heat spreader? In other words, the initial effort is to determine how the heat is to be dissipated and the most efficient and effective heat path for transferring the heat.

Upfront design work for an LED assembly can be performed either in-house by the manufacturer, or with the assistance of an outside service, namely, a converter experienced in the dissipation of heat generated by electronic and optoelectronic components. In some cases, determining how best to dissipate the heat may benefit from in-depth thermal analyses using temperature modeling software for LED-based module designs.

Once the thermal path has been determined, the next step in designing an LED assembly is the selection and configuration of the thermal interface materials. Among these are liquid adhesives, die cut pads, etc. that provide the required thermal conductivity and electrical insulation. Such parameters as surface flatness of the substrate and heat sink, shape and metal used for the heat sink, applied mounting pressure, thickness of the interface, contact area, etc., may also be specified.

Various families of materials have been developed for thermal management

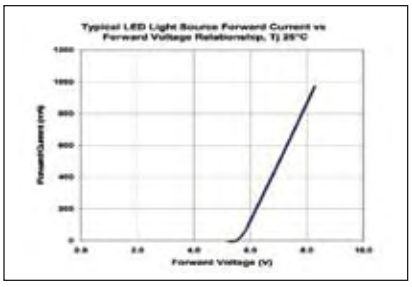

FIGURE 4. A small change in the forward voltage can result in a significant increase in the current passing through the diode. In this case, an increase of about 3.5V causes the current to rise by almost 1,000 mA. The net effect would be a rise in temperature at the p-n junction, adding to heat dissipation problems. Note that in determining the data points, an initial junction temperature of 25°C is assumed.

in electronic and optoelectronic assemblies. Options include both off-the-shelf or custom formulations in specified thicknesses and configurations, as well as a variety of choices in types of material: conductive adhesives and greases, tapes, ceramic and metal-filled elastomers (also called "gap fillers"), coated fabrics, and phase-change materials.

Adhesives and greases have historically been the means of attaching a heat-generating device to a heat sink, and are relatively inexpensive. Pressure-sensitive tapes are also used for mounting components to heat sinks, as are elastomer gaskets, which can be coated with an adhesive on one or both sides, and can be die-cut into almost any shape. Thermal fabrics are typically fiberglass-reinforced, ceramic-filled polymer sheets that can provide both thermal conductivity and electrical isolation. Tapes, elastomer pads, and coated fabrics can be formulated to achieve specified performance values in terms of dielectric strength, thermal conductivity, and thermal impedance.

Phase-change materials change from a solid to a liquid during the process of absorbing heat at specified temperatures. The net result is the transfer of heat from a heat-generating device, such as a microprocessor, which is thermally coupled through the material to a heat sink.

Note that the role of a converter involves more than recommending the use of certain materials. For most requirements, the converter provides the finished part – for example, a die-cut gasket. Depending on the needs of the manufacturer, the converter should be able to perform the actual assembly work. While the requirement may typically involve thermal transfer, the binder,

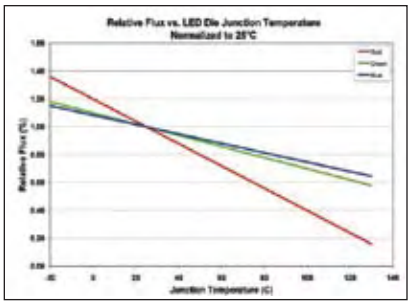

FIGURE 5. LED light output can diminish over time with rises in temperature. The example provided for R (red), G (green), and B (blue) LEDs indicates that red lamps tend to lose brightness the most, and the fastest, as the junction temperature increases.

FIGURE 6. Types of thermal management products. The choice will depend on the amount of heat to be transferred and the assembly configuration.

filler material, size and shape of the pad, type of adhesive, method of application, etc. are electrical insulation considerations. So too is EMI/RFI shielding, if needed. Then, too – again depending on the product – environmental sealing may also be required, since LED applications often entail operation under environmental extremes of temperature and weather, and even vibration. (Consider, for example, the vibration requirements for a sealed LED headlight.)

While LEDs seem cool to the touch, heat can be a significant problem, and could cause a product failure. Though excessive heat is not going to cause a color shift that results in a red stop light changing to green, the traffic signal could go out, or more likely, it could dim to the point of not being easily visible.

In designing LED-based products, the heat generated both by the LEDs and surrounding components, if any, requires serious consideration by the product designer, the materials engineer, and the converter contracted to provide a viable, cost-effective solution. **CA**

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FIGURE 1. Programs are quickly launched to address problems, with customers getting constant feedback to ensure execution remains paramount.

FIGURE 2. Mack's plants are considered open to customers' engineers.

The Big MACK ATTACK

Mid-tier EMS provider Mack Technologies uses a data-driven approach to satisfy customers.

by **MIKE BUETOW**

For two years running, Mack Technologies has taken home top honors in Circuits Assembly's Service Excellence Awards for companies of $100 million to $500 million in annual revenues. What's its secret?

A customer service strategy based on execution performance and using data, derived through open and honest communication with customers, to drive improvements in performance, company officials say. Westford, MA-based Mack (macktech.com) attributes its ability to follow this strategy to an evolving corporate culture that places a high value on supporting customer requests and exceeding expectations.

In an interview with Circuits Assembly, president John Kovach and vice president of sales and marketing Will Kendall described Mack as a fairly conservative company, one that chooses its customers as much as it is chosen by them. Mack, they said, pays close attention to its customers' financial stability and engineering needs, and once engaged, spends countless hours assessing their customers' needs and Mack's performance in meeting those needs. Excerpts:

CA: Describe Mack's quality system.

JK: Employee performance is evaluated based in part on customer quality scorecards. We do the same things the same ways in all three sites. Profit sharing is tied to company profitability and customer satisfaction. The scorecard looks at five to six aspects with detailed subheadings. We ask for comments and feedback for any score that's not best in class. Program managers and executive sponsor (VP, GM, president) for most accounts.

We meet as frequently with customers as we can, and go through scorecarding with them. Ownership fosters long-term relationships. Mack strives for long-term partnerships, and we avoid doing anything for short-term financial gain that might negatively affect a long-term customer relationship.

CA: What are the metrics you use?

WK: On the tactical side, customer metrics focus on execution, like on-time delivery; return material authorization (RMA) turnaround; quality – yield at customer site, returns, internal DPMO; availability of quality info, such as frequency and accuracy; flexibility – we let the customer dictate that; for every customer it's different. We define flexibility as "changes to the steady state of business."

We design a supply chain to fit the customers' inventory management and needs.

Moreover, compensation has been tied to profits and customer satisfaction since the inception of Mack Technologies. If you concentrate on something long enough, it becomes part of the culture. It's part of the belief system of the team.

CA: Is the scorecard-related compensation substantial?

WK: The maximum payout can be a significant portion of an employee's compensation. The formula was developed about 25 years ago, and the axes sometimes change, but the internal payout rates have been consistent.

CA: Does Mack approach its suppliers with the same level of detail?

WK: Our supply base is a major factor in our performance for our customers.

JK: We're demanding but fair, and view (the supply base) as a long-term extension of our own capabilities.

CA: Are the metrics qualitative or quantitative?

WK: Some of the qualitative things include asking customers to rank us against our competitors. This is a major factor in our analysis. We ask if their view of us is favorable or not.

Quantitative metrics are rolled up and put into an algorithm, and weighted with qualitative metrics. It's a home-

'FLEXIBLE, BUT DILIGENT'

A good, seasoned team of professionals that offers a lot of industry knowledge when you need it."

That's how customers see Mack Technologies. As part of this reporting, CIRCUITS ASSEMBLY spoke with a pair of Mack customers: Thomas Kokernak, director of global supply chain management at Kopin Corp. (kopin.com), an OEM of ultra-small LCDs and heterojunction bipolar transistors for consumer, industrial and military applications, and a Mack customer for almost three years; and Glenn Cozzens, vice president of engineering, operations, and information technology at ThingMagic (thingmagic.com), a developer of RFID technology. (Cozzens has outsourced to Mack at multiple employers.)

CA: What services does Mack provide you?

GC: Printed circuit board and box-builds. Mack does the parts procurement through functional test. What we call a box-build is really a small reader, like a router. These are RF devices. Mack also manages the material required from other suppliers.

TK: Mostly manufacturing, but when needed they can perform environmental test and can support various other things such as manufacturing solutions for coatings and boards. They also offer us higher-level manufacturing services like component procurement. We are leveraging some of [Mack's] Florida asset capability for some of our customers. From quality perspective, they are serving us in both locations, as some of our customers are near their Florida site. The other thing I like is the parent company [Mack Group] has molding capability, so if I wanted to bring them a box-build program, they span the network of what I would need done. And they have prototyping capability.

