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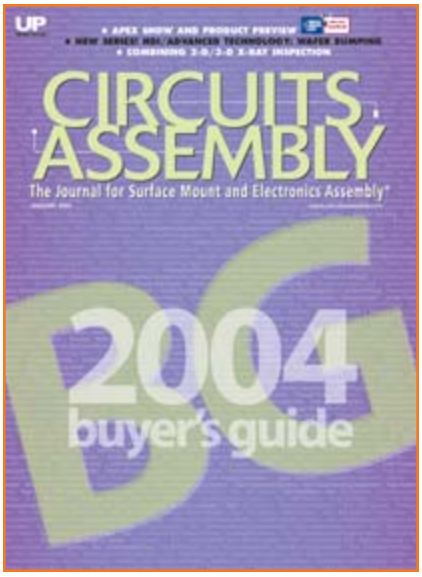

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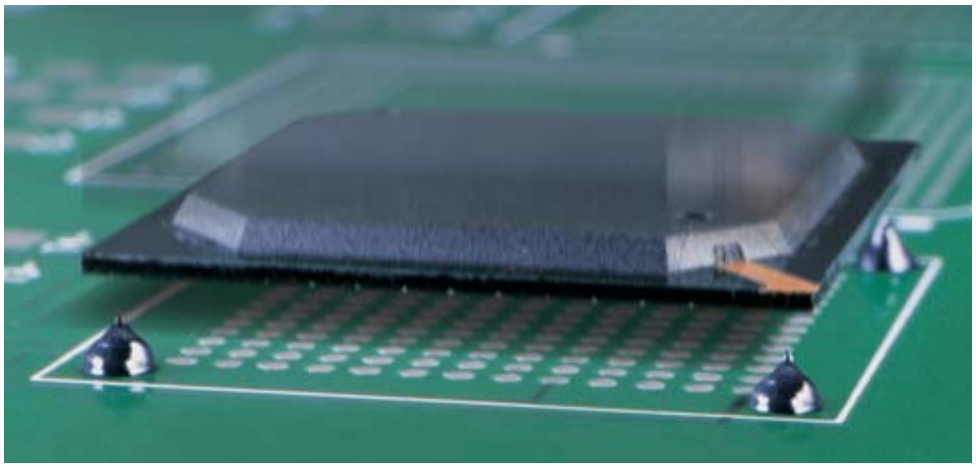

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The Art of Negotiation

One of the most insidious words in this industry today is *partnership*.

Killer line. Wish I could have said it.

Instead, it came from Charlie Barnhart of Technology Forecasters, Inc. (TFI) at that company's recent Quarterly Forum at Cisco in California. A many-year electronics manufacturing services (EMS) veteran, Charlie was given free reign at the end of a session titled "OEM Panel: Contracts, Relationship and Trust." Woo-wee, that's a can of worms to consider, and Charlie knew it.

Inciting those present to kill the word *partnership* from their vernaculars, Charlie made the point that the reality of the outsourcing situation is that both parties—the EMS provider and the original equipment manufacturer (OEM)—are entering into a buy/sell relationship. And, although partnership is a warm, fuzzy idea much touted in this age of political correctness, it does not accurately describe the for-profit business relationship of the EMS company and its OEM customer.

According to Charlie, in their business dealings both OEMs and EMS companies are responsible to three interested parties:

- their employees
- their shareholders
- their community.

Nowhere in that equation is fiduciary responsibility to your suppliers suggested.

A panelist serving on that day's discussion agreed in spirit with Charlie's assessment of the business relationship, with his answer to the following question: What is an acceptable level of profit for the EMS partner?

This panelist—from OEM HP—said, simply, that the OEM does not have any duty to pay an EMS company enough to keep them alive. At the same time, however, the OEM has to realize that a bankrupt supplier does the OEM and its products no good. The key is balancing the profit of both companies, with the understanding that price and all the trappings that come with it is something that is always negotiable.

Indeed, something must be working correctly in the OEM/EMS business relationship, because TFI announced that it has seen in its recent research "a strong resurgence in the industry." EMS revenue turned the corner in 2003, and TFI forecasts a compound annual growth rate (CAGR) of 11.6% for EMS companies' revenue—from 2002's $88 billion to 2007's nearly $153 billion. That CAGR is not the rate of yesteryear—with predictions that swelled to 20 to 25% and that were delivered in the glory days of 1999/2000. However, TFI does stand by that initial prediction, forecasting that the industry will return to a 20/25% growth rate at some point—just not, and this is key, in the next five years.

According to TFI, even though the wounds of the telecom and Internet bubbles are starting to heal, EMS companies still have their work cut out for them. Several are still riding low with debt and overcapacity; they're also facing an increasing threat from original design manufacturers (ODMs) who are beginning to serve more and more OEMs such as HP, Dell and Gateway who want to quickly enhance their product lines with ODM offerings.

In the end, at least in capitalistic societies and those struggling that way, competition and negotiations are what makes the industry stronger. If an OEM doesn't like the price an EMS company is quoting, that OEM can jolly-well head to another contractor. Same goes for the EMS company—if it doesn't like a particular deal an OEM is forcing, it can find another OEM to serve.

In a business relationship, there's tension. There's negotiation. And that's a good thing. Long live the ability to realize each others' goals without making enemies.

Lisa Hamburg Bastin, Editor-in-Chief
e-mail: lhbastin@upmediagroup.com

NETgain

THE LATEST THE INTERNET HAS TO OFFER

Web Sites Worth Mentioning

www.cadtransformers.com This site provides online collaboration for the electronics industry. The completely Web-based service provides a printed circuit board and schematic viewer with markup tools that helps engineers, designers and manufacturing professionals with tools for exchanging feedback based on design data.

www.designchainassociates.com The Design Chain Associates consulting firm recently updated its site. Features include a list of resources related to counterfeit parts, the lead-free mandate, wafer fab capacity utilization and allocation, original equipment manufacturer's tools and systems, business processes and component engineering.

www.BareBonePCB.com Advanced Circuits has a new prototype printed circuit board service designed to cut project time and costs. Offered via the Web, a basic two-layer board is manufactured and shipped the next day. The board replaces the "bread-board" or other hand-wired versions used to test new circuit designs.

www.howstuffworks.com/question279.htm Although you probably will not get this in time to impress revelers this year, take a look at the meaning, history and lyrics of the song that nobody seems to know, "Auld Lang Syne." You'll be able to sing the full version of the old Scottish song next New Year's Eve.