Why do they make us happy? The quality is good, even first time out the door. Mack is very flexible and very responsive, but diligent in making sure documentation is in place.

CA: How do you typically communicate with them?

GC: We do a hybrid. As head of engineering and operations, I talk to Will Kendall. Our test engineer talks to their test engineer. Our process engineer talks directly to their process engineers and program manager. We go there regularly and have weekly meetings. We use email, phone, text and electronic transfer of data.

TK: Through the program manager, or engineers talk to engineers. The relationship is such that it's not unusual for our engineers to say they are going to talk to Mack's.

CA: How have you handled quality issues?

GC: When we run into a manufacturing defect – and everyone has them – we formally request a corrective action. First, we want to see a containment measure, in order to prevent more failures from making it out. Then we work on root cause. Of all the CMs I've worked with, they are the best at diagnosing failures on the line. Sometimes the corrective action is on their side, like a process change or a footprint change; sometimes our tester didn't find something that needs to be corrected.

TK: If there is a quality issue, they are very responsive. In some cases they have helped with quality issues with our customers. We've also used them for training our lab workers for soldering to IPC standards.

CA: Do you have specific metrics for grading its suppliers?

GC: ThingMagic uses on-time delivery, cost, quality. We do post-pack audits where we retest 10% of the deliveries we receive. If one fails, we send the whole batch back for retest. After-market, we monitor dead-on-arrival rates and infant mortality rates.

TK: Kopin uses a supplier performance review whereby quality is 45%; supply chain is 40%, and technical, meaning engineering services, is 15%.

CA: How does Mack grade?

TK: In the high 90s.

CA: How does Mack rate among your EMS providers?

GC: I think they are the best we have. We have three CMs that build PCBs and assemblies. By doing that [having multiple suppliers], we ensure competitive bidding. What we do over time is whoever rises to the occasion gets the project. Usually, that is Mack.

TK: We also have a couple small ones. Mack would be at the front of pack. For the military environment I'm in, they are who we rely on.

grown formula that has existed for quite awhile. We also push for the qualitative aspects. The typical scale is 1 to 5. (For the internal scale, it's 0 to 100). The score goal is aggressive and consistent year-to-year.

CA: One of the problems in a long-term customer relationship is that mistakes are bound to happen. How do you avoid those mistakes from building up to the point where, in the customer's eyes, you have become an inferior supplier?

WK: What separates companies in terms of customer perception is how you react to mistakes to ensure the same mistake never happens again. Are you implementing procedures to minimize the impact and ensure they don't happen again?

JK: I think quality reviews help keep that on balance. If you continue to meet with their senior executives and objectively review performance data, you establish credibility and can view the overall performance in context of the whole relationship, as opposed to a specific instance that may be more emotionally memorable, but overall insignificant in the greater scope of the relationship. At the end of the day, what matters most is our longstanding execution and performance for our customers.

WK: With quality business reviews, it helps both companies look at all the data for a given period, instead of just the performance for the immediate short-term period leading up to the review.

CA: How do you ensure the Mack approach can withstand the loss of key personnel?

JK: The systems are well-designed, so that if we lost key members of the staff, the system would survive. Then it's a level of discipline. All three sites [Ed.: Mack has facilities in Massachusetts, Florida and Mexico] meet one to two times each week. There are monthly performance data meetings. The system is simple to understand. Sales and operations talk across all three sites.

CA: How do you ensure the Mack culture during the hiring process?

JK: Internal management has been in place for a long time, so there's mentoring. We try to vet the employee recruiting process, so we can find the right people for the task. We look at their background. Mentioning only "profit" without also mentioning customer satisfaction and service is a red flag. We look for candidates who talk about the customer.

CA: Besides the program managers, who within Mack is allowed to engage with the customers?

JK: Quality, Materials, Test, Finance and Operations. The majority of people with access to communications are allowed and encouraged to talk with customers. The program manager is always involved in the communication too.

Meetings are generally by phone or onsite, depending on the customer location. We like to see the customers in person when it makes sense.

CA: Say you attained the corporate goal in a given year. Now what do you do?

JK: We don't stop once we achieve the goal. When your performance is good, you are establishing credibility. Over time, we strive to further enhance our performance – even when we have set a high watermark for expectations from our customers. If you are missing 20% of your metrics underperforming, the relationship isn't going to go anywhere.

WK: Customers tell us when they think we aren't performing. This openness and honest communication really only works when the customers feel comfortable that they can tell us where we can improve and that we will constructively receive the feedback. We have a flat management team. There are not many people our customers have to call in order to get an answer. Information usually can be transferred quickly because we are flat. Our structure enables a level of communication that some others might not have.

JK: I think your reputation becomes critical in the sales cycle.

CA: What is the program manager's role in all this?

WK: The manager is responsible for ensuring staff is following through. It comes from the top and flows to the whole team. All feedback is shared with teams, so there's a lot of formal feedback.

JK: We use the same scorecard across the company, so when we hire a PM, it's a critical part of their training. And we launch programs to address problems and bad trends, e.g., RMA. CA

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ROI, continued from p. 18

people management so you are consistent in how well you treat all the related people – suppliers through customers – can you begin to focus on providing the value-adding process management they all seek.

Disney and Apple seem to get this. Disney parks are consistent in their customer focus and process management to make sure that all customers ("guests") feel they had the best experience and received the greatest value for their money. Ditto with Apple; its retail stores emphasize service, support and the total "Apple" experience, and hence, the value-add of buying its products and much of its brand loyalty.

In our industry, the highest level of value-add is in supporting engineers who create cutting-edge technology with the often-invaluable manufacturability input we can offer. It's about making the buying experience easy and seamless for that engineer or the buyer who is under pressure to cut all costs. Value-add is building the personal relationship of being the company that can "make it happen." And yet, when resources are committed, investments made, and HR reviews given, the people side of process management is all too often the area ignored or neglected.

If only managers and workers realized how important their attitude, commitment and over-the-top involvement means to the bottom line of their customers, as well as their colleagues. Going above and beyond is great, but when that attitude, skill set and commitment are part of the process management – process improvement – then true value-add will be provided to customers and suppliers. PCD&F

Maintaining Print Process Health

First of a two-part look at ways to keep print operations running smoothly.

With all the advances in screen printing technology – from cycle times to accuracy to inspection capability – it's sometimes easy to forget that, just like your own health, keeping your process in check requires periodic preventative maintenance. So, in this column and the next, I'll discuss the three areas central to a healthy print process, along with simple remedies for certain problems. They are:

1. Correct volume.
2. Correct location.
3. Timeliness and repeatability.

First, let's talk about material volume – either too little or too much solder paste. For insufficients (too little paste), I generally analyze four things: volume of paste in front of the blade, material compatibility with the process, squeegee type/squeegee angle and the stencil.

- Paste volume in front of the squeegee blade. Remarkably, this is a common issue, but is easily resolved. The rule of thumb is that there should be a 15 mm (about 0.75″) diameter roll in front of the blade. While this seems easy to monitor, in busy factories, it is often overlooked, but can be remedied through use of automatic paste height monitors.
- Material compatibility with the process. Many firms have taken on miniaturization from a manufacturing point of view, but not necessarily followed suit with their materials. For smaller ranges of apertures (sub 200 µm), a Type 4 or even Type 5 solder paste may be required. In general, at least four to five solder particles should fit across the width of the smallest aperture. If aperture width has been reduced, but solder paste type not adjusted, insufficients may result because of blocked apertures. Also consider material age. If a product has been running fine and then all of a sudden insufficients begin to appear, it could be a material drying issue. Even a slight change in the material will impact the print, especially when running a process with incredibly small apertures.
- Stencil considerations. Of course, stencil integrity and cleanliness also factor greatly in proper paste volumes. Improper cleaning can render an aperture area ratio significantly reduced from the ideal of 0.66. If the stencil has been designed improperly, without regard to area ratio rules, or if it isn't manufactured with properly calibrated lasers or a process that ensures debris-free aperture walls, then insufficient volumes could result.
- Squeegee type and angle. Squeegee angle is incredibly important, and slight adjustments can have a huge impact on aperture fill. Plus, it's not just the manufacturer-recommended angle to be concerned with: Pressure also must be evaluated. If you're putting a tremendous amount of pressure on the squeegee, the bend will affect the angle and, therefore, the print. Proper maintenance also is key. Just because squeegees are metal doesn't mean they are indestructible. Warped squeegees and worn tips can wreak havoc on prints. All it takes is a few seconds at the end of each shift to look down the length of the blade for damage. If there is, the blade should go in the bin.