Industry Resources

www.pcdandm.com/pcdman/resource/pcb_basics.shtml The fourth edition of *Printed Circuit Board Basics* is now available. From design and manufacturing to purchasing to considerations for managing the business, concepts are explained in simple terms. This edition contains an updated primer on single-, double-sided and multilayer PCB manufacturing processes; a review of new technologies such as embedded components and microvias (HDI); updated PCB specifications; a history of the industry; and an updated glossary of terms and definitions.

Surveys and Guides

www.circuitsassembly.com/resource/dems.html Are you an EMS provider wanting to attract more OEM customers? Then, don't miss the opportunity for your free listing in the original Directory of Electronics Manufacturing Services Providers (DEMS).

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  Robin Norvell, Assistant Editor
- **Process Defect Clinic**
  Bob Willis, EPS

Would you like to contribute to NET gain?
Contact Robin Norvell at **rnorvell@upmediagroup.com**

Cookson Electronics Launches CE Analytics

Responding to the electronics and surface finishing industries' growing need for qualified analytical resources to help solve specific and complex application problems, Cookson Electronics (Foxborough, MA, www.cooksonelectronics.com) has launched CE Analytics (Jersey City, NJ), a $5 million technology facility staffed with scientists and application engineers.

CE Analytics is an analytical and diagnostic center with the capability to perform interpretative analysis for the development of future technology requirements and to provide solutions to current application challenges. The facility is equipped with advanced instrumentation and industry expertise to analyze a range of devices, components and materials, including circuit assemblies, connectors, leadframes, printed wiring boards, semiconductor packages, decorative accessories and functional items.

Ticona, LPFK Sign License Agreement

LPKF Laser & Electronics (Wilsonville, OR, www.lpkfusa.com) has entered a know-how and license agreement with Ticona (Kelsterbach, Germany) for the material Vectra liquid crystal polymer (LCP). The agreement enables Ticona to modify its LCP material for the LPKF laser direct structuring (LDS) process to produce 3-D molded interconnect device (MID) circuits.

With the combination of the LDS process and the new polymer material, conductive paths can be deposited directly on molded plastic structures, combining the electrical and mechanical functions in one component to form an injection-molded circuit carrier. The electronics housing substitutes for the conventional circuit board, encouraging miniaturization.

The laser-based process is realized with few manufacturing steps. The structure is molded in a standard mold, the desired interconnect pattern is directly written on the resulting molded part utilizing a laser system and the conductive paths are plated. The plating adheres only where the laser has activated the plastic. Due to the high temperature resistance, the circuit structures on the LCP material are solderable. The technology is ideal for mobile communication devices, hearing aids and sensory technology for automobile electronics.

Feinfocus Partners with BIR

Feinfocus (Stamford, CT, www.feinfocus.com) has announced a partnership with Bio-Imaging Research Inc. (BIR, Lincolnshire, IL, www.bio-imaging.com), a manufacturer of computed tomography (CT)/ digital radiography (DR) systems. BIR will supply Feinfocus with advanced computed tomography imaging systems (ACTIS) for volume CT scanning on the Feinfocus µCT FOX x-ray inspection system.

The industrial x-ray inspection system includes functional 2-D and 3-D modalities in one system. The system visualizes the most inner components and precise structural modeling of a device. Cracks, voids, delamination and other crucial anomalies can now be depicted in their actual 3-D position, providing insight into the design and manufacturing processes of these devices. This ability makes the new system suited for sensor, microelectromechanical systems (MEMS), medical device and complex electromechanical component inspection applications.

Juki, Universal Sign Business Alliance

Juki Corp. (Tokyo, Japan, www.jas-smt.com), a manufacturer of mid-range surface-mount equipment, and Universal Instruments Corp. (Binghamton, NY, www.universalinstruments.com), a manufacturer of surface-mount equipment, have signed a comprehensive business alliance agreement. Development and manufacturing of subassembly parts and optional units are stipulated as the first collaboration in the agreement. Both companies will soon begin technical discussions for the initial collaboration efforts.

To cope with the market situation, Universal and Juki discussed how they might collaborate with each other by analyzing where the advantages of products and strengths of each company stand. As a result of the analysis, the companies reached an agreement to sign this comprehensive business alliance agreement.

The agreement provides an opportunity to expand the relationship in the future, which could include research and development, manufacturing, sales, marketing and service support.

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In Brief

FlexLink Systems (Bethlehem, PA) has promoted **Paul Jarossy** to marketing manager for the Americas. Jarossy has held various product and segment management positions since he joined the company five years ago.

ASAT Holdings Ltd. (Hong Kong, China) and ASAT Inc. (Pleasanton, CA) have appointed **Jay Carlos Nunez** as vice president of North American sales. During his career, Nunez has held numerous senior level management positions at semiconductor companies including National Semiconductor Corp. and Motorola Semiconductor Products Sector.

SMTC Corp. (Toronto, Ontario, Canada) recently appointed **John Caldwell** as interim president and chief executive officer (CEO), replacing Paul Walker, founding partner and CEO. Caldwell is a member of SMTC's board of directors and previously served as president and CEO of Geac Computer Corp, an ERP software vendor.

GE Global Electronic Solutions (San Diego, CA) has appointed **Roger Innes**, a founder of Equipment Lifecycle Management for the semiconductor industry, as Managing Director-Capital Markets and Business Expansion. Innes was co-founder and president of Comdisco Electronics, whose portfolio was acquired by GES in April 2002.

DEK (San Jose, CA) has named **Raj Lakhotia** to the position of financial controller for U.S. operations. Lakhotia has over a decade of financial management experience and has spent the last seven years of his career in the semiconductor industry.

Wolf Electronix (Orem, UT) has promoted **Dennis Gleason** to senior vice president and **Wallace Harkness** to director of marketing and sales. Gleason will manage current and future customers' needs, and Harkness will enhance his current responsibilities to include customer relations and Utah-area sales.

Elcoteq, Siemens Enter Manufacturing Agreement

Elcoteq Network Corp. (Irving, TX, www.elcoteq.com), a provider of electronics manufacturing services (EMS), and the Networks Division of Siemens Information and Communication Mobile Group (Munich, Germany, www.siemens-mobile.com) have signed an agreement under which Elcoteq will provide services for products that are part of Siemens' GSM base stations. Production ramp-up started in November 2003 at Elcoteq's plant in Pécs, Hungary. In addition to the manufacturing agreement, Siemens Mobile granted Elcoteq an approved EMS supplier status.

Siemens Mobile offers a range of mobile solutions including mobile devices, infrastructure and applications.

SMTA Announces Pan Pacific Symposium Program, Keynotes

The ninth annual Pan Pacific Microelectronics Symposium and Exhibit will take place on Feb. 10-12, 2004, at the Turtle Bay Resort, Kahuku, Oahu, HI. The event promotes international technical interchange and provides a forum for networking among microelectronics professionals and business leaders throughout the Pacific Basin.

Sponsored by the Surface Mount Technology Association (SMTA, Minneapolis, MN, www.smta.org), the symposium focuses on the critical business markets and technologies of microelectronic packaging, interconnection, microsystems, assembly, global markets and related business issues.

The 2004 event technical program will consist of 15 sessions with 53 papers on topics including flip chip, 3-D packaging, novel chip connection, embedded components, design and modeling, reliability, printed wiring board (PWB) materials and processes, suface-mount assembly optimization, packaging materials, inspection and test, industry and research standards, lead-free, power device packaging, optics and microelectromechanical systems (MEMS) and nanotechnologies in high reliability applications.

Also featured are three keynote addresses: "Flip Chip Packaging—Current Trends and Roadmap," presented by Maniam Alagaratnam, LSI Logic; "A Key Role of PCB in Recent Packaging Solutions," by Yutaka Tsukada, Kyocera SLC Technologies; and "Technical Challenges in Memory Packaging,"by Se Yong Oh, Samsung.

Productronica 2003: The Numbers Are In

Messe München GmbH, the organizers of Productronica (www.productronica.de), the electronics manufacturing tradeshow that occurred Nov. 11-14, 2003, in Munich, Germany, recently released exhibitor and attendance numbers for the show.

According to Messe München, 1,486 exhibitors and 67 additionally represented companies came from 29 countries to Productronica. The show also garnered 38,000 attendees from 87 countries; show organizers stated that more international visitors came to this year's event than the previous show in 2001.

Productronica

According to Messe München, exhibitors were pleased with the results of Productronica and with the recovery the electronics manufacturing market is making in general. A show survey revealed that 62% of exhibitors and 61% of visitors expect the market to recover soon.

Michael Brianda, general manager of DEK Printing Machines, stated: "In Europe I've been seeing a positive trend for the past three or four months; by next summer the entire industry should be reaping the benefits."

The next Productronica will occur Nov. 15-18, 2005, at the New Munich Trade Fair Centre.

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FOCUS ON: HDI/ Advanced Technology

Powell-Mucha Consulting to Present EMS Tutorial at APEX

Why aren't there only three large electronics manufacturing services (EMS) providers dictating pricing to original equipment manufacturer (OEM) customers as has been predicted for nearly five years? How can EMS providers differentiate their services to customers, given that these services are essentially the same? How can productivity be increased in the EMS sales process? These questions will be addressed in Powell-Mucha Consulting Inc.'s (El Paso, TX, www.pmcitraining.com) tutorial, "Creating Competitive Advantage in Today's EMS Market." The tutorial will be presented on Feb. 23, during the IPC Printed Circuits EXPO/IPC SMEMA Council APEX conference.

"The EMS market has some unique characteristics that don't get taken into account in strategic planning activities," said Susan Mucha, president of Powell-Mucha Consulting. "Most notably, industry consolidation assumptions are derived from business school models developed for industries with much different supply chain, customer base and manufacturing infrastructure characteristics. In this tutorial, we look at those models and discuss their relevance to EMS. We also dissect the entire EMS value proposition and look at business models appropriate in various industry tiers."

The tutorial covers five key areas: sources of competitive advantage in EMS services, brand definition/promotion, lead qualification/mindshare maintenance, packaging EMS services and account acquisition and growth strategy.

IPC Announces APEX/Printed Circuits Expo 2004 Keynotes

IPC (Northbrook, IL, www.ipc.org) has announced the three keynote speakers for its APEX/Printed Circuits Expo/Designers Summit exhibition and conference, taking place Feb. 22-26 at the Anaheim Convention Center, Anaheim, CA.

Michael Cannon, Solectron Corp.'s president, chief executive officer and board member, will kick-off the first day of the exhibition. In his address, Cannon will share the direction of Solectron and the current environment for the electronics manufacturing services (EMS) industry. Cannon has more than 25 years of manufacturing and technology experience. Prior to joining Solectron, Cannon was president, chief executive officer and a director of Maxtor Corp., a provider of hard-disk drives and storage systems.

On Wednesday, electronics industry forecaster Walt Custer, Custer Consulting Group, will present "Business Outlook: Global Electronics Industry." Custer will discuss industry data that points to an industry recovery, analyze the impact of low cost offshore production and examine the outlook for the printed circuit board and EMS industries. Winner of the Raymond E. Pritchard IPC Hall of Fame Award in 2001, Custer is a member of the IPC Suppliers Council and the Technology Market Research Council (TMRC) steering committee.

On Thursday, Bill Nye-The Science Guy will discuss the value and importance of science. A scientist, comedian, teacher and author, Nye states that his mission is to teach children the wonders of science. He earned a bachelor's degree in mechanical engineering from Cornell University and later worked as an engineer at The Boeing Co.

Kulicke & Soffa, Nidec Tosok Form Alliance

Kulicke & Soffa Industries Inc. (K&S, Willow Grove, PA, www.kns.com) and Nidec Tosok Corp. (Tosok, Zama City, Japan, www.tosok.co.jp) have agreed to combine products and technologies to provide integrated solutions for high-speed, reel-to-reel packaging of discrete devices.

A supplier of wire bonding equipment, materials and test interconnects, K&S delivers wire bond solutions over a range of applications. Nidec Tosok Corp. is a supplier of die bonding equipment for the processing of discrete devices, with particular expertise in very high-speed, reel-to-reel processing of these components.

K&S has expanded its market to include low I/O packages in strip and lead-frame format. The new alliance with Tosok further extends market potential by adding a configuration for reel-to-reel discrete packages.

The two companies first established a relationship in 1965 with a technical agreement and have continued to partner on various projects throughout the years. K&S has now agreed to manufacture a configuration of its NuTek wire bonder specifically adapted for reel-to-reel discrete devices exclusively for Tosok. Tosok will mate the Nutek configuration with its own die bonder in various custom configurations to meet customers' specific needs. Tosok will sell, market, and service the die attach-wire bonding integrated systems under this alliance.