Conversely, too much solder paste can result in bridging or stringing, and certain inputs should be evaluated to reveal the source. Similar to problems that occur with too little paste, factors that should be analyzed in relation to excessive volume include materials, squeegee, stencils and tooling support.

- Material. If the viscosity of the solder paste isn't right, then slumping, bridging and stringing can occur. Aside from the obvious formulation issues, viscosity also can be impacted by environmental conditions (high humidity, for example) and cleaning solvents on the stencil. All of these potential viscosity challengers should be evaluated.
- Squeegee. Again, the angle is essential for ensuring the proper amount of solder paste in the apertures. An angle that is too shallow (45° and below) may create a volume that is too high. But, as noted, blade pressure also can impact volume. A 60° blade, under excessive pressure, could cause material volume to be overshot.
- Stencils. Precise fabrication of the stencil is critical. Apertures that are too large – even slightly – can release too much paste volume, leading to bridging. Cleanliness also has an impact. If a smear is left on the stencil, the extra thickness might cause too much material volume to be pulled when it is released from the aperture.
- Tooling supports. All tooling needs to be clean, flat and maintained. You'd be amazed at how many tooling supports are covered in dried solder paste, which, once set, is much like cement. With too much dried paste on the tooling block, the board often doesn't gasket well to the stencil; these gaps will lead to extra material volume.

Monitoring these "gotchas" on a regular basis will most certainly lead to a healthier print process. In my next column, we'll continue this discussion with a look at location/accuracy and repeatability. Until then, keep an eye on those paste volumes! CA

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Why Preheating is Important for Selective Soldering

Avoid molten solder on the pad, which could minimize pad material dissolution.

LARGE, HIGH-MASS ASSEMBLIES are a challenge for any soldering process, but are particularly troublesome for selective soldering, where process heat is applied only to the bottom side of the assembly. Such boards require continuous, real-time topside preheating during the selective soldering process.

For this reason, we often find selective soldering machines equipped with a preheating module that applies heat to the top side of the PCB during soldering. For high-mass assemblies, topside preheating promotes the draw of the solder through the barrel to the top side of the board, enhancing solder fillet formation. The implementation of internal continuous preheat during selective soldering improves thermal distribution and solderability of difficult assemblies.

This type of topside preheating configuration is not practical or possible on machines that grip and robotically move the PCB, since the preheater would need to travel with the board, and the gripper simply is in the way. A topside heating module can be used as the primary preheating function, or to maximize productivity when used in combination with optional discrete preheaters to maintain board temperature during soldering. Some systems are equipped with an optical pyrometer that reads the actual PCB temperature during the process and provides closed-loop control. The importance of proper closed-loop preheater control based on PCB temperature cannot be overemphasized.

Our selective soldering systems typically run solder temperature in the 300°-325°C range. It is important to remember we are replacing/emulating hand soldering, where the soldering iron tip temperature is around 375°C. We are not reproducing wave soldering. Molten solder has significant thermal capacity and heats the solder site much more rapidly than the conventional iron, overcoming most of the difficulties soldering heavy pins. However, on thermally demanding sites or thick multilayer boards, preheating contributes significantly to the outcome quality and provides two distinct advantages. First, the process is expedited significantly, depending on the thermal mass the wave would need to heat. Second, the molten solder does not need to dwell on the pad any longer than necessary, thereby minimizing dissolution of the pad base metal. (This can be a big problem with Pb-free alloys due to the aggressive behavior of molten tin.)

Another option is the use of both standalone and inline preheaters for high production systems. These units raise board temperature while the previously heated board is being fluxed and soldered in the selective machine. However, on extremely demanding boards (e.g., backplanes) with many sites to be soldered (and with a long soldering process time, such as 5 min. or more), the board may partially cool, causing a gradual change in the process, and thus negatively affecting solder joint quality. Therefore, for maximum productivity when processing such boards, use of both inline and on-board preheaters (in concert) is recommended.

Mention preheating, and most people envision a flat panel or array of lamps, but selective soldering machines can focus and control superheated nitrogen delivery to a very small, user-defined area of an assembly (**FIGURE 1**). This preheater type is appropriate for soldering operations where large area bottom-side or topside preheating are not feasible, and in situations where extended preheat cycles or solder dwell times represent a danger to the subject component or adjacent components.

We find this is a good method to proportionately control a number of critical parameters, including ramp-to-temperature, volume of flow, and dwell time, creating a true small-area pre-heat profile. Used in conjunction with a machine's nozzle and nitrogen cap design, the user in many cases can program the delivery of the right amount of nitrogen, with the proper profile, through the solder nozzle before the solder can begin to flow, effectively preheating and preparing the soldering site with the protection of nitrogen, which is usually at the solder liquidus temperature, without any oxidation or degradation. It's just another effective tool in the selective soldering user's arsenal. **CA**

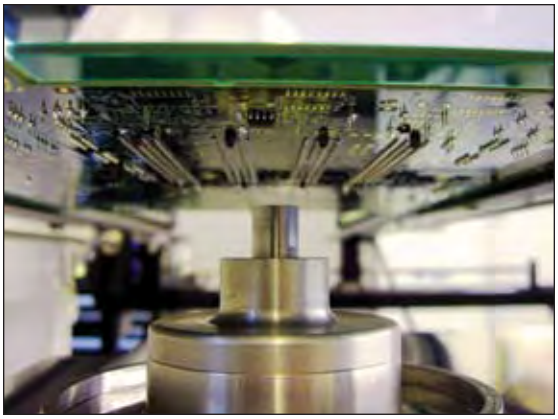

FIGURE 1. A topside preheater on a selective machine can deliver superheated nitrogen to a very small, user-defined area.

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Cleanliness and Corrosion Mitigation

Any metal that comes into contact with the electrolyte could corrode. Several types of corrosion commonly occur – and in several ways.

A critical factor in preventing corrosion in electronics is maintaining the state of cleanliness. This is not easy. Corrosion is defined as the deterioration of a material or its properties due to a reaction of that material with its chemical environment.[1] So, to prevent corrosion from occurring, either the material or the chemical environment must be adjusted. Adjusting the material usually means replacing it with a less reactive material or applying a protective coating. Adjusting the chemical environment usually means removing ionic species through cleaning, and removing moisture, usually with a conformal coating or hermetic package. Ionic species and moisture are problematic because they form an electrolyte able to conduct ions and electricity. Any metal that comes into contact with the electrolyte can begin to corrode.

Several types of corrosion can commonly occur on electronics assemblies.

Gas phase corrosion. Some metals used in electronics, such as copper, nickel and silver, are susceptible to gas phase corrosion. In the cases of copper and nickel, the metals react with oxygen in the air to form a thin oxide layer and an unsolderable surface.

TABLE 1. Material Examples from the Galvanic Table

MORE ACTIVE (ANODIC)
▲ Magnesium
Zinc (hot dip, die cast or plated)
Beryllium (hot pressed)
Cadmium (plated)
Aluminum
Tin (plated)
Lead
Copper (plated, cast or wrought)
Nickel (plated)
Chromium (plated)
Tantalum
Tungsten
Bronze 220
Copper 110
Molybdenum, common
Titanium
Silver
Gold
Platinum
Palladium
▼ Graphite
LESS ACTIVE (CATHODIC)

This is why surface finishes are used. They serve as protective coatings by preventing copper from oxidizing and retaining a solderable pad on a bare board. One such surface finish, immersion silver, protects the underlying copper, but the silver itself is susceptible to attack from sulfur-containing materials and gases in the atmosphere, leading to tarnish (**FIGURE 1**). Prevention of exposure to sources of sulfur is key to preventing tarnish from occurring. Sulfur is found in air pollution, rubber bands, latex gloves, desiccant, and sulfur bearing paper used to separate parts.

Uniform corrosion. Uniform corrosion is evenly distributed across the surface with the rate of corrosion being the same over the entire surface (**FIGURE 2**). One way to determine the severity of the corrosion is to measure the thickness or penetration of the corrosion product. Uniform corrosion is dependent on the material's composition and its environment. The result is a thinning of the material until failure occurs.[2] Uniform corrosion can be mitigated by removing or preventing ionic residues and preventing moisture.