DALSA selects EV Group to Supply MEMS Wafer Bonding Equipment

EV Group (EVG, Schärding, Austria, www.evgroup.com), a manufacturer of microelectromechanical systems (MEMS), nano and semiconductor wafer processing equipment has been selected by DALSA Semiconductor (Waterloo, ON, Canada, www.dalsa.com), a supplier of specialized and custom wafer foundry services, as the strategic supplier for MEMS wafer bonding and thick polymer lithography semiconductor production equipment.

Initially, EVG will provide DALSA with the GEMINI Wafer Bonder Cluster tool and the HERCULES Thick Polymer Lithography tool customized to DALSA's specifications. The systems will be the key to move MEMS into the high-volume manufacturing (HVM) spotlight.

Later, the two parties intend to cooperate to enhance the capabilities of the equipment sub-modules to handle new materials and processes. DALSA expects preliminary equipment operation in four to six months. The two high-volume production systems from EVG will enhance DALSA's MEMS production capabilities—especially in the areas of intelligent MEMS and low temperature process.

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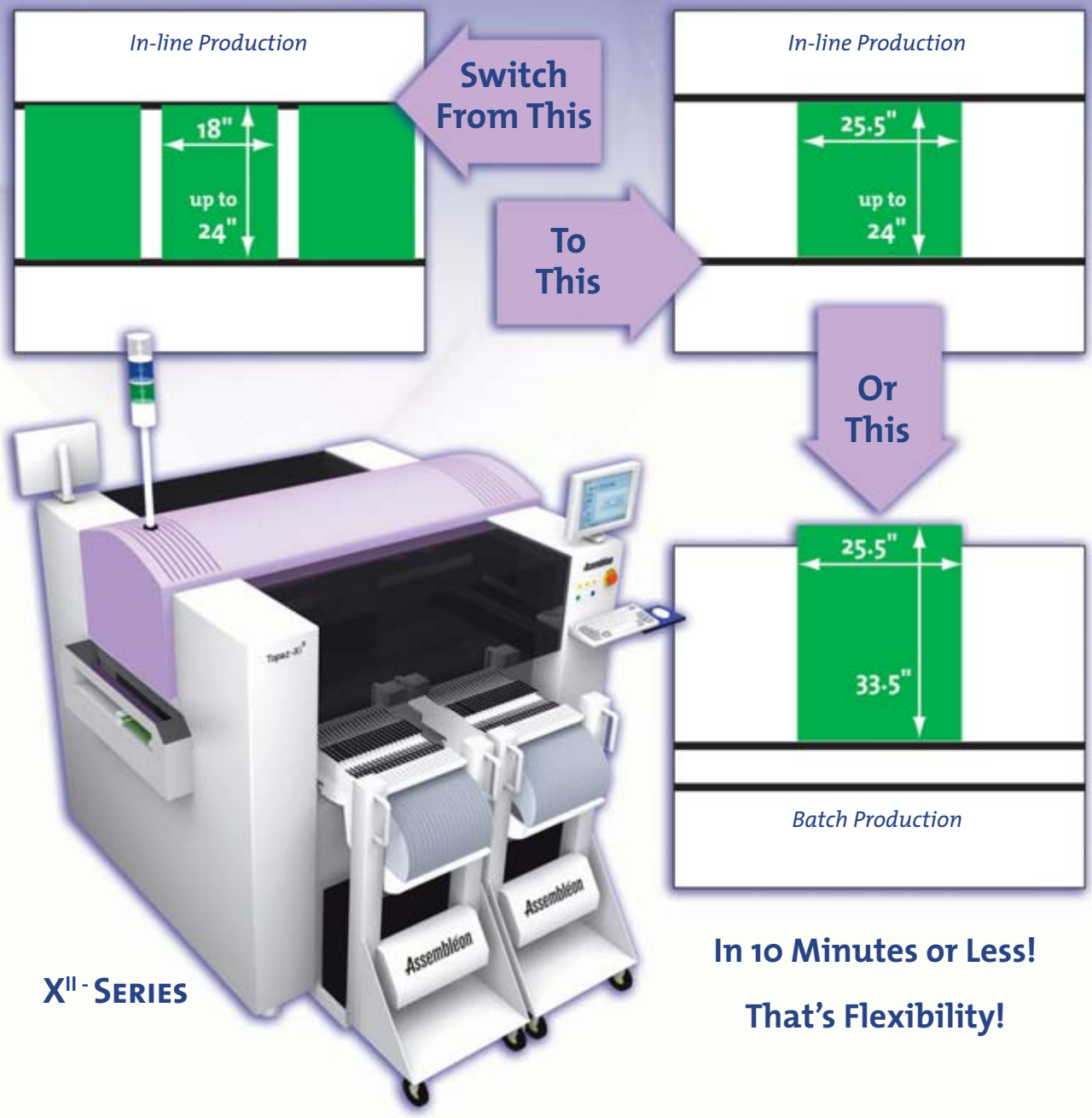

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RFID in the Supply Chain: The Wal-Mart Factor

Venture Development Corp. (VDC, Natick, MA, www.vdc-corp.com) attended the Wal-Mart radio frequency identification (RFID) meeting in Springdale, AR, in November 2003. Wal-Mart announced in June of last year that it will require their suppliers to place EPC transponders on pallets and cases beginning in January 2005.

Wal-Mart has tapped RFID as the technology that will help them limit out-of-stocks, allow supply chain visibility in real or near-real time and reduce costs and labor. The benefit for Wal-Mart is clear: high costs and poor inventory control in the supply chain do not help anyone. Selling over $245 billion worth of goods in 2003, a 1% improvement in the out-of-stock issue could generate nearly $2.5 billion in very profitable sales.

What is the incentive for suppliers? A primary benefit conveyed to Wal-Mart's supply chain partners is the additional sales revenue that suppliers can generate due to improved out-of-stock levels. Next, lower operating costs can be realized through labor reduction and improved business processes. Wal-Mart directly asked their suppliers to look for a return on investment within their own operations.

Some of Wal-Mart's suppliers are wary of committing to RFID due to the lack of RFID education and the complexity and costs associated with RFID systems. Challenges and questions surrounding system performance, data synchronization, consumer privacy, integration with legacy systems and non-compliance repercussions remain at the forefront of supply partner minds.

The majority of Wal-Mart's suppliers appear ready to embrace RFID and begin working toward compliance. Given the size and influence of some of the suppliers who are ready to commit to RFID, this speaks significant volumes about the potential impact the mandate may have on the RFID industry in terms of revenue, transponder and reader shipments, and overall market development.

Undeniably, Wal-Mart's edict may be the single most important milestones for RFID to date. However, the timing begs the question: Is RFID technology prepared for Wal-Mart and vice-versa?

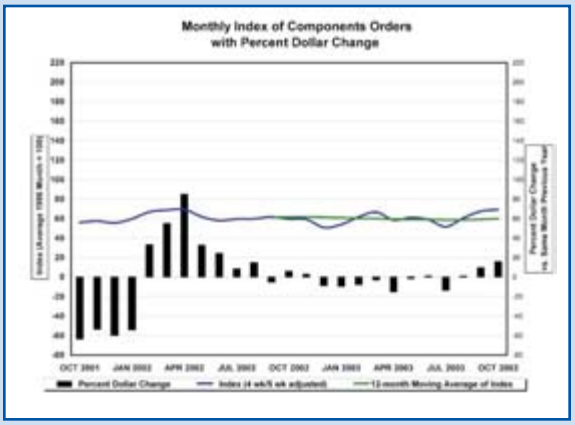
Whether or not the 2005/2006 deadlines are achieved remains in question. Wal-Mart, supplier and technology vendor actions over the next six months will solidify this perspective. Regardless, Wal-Mart's suppliers now have their marching orders and things have been officially set in motion.

—Michael J. Liard, VDC, Senior AIDC/RFID Analyst

ECA Cautious Despite Continued Growth in Components

Electronic component orders continued their upward movement in October 2003, according the Electronic Components, Assemblies & Materials Association (ECA, Arlington, VA, www.ec-central.org). October marked the third consecutive month of gains following 20 months of little or no movement.

Manufacturers at ECA's recent executive committee meeting in Chicago, IL, reported modest business increases over the past two to three months. Increases in Asia are being driven by the personal computer and wireless markets, while specialty items account for growth in North America. Despite the relative prosperity, the watchword is still caution, according to Bob Willis, ECA president



Willis said that, despite the growth potential in Asia, particularly China, manufacturers continue to question whether capacity estimates in the area are accurate and what effect this will have on pricing. "There's little incentive to compete in the commodity markets with pricing at rock-bottom levels. Unless demand catches up with capacity, it will be difficult to stabilize prices, much less increase them."

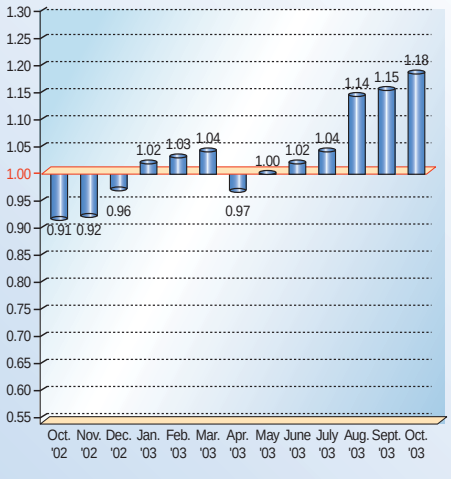
ECA represents manufacturers and producers of passive and active components, component arrays and assemblies, and materials and support services. It is a sector of the Electronic Industries Alliance.

October 2003 Book-to-Bill

Climbing for the sixth consecutive month, the North American IMS/PCB Industry Book-to-Bill Ratio for October 2003 was 1.18. The ratio is calculated by averaging the index numbers for orders booked over the past three months and dividing by the average index numbers for sales billed during the same period. A ratio of more than 1.00 suggests that current demand is ahead of supply, which indicates probable near-term growth.

Industry sales billed (shipments) in October 2003 decreased 6.6% from October 2002, and orders booked increased 20.4% from October 2002.

Compared to 2002, shipments of PCBs are down 20.8% year-to-date, while bookings of PCBs are down 10.2% year-to-date.



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Li Appointed President of Data I/O China

Data I/O Corp. (Redmond, WA) has announced the appointment of Robert C. M. Li, Ph.D., as president of Data I/O China.

Dr. Li grew up in China and is fluent in Mandarin Chinese as well as English. After spending several years in academia teaching at Brooklyn Polytechnic and working at the Massachusetts Institute of Technology (MIT)'s Lincoln Laboratory, Dr. Li jointed Tektronix Inc. and later became chief operating officer of Precision Interconnect. Since 1993, Dr. Li has been principal of Virtus Consulting, providing general management and mentoring in high-tech companies.

Data I/O China has offices in Hong Kong, Shenzhen and Shanghai.

Is China Alpha or Omega for the Rest of the World?

A new, free white paper from In-Stat/MDR (Scottsdale, AZ, www.instat.com) addresses a number of questions with regard to China and its continuing and significant impacts on the rest of the world.

As the U.S. continues to lose dominance in the semiconductor and electronics industries, how does China continue to draw foreign investment and activity? Can China be wholly blamed for the misfortunes of other geographic markets? What are the economic/financial issues with regard to China and the rest of the world? What do the capital spending numbers look like? How many wireless subscribers are there in China? How many landlines?

To download the paper, visit: www.instat.com/catalog/downloads/china.htm.

Nam Tai Subsidiary J.I.C. Expands

Nam Tai Electronics Inc. (Vancouver, British Columbia, Canada, www.namtai.com), an electronics manufacturing and design services provider, has announced that its Hong Kong subsidiary, J.I.C. Technology Co. Ltd., an LCD panel manufacturer, has entered into a lease agreement for new factory premises. The company plans to replace its existing factory and expand its manufacturing facilities to cope with future development. Located in Baoan County, Shenzhen, China, the new factory area, including dormitories, is about 600,000 sq. ft., twice the size of the existing factory.

"In addition to providing additional working space, the increased manufacturing space will also provide room for future expansion, such as setting up of its own chip on glass production line and also adding more production lines for LCD panels," said Tadao Murakami, chairman of Nam Tai.

Upon the completion of construction and installation of equipment, J.I.C. expects to move into the new factory premises within the second quarter of 2004.

Cadence Inaugurates Beijing IC System Design Institute

Cadence Design Systems Inc. (San Jose, CA, www.cadence.com), Beijing Zhongguancun Software Education Investment Co. Ltd. (Beijing, China)—a consortium of investment companies, and the Beijing government have opened the $30 million Zhongguancun Cadence Institute of Software Technology (ZCIST, Beijing, www.zcist.com).

Designed to help transform China from an electronics manufacturing base into a world-class center for integrated circuit (IC) and system design, the 120,000 sq. meter ZCIST is the first of its kind in the Asia Pacific region. Unlike other training institutes for IC design software tools, ZCIST will provide engineers with IC and system design methodologies, skills and knowledge to increase their design capabilities.