Pitting corrosion. Pitting corrosion is a localized form of corrosion where the bulk material may remain passive, but pits or holes in the metal surface suffer localized and rapid surface degradation (**FIGURE 3**). Chloride ions are notorious for forming pitting corrosion, and once a pit is formed, the environmental attack is autocatalytic, meaning the reaction product is itself the catalyst for the reaction.[3] Pitting corrosion can be mitigated by removing or preventing ionic residues and preventing moisture.

Electrolytic metal migration. In the presence of moisture and an electric field, electrolytic metal migration occurs when metal ions migrate to a cathodically (negatively) charged surface and form dendrites. The dendrites grow and eventually bridge the gap and create an electrical short. Materials susceptible to metal migration are gold, silver, copper, palladium and lead. These metals have stable ions in aqueous solution that are able to travel from the positive electrode (anode) and deposit on the oppositely charged negative electrode (cathode). Less stable ions, such as

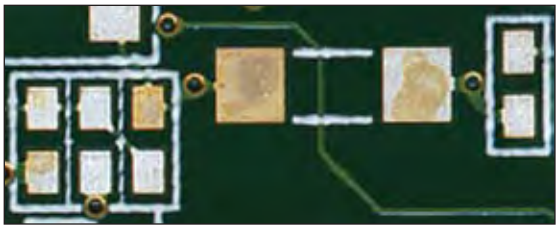


FIGURE 1. Areas of tarnish on a board with an immersion silver finish.

ACI TECHNOLOGIES INC. (aciusa.org) is the National Center of Excellence in Electronics Manufacturing, specializing in manufacturing services, IPC standards and manufacturing training, failure analysis and other analytical services. This column appears monthly.

FIGURE 2. Uniform corrosion observed over all the metallic surfaces.

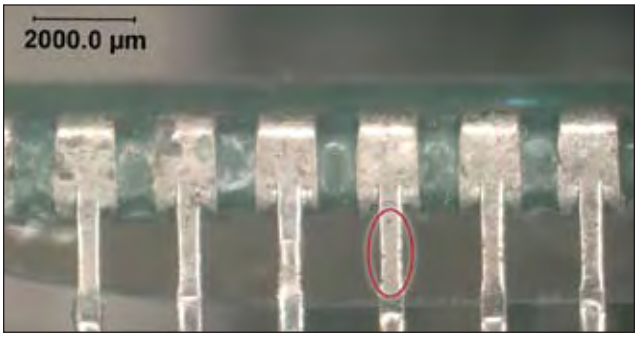


FIGURE 3. Pitting corrosion observed along the component leads.

those of aluminum, form hydroxides or hydroxyl chlorides in the presence of high humidity and chlorides. An example of a copper dendrite is shown in **FIGURE 4**. Electrolytic metal migration can be mitigated by removing or preventing ionic residues and moisture.

Galvanic corrosion. Galvanic corrosion occurs when two dissimilar metals come in contact with one another or are connected through a conductive medium such as an electrolyte. A soldered joint is a composite system where many different materials are connected. Within the joint or between joints and other conductive circuitry, DC circuits can be established that will corrode the most anodic material.[4] When ionic species are present, such as flux residues and moisture, an electrolyte can form. The corrosion at the metal forming the anode will accelerate, while the corrosion at the cathode will slow down or stop. In a poorly deposited ENIG surface finish, a porous immersion gold layer exposes the underlying electroless nickel. The large difference in electrochemical potential between the nickel and gold causes corrosion of the nickel layer, while the gold acts as a powerful cathode. As corrosion proceeds, pitting of the nickel can extend into the underlying copper and cause further corrosion. If there is no porosity in the gold layer, but instead, a gap between the metallic component and the resist edge, the metallic layers can be exposed to solution allowing galvanic corrosion.[5] **TABLE 1** lists metals in order of their relative activity in sea water (the Galvanic Table from MIL-STD-889, Dissimilar Metals). Generally, the closer the metals are to one another in the listing, the more compatible. However, in any combination of dissimilar metals, the more anodic metal will preferentially corrode. To prevent galvanic corrosion, careful selection of adjacent materials must occur in the design phase. To mitigate galvanic corrosion from occurring in the field, an electrolyte must be prevented from depositing on any connection of dissimilar metals.

Corrosion can be mitigated by preventing electrolytes from forming. This is accomplished by ensuring that any ionic residues are removed after component handling, bare board fabrication, and assembly, as well as preventing salts from depositing on the assembly from extreme environmental conditions. Moisture can be prevented by using a conformal coating or hermetic package. Also, materials selection in the design phase is important so that metals with dissimilar electrochemical potentials are not directly connected. If dissimilar metals must be used, such as when using specific surface finishes, like ENIG, then ensuring good bare board construction is a critical step in reliable, corrosion-free electronics. CA

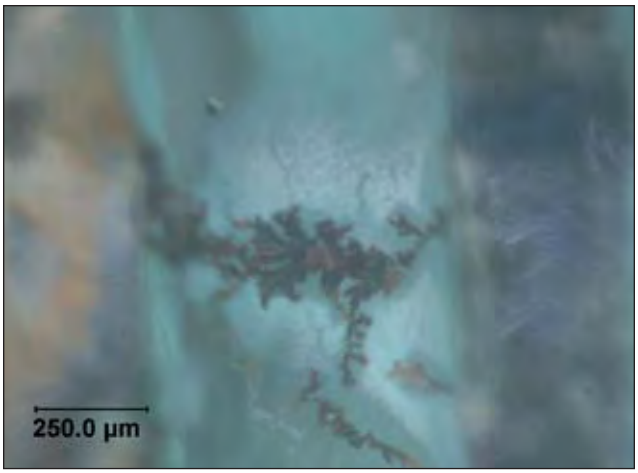


FIGURE 4. Dendrite that grew between two leads and is surrounded by salt residue.

Programming In-System versus Offline

The decision rests on the line beat rate versus ICT test cycle time.

MODERN ELECTRONICS – CELLPHONES, TV set-top boxes, laptops – contain at least one programmable device on board that usually contains boot-up or self-test firmware to enable these products to perform their functions properly. In general, there are two methods by which these devices are programmed: offline or in-system.

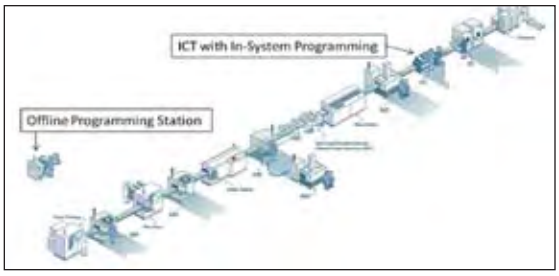
How does one decide on offline programming or ISP? One key consideration is the cost of each method. Let us look at pros and cons of these two methods that contribute to the overall costing.

First, let's define each of these methods:

- Offline programming. Device programming carried out independently of the actual production line before device is attached to the printed circuit board.
- ISP. Device programming carried out in the actual production line; device is installed on the assembly before programming is performed.

The sole benefit of programming offline versus in-system is that it takes out that time from the overall ICT test cycle time equation. If the SMT line beat rate is much faster than the overall ICT test cycle time, the ICT station will be a bottleneck for the production line. Removing the programming portion from the ICT stage will improve the overall efficiency of the production line. The programming time depends on many factors, like the size of the data to be programmed, programmer clock speed, number of devices to be programmed, whether the program is implemented directly onto the device or via an upstream boundary scan JTAG port to program device, etc.

On the other side of the coin, offline programming does have some big challenges. The first is inventory control. There will be multiple firmware versions across the customers' range of products, and there will be even cases of multiple firmware versions for a single product with different functions turned on for different market needs. Having offline programming for all these devices will require a good inventory control process. Imagine loading the wrong preprogrammed devices onto boards: the effort and cost of replacement would be tremendous.



The second challenge with offline programming is the inability to reprogram the device post-soldering. Often, firmware versions are frequently changed, especially during NPI. New firmware may be released during the production build, and the inability to reprogram the device online means one has to replace the device manually. Or, if boards have been returned from repair, functional test or outside the factory, there usually are slight changes to the firmware, and the boards must be reprogrammed in the ICT. This reinforces that the ability to program in the ICT station is critical in a production environment.

An offline programming station requires additional resources: operators, real estate, and of course the programming station itself. On the other hand, implementing ISP may require additional hardware or software on top of the existing ICT, not to mention development of the ISP solution.

Simultaneous Programming

Performing programming on two similar boards simultaneously achieves two boards within one test cycle time. It can also mean programming two or more devices within the same board simultaneously, circuit topology permitting. How fast can ISP be? Consider real-time data I collected from two recent ISP projects. In both cases, the ICT was an Agilent Medalist i3070 Series 5 with plug-in cards.