ZCIST is a two-phase development—the first of which will serve 500 students. It has been designed to provide training for up to 1,000 residential students per year with courses ranging from three to 12 months.

The institute will offer six bilingual courses covering practical and advanced training on system-level design, logic design and verification, synthesis and place and route, analog/mixed-signal design, custom IC layout design and high-speed board design.

International Rectifier Breaks Ground in Xi'an

International Rectifier Corp. (IR, El Segundo, CA, www.irf.com) broke ground in October 2003 on a new manufacturing site in Xi'an, China.

The new assembly and test facility, which will manufacture key power management components needed to support the world's growing requirement for power supplies, motion control, personal computers and other consumer electronic products, is expected to become operational in early 2005.

Sun Qing Yun, the mayor of Xi'an, said, "We're honored that International Rectifier has chosen to build its new site here. IR's new facility will be the largest international semiconductor assembly and test factory in the area."

The new site will be located in the Chang'an Technology Park in Xi'an's High Technology Industrial Development Zone. In addition to the new manufacturing facility, the company maintains design and applications centers in Xi'an, a trading company in Shanghai and has multiple sales offices throughout China. IR operates facilities in 19 other countries throughout North America, Europe and Asia.

Walf Lifsy, executive vice president of IR's worldwide operations and chairman of Xi'an IR Microelectronics Co. Ltd. (left), and Li Zhang Shu, deputy secretary of the Shaanxi Provincial Party Committee and secretary of the Xi'an Municipal Party Committee, inagurate IR's new manufacturing site in Xi'an China.

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On the Forefront

E. Jan Vardaman

Future R&D for the Electronics Industry: Who's in Charge?

Can the lost art of R&D be regained?

With recovery on the way, the electronics industry is experiencing the need for new materials, process developments and reliability analysis. Where will the research and development come from? Who will pay for it?

The Old Days

In the old days, companies such as AT&T and IBM were the source of a tremendous amount of research and development (R&D) in the electronics industry. Not only were new packages and assembly technologies developed, but the companies also focused on new material developments—working closely with material suppliers. A great deal of time and effort went into the development of process technology and reliability analysis.

With downsizing and divestiture, R&D in today's companies is a lost art. Most companies have reduced R&D spending, shed manufacturing and cut employees. R&D on materials, process and even labs for failure analysis and testing are a distant memory. At some point, the oil companies conducted R&D on new epoxy-based materials, but these companies have long since left the electronics business to focus on huge profits in oil and gas.

Squeezing Profits and Limiting R&D

With the tremendous outsourcing both in integrated circuit (IC) package assembly and board-level assembly, most companies no longer have the personnel to conduct many R&D projects in-house. Compounding the problem are the low profit margins at assembly houses that do not allow large R&D budgets. With continued cost pressure driving margins thinner, little hope is in sight.

The Role of the University

Historically, universities were the source of much basic science. The National Science Foundation continues to support centers of excellence in semiconductor packaging and assembly. With scarce resources during the recent downturn, many companies have turned to universities for more than just basic R&D.

Research activities at the University of California Berkeley, Stanford University and the University of California Los Angeles (UCLA) are famous. Cornell is well-known for its materials research and research in underfill materials. Rensselaer Polytechnic Institute (RPI) has a strong electronics packaging program. The Georgia Institute of Technology (Georgia Tech) has a worldwide reputation for its electronics packaging research—including system-in-package, underfill materials, substrates and other areas.

The State University of New York (SUNY) Binghamton is known for its work in electronics packaging. The University of Maryland's reliability and failure analysis is highly regarded. The University of Texas at Austin has a strong reputation in materials research. The University of Arizona is famous for modeling and simulation

With the tremendous outsourcing both in integrated circuit (IC) package assembly and board-level assembly, most companies no longer have the personnel to conduct many R&D projects in-house. Compounding the problem are the low profit margins at assembly houses that do not allow large R&D budgets.

***E. Jan Vardaman** is president of TechSearch International, Austin, TX; email: jan@TechSearchInc.com.*

work. North Carolina State University—with its location in Research Triangle, NC—has electronics-related activities. Arizona State University has electronics industry research programs based on its close proximity to Intel and Motorola.

Auburn University is highly regarded for its reliability work in automotive electronics and has expanded its activities into wireless communications. With Auburn's new professors, the university will now be recognized as the premier very large scale integration (VLSI) test center in the U.S.

Each of these universities has developed corporate partnerships with industry, and the industry is increasingly depending on the cooperative research and development at these academic institutions. Will this be sufficient to meet the future needs of the electronics industry?

One cause for concern is the decline in the number of foreign students that are now coming to U.S. universities. Why should anyone be concerned about this? Students outside the U.S. make up an increasing portion of the engineering population at most universities. Since the events of September 11, 2001, it has become increasingly difficult for foreign students to obtain visas to study in the U.S. Without students to do the research, how will university and industry goals and objectives be accomplished? Clearly, U.S. government policy needs to address these issues.

Industry Developments Today and Tomorrow

Future electronics packaging developments will depend on the coordinated efforts of strong industry leaders in bringing equipment, materials and assembly suppliers together to work on problems. A good example of a positive development is LSI Logic's development of assembly and packaging solutions for silicon with low-k dielectric material. Activities at LSI Logic included coordinating the work of the silicon foundry, low-k dielectric material suppliers, assembly houses, wire bond equipment makers, molding compound material suppliers and flip chip underfill material suppliers. Similar activities will be required for the future if the industry is to achieve growth and prosperity.

The future competitiveness of the electronics industry depends on strong activities in R&D. Leaders and members of the government, industry and academic community must all pay attention to and take a role in the R&D activities that are required. ■

Jack Crawford

Publishing an Industry-Consensus Standard

The pros and cons of an open process.

The IPC Technical Department is preparing for an audit by the American National Standards Institute (ANSI). As audits go, it will be pretty typical. We will set out stacks of papers, and the auditor will examine them for errors. A question will come up about something, and we will have to look through more papers. This year's audit is focused on standards that had to be reballoted because of negative votes. The concern is that IPC staff assured that the committee made every effort to resolve the vote to everyone's satisfaction.

We have an over 30-page document that defines the process we are required to follow. The process itself is periodically reviewed by ANSI against a set of minimum requirements. We know that every ANSI document we publish is subject to audit, and we are prepared. In the end, the auditor will present some recommendations to both our process and implementation.

Sometimes we have to negotiate on any changes in our process because IPC's peer-consensus process is more open than that of many other standard development organizations. Although, for example, ANSI can relegate final approval to its Board of Directors or to a small representative group from the industry, this approach is not acceptable to IPC.

We have learned that standards with the largest development group have the broadest content and are more readily accepted by industry. We have also learned, sometimes painfully, that large groups present our volunteer leaders and IPC staff liaisons with some pretty big challenges.

Because of our desire for maintaining an open process, we are willing to work through these challenges. For example, the IPC-A-610 committee has over 150 members and a typical meeting has 35 to 40 impassioned participants. With several hundred thousand users around the world, the committee recognizes that they cannot please everyone all of the time. Sometimes the best solution comes from recognizing that only one answer that is the best does not exist.

Our process of openness probably adds months to the development cycle. Staff liaisons to a committee must assure that every technical comment submitted to a draft is reviewed and resolved by the committee. They must also assure that the comment and resolution are made public.

IPC membership is not required to participate in document development, and committee participation does not require attendance at every meeting. We ask that you review documents that will impact your business and keep your comments technical and constructive. Also, be sure to substantiate your recommendations. ■

Jack Crawford *is director of assembly, standards and technology with IPC, Northbrook, IL; (847) 790-5393; email: JackCrawford @ipc.org.*

Assembly Standards Update 2003 Published Standards

Design

IPC-2221A, *Generic Standard on Printed Board Design*

IPC-2226, *Sectional Design Standard for High Density Interconnect (HDI) Boards*

IPC-2501, *Definition of Web-Based Exchange of XML Data*

IPC-2546, *Sectional Requirements for Shop-Floor Equipment Communication Messages (CAMX) for Printed Circuit Board Assembly with Amendment 1*

Electronics Assembly

IPC/EIA/JEDEC J-STD-002B, *Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires*

IPC/EIA/JEDEC J-STD-003A, *Solderability Tests for Printed Boards*

IPC-J-STD-027, *Mechanical Outline Standard for Flip Chip and Chip Size Configurations*

IPC-A-610C, *Acceptability of Electronic Assemblies in German, Danish, Finnish and Japanese*

IPC-7912A, *Calculation of DPMO and Manufacturing Indices for Printed Board Assemblies*

Printed Circuit Boards and Materials

IPC-WP/TR-584, *IPC White Paper and Technical Report on Halogen-Free Materials Used for Printed Circuit Boards and Assemblies*

IPC-5701, *Users Guide for Cleanliness of Unpopulated Printed Boards*

IPC-9151A, *Printed Board Process, Capability, Quality and Relative Reliability (PCQR2) Benchmark Test Standard and Database*

Optoelectronics

IPC-0040, *Optoelectronic Assembly and Packaging Technology*

IPC-8413-1, *Specification for Process Carriers Used to Handle Optical Fibers in Manufacturing*

IPC National Technology Roadmap for Electronic Interconnections

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Optimizing Solder Paste for Wafer Bumping

Maureen Brown and Fritz Byle

This investigation examines the variables of wafer bumping using solder paste printing techniques.

Solder paste is used for an array of electronics assembly applications and is finding more uses for the microelectronic and semiconductor industry. Wafer or substrate bumping, which is creating bumps or interconnects on wafers and substrates with very fine mesh solder pastes, has created much interest.

Several options for bumping a wafer are currently in use. Solder paste printing is the second most common method, with electrodeposition, gold stud bumping, evaporation and ball placement in the minority.[1] Electroplating is a popular bumping technology that drives tighter pitches capability. After the under-bump metalization (UBM) is deposited onto the wafer, a photo resist is applied, exposed and developed. The solder is selectively plated as the UBM acts as an electrode for the plating process. The photoresist is then removed, and the wafer undergoes a reflow process to form spherical bumps.[7]

The solder paste bumping process typically places the wafer in a fixture for additional support during the stencil printing process. An automated measurement system in-line that quantifies the volume of solder paste deposited for process monitoring is beneficial. The bumps are then formed in an inerted reflow oven. For later processes the wafer must be cleaned to remove any flux residues. The bumps are subsequently inspected to ensure coplanarity.

The main driver for solder paste bumping gaining in popularity is its lower costs as compared to other bumping technologies.[11] On average the cost of electroplating is 2.2 times greater than solder paste bumping.[5]

Lead Free

Due to recent lead-free elimination policies worldwide, solder paste bumping should be capable for a large range of lead-free alloys (binary, ternary and quaternary). Solder paste bumping will inherently be an easier drop-in solution than plating technologies, as maintaining the homogeneity of the multiple elements in the powder generation process is easier than controlling the electroplating bath composition of greater than a two-part alloy.

Voiding

Another major concern of solder paste bumping is the presence of voids as compared to electroplating. The current upper specification limit promoted by electroplating service providers is 10% voids. As solder paste has evolved over the last several years, the voiding levels have declined. In most applications solder paste bumping void levels are competitive to the electroplating process, and in some applications voiding can be reduced to levels below 3 to 5%.

Technology Limitations

The current greatest limitation of the solder paste bumping process is the minimum pitch, which is 180 to 200 microns. This limitation has been challenged by the marriage of a photoresist as an in-situ stencil that creates a cavity, which facilitates the low cost processing of solder paste bumping. This innovative intermingling of the best of the two most common wafer bumping technologies allows this lower cost option to print to tighter pitches as low as 70 to 100 microns.[2, 3, 8]

Solder paste suppliers are investigating finer solder powders to further permit solder paste bumping of tighter and tighter pitches. The current demand is for Type 5 powder with greater interest for Type 6. Very few applications require finer particle size distributions than Type 5 or 6, but suppliers of wafer bumping pastes are anticipating future industry demands and development work is continuing.

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The further improvement for a capable process has been largely driven by the forecasted demands of the industry. Flip chip (FC) applications are growing.[10] Prismark Partners reported a compounded annual growth rate (CAGR) of global FC production from 2000 to 2005 at 45% annually.[4, 5] Beyond the increasing demand of FC opportunities, the industry trend wants to increase the I/O count with an emphasis of maintaining die footprint area. Decreasing the pitch is the most common method to meet market demand of increased I/O count.

Area Ratio	Aperture Dimension (D)*	1.5D	1.75D	2D	4D
3.00	66	100	116	132	264
2.75	73	110	128	146	292
2.50	80	120	140	160	320
2.25	89	134	156	178	356
2.00	100	150	175	200	400
1.75	114	171	200	228	456
1.50	133	200	233	266	532
1.25	160	240	280	320	640
1.00	200	300	350	400	800
0.75	267	401	467	534	1068

Note: The apertures are square geometries with a length and width of D (µm).