Project #1:

Product: Smart meter
Fixture: One-up (single board)
Programming three different devices on board: M24512 (EEPROM), M25P10 (SPI flash), STM32F101 (MCU)

OPERATION (M24512 – EEPROM) DATA SIZE = 512 KB	TEST TIME (SEC.)
Programming	4.05
Verify	3.05
Run all script	7.75

OPERATION (M25P10 – SPI FLASH) DATA SIZE = 1 MB	TEST TIME (SEC.)
Erase	1.20
Blank Check	0.65
Program	1.15
Verify	0.40
Run all script	4.15

(continued on p. 54)

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Recognizing Constraints

Eliminating waste through Lean principles means balancing tradeoffs.

Practitioners of Lean manufacturing are familiar with Taiichi Ohno's seven deadly wastes: overproduction, waiting, transportation, inappropriate processing, unnecessary inventory, unnecessary or excessive motion and defects. While focusing on waste elimination in each of these areas is desirable, often dealing with production realities means tradeoffs must be made.

As a result, reducing costs by improving efficiency drives manufacturing and quality engineers to become combinations of risk analysts, strategic planners and coaches. This is because all wastes tie into one another and reducing one may fix others. So, the most effective Lean strategies look at the overall organization and the way each action impacts other actions. A robust Lean program emphasizes to each employee that customers include both the party receiving the product and the person who touches a product after they finish processing it. The result is an organizational culture that focuses on improvement, but also recognizes constraints.

Cause and effect. Nowhere are constraints more evident than in the electronics manufacturing services environment. Even when customers are targeted based on their maturity in Lean practices, variations in forecasting, processing and supply chain are introduced with every new customer. This month, we look at each of the seven wastes and likely tradeoffs that must be considered. We also look at practices EPIC has found successful in achieving balance between Lean best practices and the reality of serving a diverse customer base.

Overproduction is a waste typically driven by inefficient processes and as such, it often reflects elements of the other six wastes. Overproduction results when inefficient processes drive higher scrap levels or shortages, and production output is increased to ensure demand is met. Automation is one way to increase production efficiency and quality, but EMS automation strategy needs to be flexible to support likely variations in product configuration and demand. Higher levels of automation can also drive higher cost, so the "perfect" level of automation may never be achievable. Plus, automation is only half the equation. Preventive maintenance and calibration are important in ensuring repeatable processes, as equipment that fails or is out of spec will add bottlenecks or defects. Smaller lot sizes can help minimize overproduction, but every changeover introduces an opportunity for failure and decrease in operational efficiency.

EPIC's model looks at automation strategy carefully. Equipment and process variation is minimized. The same platform is used in all facilities, so improvements made in one facility are easily transferred. Specialized wave solder equipment and vapor phase reflow are used to create a broader process window that either permits automated changeover or doesn't require any change between products. All SMT lines are identical. There are no specialized topside or bottom-side lines. Production personnel are cross-trained in multiple processes so they can move between processes based on demand patterns. Smaller lot sizes can be processed with minimal changeover impact, and demand variations driven by multiple customers are accommodated with minimal waste of resources or bottlenecks. Design for manufacturability/testability (DfM/DfT) recommendations help guide customers toward practices that better utilize production resources and minimize defects. The effect is minimized overproduction.

Waiting is a simple waste. Products in wait state at any point in production are essentially stagnant money merely sitting on the floor. Increasing throughput by processing in smaller batches converts waiting to free cash. However, elimination of waiting is achievable only if material is available. A single, inexpensive passive component delay can halt a production build, negatively impacting inventory turns and cash flow.

EPIC's system typically processes product into finished goods within 48 to 72 hr. Material bonds are established and buyers are focused not on ordering to JIT demand, but on managing exceptions down the pipeline. The result is the ability to identify potential material shortages with long enough lead-time to address the issue. The DfM/DfT discipline, broader process windows and smaller lot size philosophy described above also contribute to reduced bottleneck potential and an overall reduction in wait time between processes. The net effect is improved inventory turns, increased cash flow, and improvements to on-time delivery.

Transporting is the waste of excessive movement. Transport waste can be created in many ways. A poorly laid out facility is often the biggest driver of transport waste. However, inefficient automation or too much process segregation can also drive this waste.

Our factories are designed to minimize transport by moving production in a synchronous manner according to general processing requirements. Where possible, multiple processes are combined both to eliminate transport waste and potential defects that can be introduced in isolated processes. For example, in some build-to-order projects' final programming, test and packing are combined at the test station. This minimizes transport between workstations, eliminates the possibility that varying configurations will be mislabeled, and optimizes process takt times to improve product flow.

Inappropriate processing is waste driven both by lack of DfM/DfT discipline and by lack of sufficient documentation control. This can be a more difficult waste to control in the EMS environment because customers may reject DfM/DfT recommendations, and robust documentation requirements can create bottlenecks.

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EPIC's DfM/DfT system prioritizes recommendations to make it easier for customers to understand how critical each recommended design change is to overall product quality. Documentation control is centralized to make sure production only has access to the most current revision of work instructions. Design travelers accompany each work order to ensure that during shift changes or personnel changes there is a clear trail on what is being processed. Smaller batch sizes also contribute to minimizing this waste.

Unnecessary inventory is also a challenging waste to minimize in the EMS environment. Unnecessary inventory comprises raw material, work-in-process and finished goods inventory. While smaller lot sizes can minimize WIP, the relationships with customers found in EMS means forecasting and supply base choices are often a compromise between customer preferences and Lean best practices. Economy-driven variable demand further tests the system.

In the EPIC model, the program manager starts by developing the customer order replenishment methodology. The tool for determining visibility into the customer's demand is defined (i.e., ERP, EDI, etc.), and replenishment "pull" signals are defined.

Once these issues are addressed, initial finished goods kanban bin sizes are established. Trends are analyzed and bins resized as appropriate with customer approval. Strategic suppliers produce to the MRP forecast and ship to EDI release signals. Consignment, in-house stores and vendor managed inventory programs are used with strategic suppliers to maintain buffers closest to the point of use.

Pipeline status or "bond" reports are regularly reviewed with supplier teams to ensure buffers and replenishment streams are able to support planned production within a range of variation based on past historical demand, current forecasts, customer service lead-time guarantees to their end-market, manufacturing lead-times and transit lead-times.

Like the wastes of transport and inappropriate processing, unnecessary or excessive motion costs money and slows throughput. And, as with the waste of inappropriate processing, customer reluctance to implement DfM/DfT recommendations can be a constraint in improving efficiency.

EPIC's automation strategies, DfM/DfT process and focus on designing factories with sequential processes all help improve efficiency, but ultimately, the most success in reducing this waste comes when customers are willing to adopt DfM/DfT recommendations. Engaging the EMS provider during the design stage ensures optimal process efficiencies, translating to a successful and cost-effective product launch.

Excessive defects represent both the seventh waste and a byproduct of most of the other wastes. They drive unnecessary inventory and overproduction. However, completely eliminating defect opportunities carries a high cost, and most EMS providers make tradeoffs to minimize defects while aligning with customer cost goals. Other defect minimization practices include:

- Eliminating non-value-added activities.
- Minimizing touch labor.
- Maintaining a well-trained workforce.
- Using Six Sigma tools to analyze root cause of defects.

There is no one right formula for eliminating any of these wastes. The best course is developing a strong production framework with processes that accommodate the bulk of customer requirements, and fine-tuning as required. CA

Test and Inspection, continued from p. 52

OPERATION (STM32F101 – MCU) DATA SIZE = 256 KB	TEST TIME (SEC.)
Erase	0.10
Blank Check	1.25
Program	14.55
Verify	10.50
Run all script	27.10

Project #2:

Product: TV setup box
Fixture: Two-up with throughput mode
Programming AT26DF081A (flash) on board.

Note that for this project, programming was performed on two boards simultaneously. The test time shown below is actually for two boards. The programming time for one flash device by the EMS company's offline programming station took 35 sec., which was significantly slower than the ISP programming time in the table below.

OPERATION (AT26DF081A – FLASH) DATA SIZE = 1 MB	TEST TIME (SEC.)
Erase	5.359
Blank Check	4.375
Program	6.297
Verify	6.484
Run all script	23.515

Design for programmability. When adapting ISP, other than the program time incurred in the total test cycle time, one should consider design for programmability. Simply put, there must be test access to the data, clock and control signal lines of the programmable device. In most cases, there usually is a processor or controller that accesses the firmware from these downstream programmable devices. One must also consider the means for disabling these upstream devices to the programmable devices. There must be ways to disable the upstream devices properly in order for the programming to perform successfully. If upstream devices are not properly disabled, there will be interference, and programming success will be intermittent, if at all.

In conclusion, there is no absolute answer to whether to adopt offline programming or ISP. One has to decide, based on the factors above, the method that best suits the products and the production environment. Both methods complement each other.

My opinion is that ISP capability has to be implemented for every product with devices that require programming. Whether an offline programming station should be added depends on the SMT line beat rate versus the ICT test cycle time. ISP is an available and viable option to address the gaps in offline programming. It can double up as a check point to verify the data content pre-programmed by the offline programming station. Where necessary, more ICT machines with ISP can be added to match the SMT line beat rate. CA

Lifted Components

If parts are coming off the board, check the conveyor speed and lead lengths.

WHEN COMPONENTS SHOW lifting during wave soldering, the following mitigation steps might prove helpful.

Primary process setup areas to check:

- Conveyor speed too fast. Slowing the conveyor will increase the immersion time in the wave and overcome thermal mismatch or demand.
- Incorrect lead length: Shot leads may shift and can pop out of the hole.
- Board flex or warpage.

Other things to look for in the process:

- Solder wave height too high.
- Conveyor vibration.
- Board incorrectly seated.
- Solder wave uneven.
- Conveyor angle too high.
- Defective fixture.
- Excess flux blow-off.
- Early removal of board.

Other things to look for with the assembly:

- Improper board handling.
- Component lead length too long.

Things to look for with the board design:

- Poor pallet design. CA

FIGURE 1. Lifted parts typically are a sign of a process problem.

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Flux Residues Under QFN/LGA

Undissolved flux can leave a mess under low-standoff parts.

FIGURE 1 SHOWS a side view of solder joints on an LGA/QFN package. Between the terminations, evidence of flux residues is visible and would be common on a standard assembly process. Flux residues are also visible under the package.

(The typical standoff height of these packages is below 0.004˝. The example here has a standoff height of 0.008˝.)

Looking at the flux residues, it is suggested the cleaning process has not been correctly or completely reviewed. The residues look to have been through a cleaning process and are not being dissolved, or are insoluble due to poor process compatibility. A proper evaluation of the process, paste, cleaning system and chemistry needs to be conducted to confirm the residues are compatible and the cleaning system is capable of cleaning the component standoff height on this LGA/QFN package. CA

FIGURE 1. Flux residues between solder joints on an LGA/QFN.

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ACRYLIC PEELABLE SOLDER MASK

Ceasolder PAL is a temporary, peelable solder mask comprised of a thixotropic, synthetic acrylic latex designed to withstand fluxing, wave soldering and cleaning operations. Contains no ammonia; is noncorrosive to copper, gold, silver or pre-soldered surfaces. Is for robotic, pneumatic, hand-applied or template screening. Is easy to peel and non-flammable. Is available in 8 oz. squeeze bottles and 1 gal. containers.

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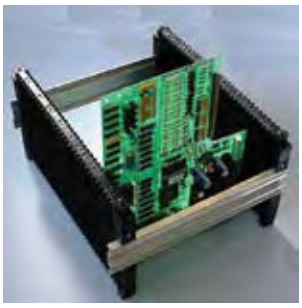


PCB HOLDING AND TRANSPORT RACKS

F9000 series is customizable. Basic unit holds 32 boards up to 6.7" long, or assembled side-by-side to hold longer PCBs. Standard card width up to 10.25", with custom extrusions available. Pop-in molding strips for the back of the side plate can be used as PCB stops. Runner spacing is 0.39" with a depth of 0.079". Capacity: 30 PCBs 6.7" long. Made of conductive plastic, temperature-rated to 176°F with a surface resistance $<10^6$.

FKN Systek
fknsystek.com

FORCED AIR CONVECTION OVEN

No. 952 is a 550°F electrically-heated bench oven for programmed heat processing. Workspace dimensions measure 26" x 22" x 16". 3kW installed in Incoloy-sheathed tubular elements provide heat to the workload. A 1/80-HP recirculating blower creates a convection air movement in the chamber. Features 3" insulated walls, an aluminized steel exterior, Type 430 stainless steel interior and an integral oven stand. Has a programmable and recording temperature controller.

The Grieve Corp.
grievecorp.com

OTHERS OF NOTE

'EASY ON/OFF' COMPONENT SHIELDS

EMI/RF shields with snap-on, snap-off covers permit easy access to components within the shields. Are designed to protect components from radio frequency/electromagnetic interference and environmental hazards, and to provide electrical grounding. Options include one-piece or two-piece construction; standard base materials, including brass, tin, SnPb, nickel, copper, and cold-rolled steel, all of which can be provided with solderable plating, and NiAg base material.

Photofabrication Engineering Inc.
photofabrication.com

IC THERMAL CHARACTERIZATION

FloTherm software has a Web-based platform that automates design tasks associated with full-spectrum thermal characterization and validation. Is said to reduce time spent on thermal characterization and design by up to 25%. Addresses full-spectrum thermal metric and compact model generation with adherence to JEDEC standards; package-aware parametric design for what-if analysis; EDA tool interfacing for detailed modeling of BGA substrates for physical layout, and data mining of simulation data.

Mentor Graphics
mentor.com

MODULAR MICROVIA DRILL

ND-1S single-spin modular drill reportedly can produce ≤100 µm diameter holes in a variety of base materials, including polyimide. ND-Q Series six-spindle mechanical drill also is capable of microvia drilling on polymer and composite materials. Is designed for high-volume production.

Hitachi Via Mechanics
hitachinet.net

CURTAIN COATABLE SOLDER MASK

PSR-4000 CC200 HRS is a high productivity solder mask designed for curtain coating. Is said to have fast exposure time and resistance to harsh final finishes such as immersion tin.

Taiyo America
taiyo-america.com

HIGH-DENSITY FPGAS

Searay high-density open pin field arrays provide maximum grounding and routing flexibility with signal integrity optimized Edge Rate contacts. Seventeen standard board stack heights, new right angle designs and press fit tail options are now available as standards.

Samtec
Samtec.com

LDI SOLDER MASK

PSR-4000 LDI (US) is said to have fast exposure, requiring as little as 50-100 mj. Reportedly produces quality imaging with straight sidewalls, fine feature resolution and registration. Has a rich green color, satin surface finish and is low halogen. Can be exposed in conventional flood exposure units. Meets IPC-SM-840D and UL 94.

Taiyo America
taiyo-america.com

WIPER ROLL CLEANER

Eco-Roll SC-ER360 removes solder paste using ultrasonic vibration. Is said to clean wiper rolls in 20 min., permitting their reuse. Measures 900 x 850 x 1200 mm. Works with most solvents.

Sawa, sawael.com

Seika Machinery Inc., seikausa.com

MACHINE STOP CONTROLLER

Cycle Stop Controller is an Ethernet-enabled device that electrically integrates with the cycle stop circuit of any machine type. When used with a software module such as line setup control, route control and MSD control, the application forces the machine to stop processing when a process validation error occurs. Eliminates the risk of building defective product due to invalid machine setup or trying to perform an operation out of sequence.

Cogiscan Inc.

cogiscan.com

COMPONENT AGE-TESTING OVEN

No. 926 is an electrically heated 250°F shelf oven and environmental test chamber. 12kW installed in Nichrome wire elements provide heat to the load. Is 68" x 30" x 66". A 1000 cfm, 1 HP recirculating blower provides horizontal airflow. Features 4" insulated walls, and aluminized steel interior and exterior. Includes digital temperature controller, manual reset excess temperature controller with separate contactors and recirculating blow airflow safety switch.

The Grieve Corp.

grievecorp.com

OTHERS OF NOTE

SOLAR CELL METALLIZATION DRYER

PVD3000 drying system enhances PV3000 metallization line. Is for solar cell production, incorporating thermal control, improved VOC management and reduced power consumption. Dryer concept is based on principles of hot air convection drying, a process conducive to thermal control at lower drying temperatures. Improves air exchange within the process chamber, enabling the dryer to manage increased VOC volume associated with higher throughput.

DEK Solar, deksolar.com

Heller Industries, hellerindustries.com

IONIC CLEANLINESS TESTING

Upgraded ionic cleanliness test systems have larger test capacity and innovative measurement software and hardware. Deliver a measurement accuracy with a range of 0.01-30 µg/cm² (auto-ranging) and measurement sensitivity of <0.25% of range. Test times are generally less than 5 min. Deliver a test measurement accuracy of better than 0.005 µS. Use a solid gold measurement cell and a ballistic amplifier in the measurement circuitry.

GEN3 Systems

gen3systems.com

INTEGRATED BOUNDARY SCAN, FLYING PROBE

FlyScan module comes on Pilot/Aerial flying probes and is said to automate test program generation in a single software environment; boundary scan creation for non-JTAG nets, using the extended test function and the flying probes to transform them into JTAG testable nets; elimination of test redundancies; fault diagnostics, with real-time generation of additional tests executed by the flying probes for the specific identification of the faulty component; and fault detection by the boundary scan test in the repair station environment.

Seica Inc.

seica.com

'AMMONIA-FREE' SOLDER MASK

Peelable Solder Mask (PSM-AF) is ammonia-free. Is noncorrosive, and for temporary solder/coating protection. Works particularly well with NiAu pad finishes.

Cobar

cobar.com

NEUTRAL PH AQUEOUS CLEANER

Aquanox A4703 reportedly is effective with concentrations as low as 3%. For use in spray batch and spray inline cleaners to remove OA, no-clean and RMA pastes and fluxes, including Pb-free residues. Is controlled by refractive index, both manually and when using an automated process control system. Completely water soluble, and operates at <~63°C. Flashpoint is 104°C; boiling point is 138°C.

Kyzen

kyzen.com

SCREEN PRINTER COVERS

Horizon screen printer now comes with new cover packages said to provide instant access to front and rear of platform; are lightweight and reportedly eliminate the need for further tooling. Have quick release panels. Preconfigured platforms include Horizon 01iX, Horizon 02iX and Horizon 03iX.

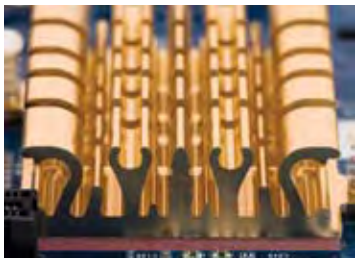
DEK

dek.com

FINE-PITCH WEDGE BONDER

Q2170 fine-wire (17-75 µm), automatic Al/Au automatic wedge bonder is for smaller lot sizes, multiple product variations and frequent setup changes. For packaging complex hybrid, CoB/PCB and LED display devices; achieves wedge bonding for fine gold, aluminum wire and ribbon, and is said to enable quick package conversions. Point-and-click bonding; unlimited wires; easy bond process editing; extensive program storage, and a bond parameter library.

Questar Products International
questarproducts.com



THERMAL INTERFACE SILICONE GEL

Sarcon GR-Ae comes in sheet form. Designed to transfer heat from its source to a nearby heat sink. Fills air gaps between delicate and uneven components. Offers a thermal conductivity of 1.3 W/m°K with a thermal resistance as low as 0.43°Cin^2/W. Gap filler pad is available in thicknesses ranging from 0.5-5.0 mm. Comes in sheets up to 200 x 300 mm, or die-cut to exact application specifications.

Fujipoly America Corp.
fujipoly.com

MANUAL REWORK STATION

MS6000 Nano rework station is a manual system for chip sizes down to 0402 mm (01005). Handles parts from taping parts feeder or individual parts feeder. Parts can be picked by a vacuum bit and positioned by the CCD camera system. Has rotatable circular glass palette for monitoring. Features dispensing capabilities with a 5 cc syringe. Options include tweezer head, center vacuum bit, and 8 mm tape feeder.

Seika Machinery Inc.
seikausa.com

OTHERS OF NOTE

PB-FREE, NO-HALOGEN SOLDER

DSP866 no-clean solder paste is said to provide print definition characterized by brick-like prints. Good release is seen on 0.00" - 0.012" apertures with print speeds in the range of 1 - 6 in. per sec. Performs during continuous printing for up to 8 hr. Residues are said to be nonconductive, noncorrosive and highly insulated. Flux classification ROL0 per J-STD-004. Comes in standard gray or patented green formula.

Qualitek International
qualitek.com

COMPONENT PLACEMENT MES SOFTWARE

PanaCIM Enterprise Edition MES software version 8.1 release has expanded functionality. Is beneficial for LED applications. Offline feeder and cart setup has been augmented to reinforce correct component reel-to-feeder and feeder-to-cart locations before production commences. All modules now support Japanese; other languages can be added. Visual control panel of the production monitoring and dispatch module can be customized for site-specific needs. Enterprise link module now permits more exportable real-time data to keep third-party ERP/MRP systems updated.

Panasonic Factory Solutions Co.
panasonicfa.com

CABLE ASSEMBLY KITS

Cable Assembly Kits address the majority of component types encountered in operational production. Use mil spec style connectors with two sizes of contacts, combined with insertion/extraction tools. Additional terminals, solder sleeves, and crimp lug terminations are provided. Include a terminal soldering kit. Feature an overlay and wire list typical of those encountered in production operations. Used in the NASA Cable and Harness Training program.

STI Electronics Inc.
stielectronicsinc.com

AUTOMATIC MODULAR SMD CABINET

istorage automatic modular cabinet manages SMD reels from 7 to 15, QFP/BGA trays, PTH components, PCBs, and other parts. Can handle up to 5,500 reels. Permits multiple pick of part racks. Is barcode driven, and calculates component quantities for single or multiple orders. Includes "countdown" management for MSDs.

i-tronik
itronik.com

'CONTINUOUS MONITORING' GRAVITY HANDLER

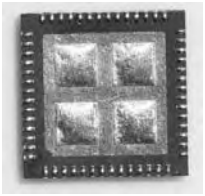
MT9928 now comes with dedicated setup to permit temperature sensor calibration. Is said to meet calibration equipment requirements with a temperature accuracy of ±1.0°C and a temperature stability of ±0.2°C. Continuously monitors temperature stability of the DUT environment during the test time. Comes on MT9928 and MT9928XM models.

Multitest
multitest.de/region.asp

CO-DOPED PB-FREE SOLDER

i-SAC 387 contains cobalt for improved melting, shiny solder joints, fine grain microstructure. Also contains germanium as an antioxidant. Has a melting point of 217°C and a specific gravity of 7.5 g/cm^3. i-SAC105 has silver composition of 0.5-1.5%, and contains cobalt for bright, shiny solder joints and fine grain microstructure, and germanium. Has a melting point of 217° to 227°C and a specific gravity of 7.4 g/cm^3.

Balver-Zinn
Balverzinn.com



LEADLESS DEVICE POLYIMIDE STENCIL

StencilMate is for reworking and hand-placing leadless devices such as QFNs, MLFs and LGAs. Controllably bumps leadless devices. Build-to-order stencil pairs are said to prevent bridging of neighboring solder joints, while accommodating QFNs into stay-in-place stencils on the PCB. Comes in 0.10 to 0.20 mm thickness.

BEST Inc.
solder.net

FLEXIBLE, LIGHTWEIGHT CART

Cantilever Cart comes in standard and custom versions. Is flexible with a lightweight, small footprint. Many accessories can be clipped onto the cart. Uses include storing bins or totes at any height or location (KanBan); holding tools or work-in-progress; staging; moving heavy items (estimated 100 lb. capacity). For use in electronics test and compliance labs, or as a repair cart for machine support and maintenance personnel.

Bliss Industries
blissindustries.com

SOLAR PROFILING KIT

V-M.O.L.E. is for photovoltaic solar cells metallization. Comes with V-M.O.L.E. thermal profiler; special solar thermal barrier, which is 0.7" in height, MAP software; and special thermocouples. Includes OK button. Three-channel profiler provides quick-charge capability to go from dead-to-profiling in fewer than 15 min.

ECD
ecd.com

OTHERS OF NOTE

MATERIAL SURFACE VISION SOFTWARE

VisionPro software combines visual defect detection and classification technology with a simple user interface. Enables defect detection, classification, and surface texture assessment during manufacturing. Monitors material visual appearance. Automatically identifies potential defects in the material's surface using statistical analysis; classifies the defects into groups based on similarity in contrast, texture and/or geometry.

Cognex
cognex.com/vprosurface

HIGH-TEMP ALUMINA ADHESIVE

Resbond 989 high-purity alumina adhesive offers continuous protection to 3000°F. Applies directly to metals, glass, ceramics, graphite and silicon carbide. Cures at room temperature and provides high bond strength and excellent electrical, moisture, chemical and solvent resistance. Applications include bonding and protecting thermocouples, heat sensors, and components from moisture and humidity at elevated temperatures.

Cotronics
cotronics.com

SCALABLE SOLDERING PROFILER

Solderstar Pro RF is for reflow and wave solder temperature profiling, the former on 6, 9, 12 or 16 channels. When used in conjunction with the Waveshuttle wave solder process analyzer, it forms a wave analysis tool capable of detailed wave temperature profile and wave contact measurements. Incorporates compact RF data-logger that provides a two-way RF data link with a PC. Analyzes temperature profile in real time.

SolderStar Ltd.
solderstar.eu

HIGH-SPEED 3-D SPI

VP6000 inspects solder paste deposition at inline speeds. Uses structured light to perform 3-D inspections. Automatically adjusts z-axis for board warpage. Reportedly programs in less than 15 min. using a single Gerber and CAD placement file. Includes full complement of SPC charts and graphs.

Omron Electronics
omron247.com

SILICONE POTTING COMPOUND

Tonsan 1521 is a two-part silicone potting material used in junction boxes to provide reliable sealing for diodes and connectors. Shows strong adhesion to PPO, TPT, brass and Sn-plated leads. Features excellent aging and heat resistance; is for automatic dispensing applications.

Beijing Tonsan Adhesives
ts.com.cn/en_index.asp

INERT ATMOSPHERE CABINET OVEN

Oven No. 799 is for processing ceramic components prior to assembly. Features max. operating temp. of 750°C; workspace dimensions of 38" x 38" x 50"; 60 KW installed in alloy wire high-temperature plug heaters; recirculating blower providing horizontal airflow; 12" thick insulated walls; and stainless steel interior.

The Grieve Corp.
grievecorp.com

MARKETPLACE

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In Case You Missed It

This column provides abstracts from recent industry conferences and company white papers. With the amount of information increasing, our goal is to provide an added opportunity for readers to keep abreast of technology and business trends.

ESD

"Electrostatic Discharge (ESD) – Sources of Electrostatic Charge in a Production Line (SMT)"

Author: Hartmut Berndt; hberndt@bestat-esd.com.

Abstract: It is necessary for everyone who handles electrostatic-sensitive devices to know the reasons of ESD failures. This paper gives an overview about possible causes for ESD in a SMT production line. Automated production lines have some processing steps where electrostatic charges increasingly are generated. So far, mitigation has focused on the operator. This is controllable. Measurements in production lines show electrostatic charges at the following processing steps: screen printer, component assembly (automated and manual pick-and-place), labeling, optical and electrical tests. Electronics components are always assembled directly, without covering the PCB. Thus, wire bonding can lead to component damage. This process step is a critical part in the production line, during which electronic devices will be directly contacted with a metal needle. *(SMTA Pan Pac Symposium, January 2010)*

Solder Joint Reliability

"Parametric Acceleration Transforms for Lead-Free Solder Joint Reliability Under Thermal Cycling Conditions"

Authors: Mudasir Ahmad, Xie Weidong, Kuo-Chuan Liu, Xue Jie and Dave Towne; mudasir.ahmad@cisco.com.

Abstract: A significant factor in the slow transition to Pb-free solders is the absence of industry-accepted Pb-free acceleration transforms that can translate lab test results into field reliability life data. Without such industry-accepted acceleration transforms, it is difficult to translate lab test data into reliable predictions of field-life performance. In this study, a comprehensive set of test data have been generated over a wide spectrum of package types, solder joint metallurgies, joint size, pitch, die sizes, PCB thicknesses and thermal cycling conditions. The effect of aging on acceleration transforms also was included. The data have been analyzed to compare with existing Pb-free and SnPb acceleration transform models. The data help explain contradictions in the existing literature, and offer more comprehensive acceleration transforms for Pb-free solders. Some publications indicate the acceleration transforms for Pb-free solders are the same as SnPb acceleration transforms. Comprehensive results of this study also show that in specific conditions, Pb-free acceleration transforms could even be lower than SnPb acceleration transforms. In addition, the acceleration transforms for backward-compatible (Pb-free solders attached with SnPb paste) assemblies are presented as a function of assembly peak temperature. Finally, finite element analysis also has been performed to better understand the effects of the different package design variables on the experimental acceleration transforms. The results have been used to derive recommendations on what package design variables to consider in ensuring good long-term Pb-free reliability. *(Electronic Components and Technology Conference, May 2009)*

"Quality and Reliability Analysis of Lead-Free PCBs in Simulated Production Conditions and Long-Term Use"

Authors: Sammy Shina, Ph.D., et al; sammy_shina@uml.edu.

Abstract: The New England Lead-free Electronics Consortium is a collaborative effort of New England companies spanning the electronics supply chain, created by the University of Massachusetts Lowell in 1999 and sponsored by the Toxics Use Reduction Institute and the US EPA. The consortium has completed and published the results of three phases of manufacturing and testing of lead-free PWBs, with the goal of achieving zero-defect Pb-free soldering processes with comparable or superior reliability to that of leaded solder processes. In this fourth phase of testing, which began in 2007, several simulated conditions of assembly and rework processes were evaluated in a matrix of multiple levels of components, PWB lead-free surface finishes and solders, and compared to a baseline of leaded equivalent materials and processes. Plated through-hole and surface mount technologies were evaluated.

All quality and reliability testing was performed with industry standard methodologies, using specially trained production inspectors for the quality evaluation, and extreme thermal cycling and vibrations for reliability testing. Results indicate that with proper selection of currently available (2009) materials and finishes, and careful control of the assembly processes, successful Pb-free assembly and rework can be achieved. Comparison of different strategies for rework, and recommendations for least copper dissolution for PTH technology processes, are discussed in Chapter 6 of a book published by the authors. Reliability testing showed inflection points for leaded versus Pb-free reliability currently being investigated. *(SMTA Pan Pac Symposium, January 2010)*

Tin Whiskers

"Local, Submicron, Strain Gradients as the Cause of Sn Whisker Growth"

Authors: Matthias Sobiech et al; matthias.sobiech@de.bosch.com.

Abstract: It has been shown experimentally that local in-plane residual strain gradients occur around the root of spontaneously growing tin whiskers on the surface of tin coatings deposited on copper. The strain distribution has been determined with synchrotron white beam micro Laue diffraction measurements. The observed in-plane residual strain gradients in combination with recently revealed out-of-plane residual strain-depth gradients provide the driving forces for whisker growth. *(Applied Physics Letters, June 2, 2009)*

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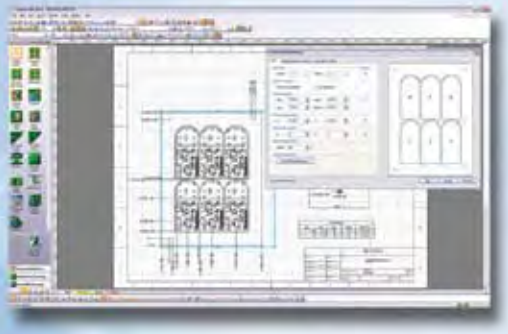

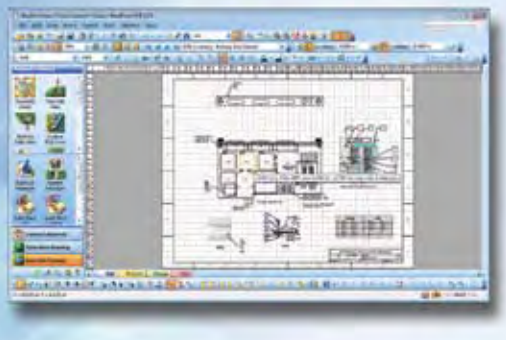

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Smart companies use Valor.

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Manufacturing System Solutions

Alta Manufacturing, a leading EMS provider recently purchased Valor's vPlan, vManage, vCheck, Trilogy 5000, and Valor Parts Library from Valor Computerized Systems for deployment of its US and China facilities.

Craig Arcuri, CEO, said "Our goal at Alta was to create the most high-powered rapid response manufacturing facility in the industry. Something with automated intelligence that supersedes anything the industry has experienced. Alta specializes in rapid response manufacturing solutions in as little as one day after material clears. Valor is a key tool in our milestone towards success.

Valor addresses our demanding immediate needs but more importantly is an extensible platform for future factory automation tools upon which Alta can build it's proprietary Alta Vision next-generation tools. The Alta Vision next-generation tools will allow Alta to leapfrog the industry by bringing new levels of quality, repeatability, speed and traceability to the electronics manufacturing process. Alta Manufacturing will deploy the Valor software throughout its existing operations in the United States and China."