TABLE 1: Stencil apertures and pitches (all dimensions reported in µm).

Project Setup

This overall project was designed to focus on the various key process modules that affect the final yield for a wafer bumping production line: printing, reflow and cleaning. This article reports on the initial phase where the greatest majority (>60%) of yield loss might be attributable to the printing module. The stencil layout attempted to take into consideration the current state of the market and the future demands of aperture dimensions and pitch.

An electroformed stencil with electropolished and nickel-plated aperture sidewalls was utilized for the experiments. Stencil thickness was 50 micron, and the aperture shape was square with corner radius. The aperture dimensions and the area ratios for the 10 varying dimensions and four different pitches are tabulated in Table 1. This stencil was used to assess the transfer efficiency, stencil aperture blockage rate and brick definition of the solder paste deposits.[12] Specifics are summarized in Table 1.

Solder Paste Materials

Substrate and wafer bumping applications require complete removal of the residues post-reflow. For paste bumping the flux residues must be completely and easily removed; therefore, water-soluble or aqueous chemistries were used in this experiment. The flux chemistries in this study differed in raw materials, viscosity and tack (Table 2). Differing viscosities and differing mesh sizes were used for applications ranging from utilizing a metal foil stencil for wafer and substrate bumping, along with those applications that have the stencil in place during the reflow.[9]

	Paste A	Paste D
Chemistry	Aqueous	Aqueous
Viscosity	Low	Moderate
Tack	Low	Moderate
Metals %		
Type 5	90.0%	90.0%
Type 6	89.5%	89.5%
Type 7	88.0%	88.0%

TABLE 2: Solder paste property table.

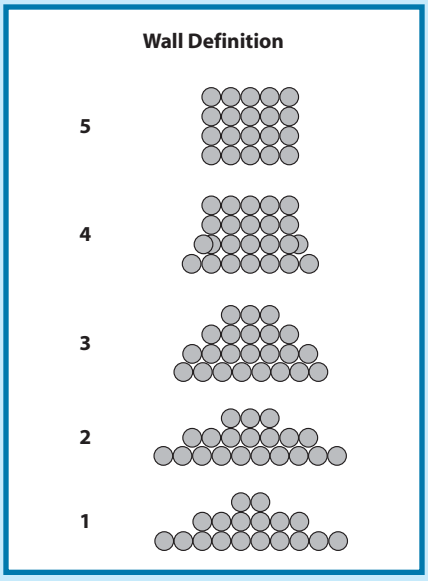

FIGURE 1: Solder deposit definition gauge.

Procedure

A stencil printer with full platen support was used. The solder paste samples were printed at a relatively low speed, less than 1 in./sec. on-contact printing, and the print pressure was optimized for each solder paste sample by concluding the optimal separation speed, squeegee pressure and print speed for each flux type. This phase of the experiment focused on the printing aspect, and, therefore, a planar non-solderable test vehicle was used. Several boards were printed for each solder paste sample. The transfer efficiency rate, or, conversely, blockage of the apertures, and solder deposit definition were recorded for each sample.

Data Analysis

Three aspects were graded for this printing investigation: transfer efficiency of the stencil, blockage of the apertures and the solder deposition definition. The transfer efficiency was visually gauged based on the quantity of solder paste that was deposited on the test vehicle substrate. The solder paste blockage of the stencil defined the percent of apertures of a specific pattern post-printing that exhibited solder paste remaining in the apertures that would prevent acceptable paste release from the stencil. For each aperture dimension and pitch, 25 by 25 apertures were in a full area pattern. Lastly, the brick definition of the solder deposit was rated (Figure 1).

As seen in Tables 3 and 4, the area ratio had the greatest effect on the overall print quality and capability. The flux formulation chosen for the bumping process had a greater effect for complete paste release from the stencil (Table 5), while the powder mesh size had a greater effect on the quality of the brick definition (Table 6). From the data analysis the pitch had no significant effect on the solder paste release from the stencil or the definition of the solder paste deposit.

The flux formulation used in bumping applications did have an effect on reducing the clogging of the stencil apertures to maximum the transfer of solder paste (Table 7). Poor transfer of the solder paste

will ultimately impact the bump heights.

The aperture dimensions and stencil thickness had a significant effect on the rate of clogging the stencil apertures. Area ratios less than 1.25 are statistically equivalent with respect to the solder paste release potential. When the area ratio ranges from 1.5 to 2.0, the release of the solder paste reduces and the area ratios are significantly different (Table 8).

Tables 9 and 10 show that a significant difference did not exist between the Type 5 and 6 powder distribution to the clogging of the stencil apertures. The finer powder distribution had a greater release characteristic to the coarser powders, but the finer powder mesh sizes of Type 6 and 7 have statistically superior brick definition to the coarser Type 5 distribution. The powder size distribution should not be selected based solely on the successful release potential or the wall definition, as the finer particle size distributions have a greater surface area to mass ratio (SAM).

Analyzing the viscosity effect on blockage (Table 11), the lower viscosity (A-T7) samples improved the deposit definition and transfer efficiency as compared to those solder paste samples that had higher viscosity (D-T5). The samples of the highest viscosity were greater than twice the lowest viscosity sample to study a wide range. Based on this experimentation, viscosity was not statistically significant for the 0.75 area ratio test pattern only (F ratio = 6.7). With other area ratios such as 1.75, the viscosity of the material, though, did have a statistically significant effect (F ratio = 30.5). Therefore, as the print deposit decreases in relation to the surface area of the aperture walls, the viscosity of the solder paste needs to optimize for the challenging application requirements.

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Area Ratio	9	9	408651.27	1668.26	<0.0001
Flux	1	1	504.60	18.5396	<0.0001
Mesh	2	2	555.60	10.2067	<0.0001
Pitch	1	1	0.00	0.0000	1.0000

TABLE 3: Effects test on blockage.

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Area Ratio	9	9	576.78483	722.7974	<0.0001
Mesh	2	2	31.69527	178.7351	<0.0001
Flux	1	1	0.65104	7.3427	0.0072
Pitch	1	1	0.03841	0.4332	0.5111

TABLE 4: Effects test on brick definition.

Flux Level			Least Sq Mean
D	A		57.600000
A		B	54.700000

Levels not connected by same letter are significantly different.

TABLE 5: Flux effect on blockage.

Flux Level			Least Sq Mean
A	A		2.4450000
D		B	2.3408333

Levels not connected by same letter are significantly different.

TABLE 6: Flux effect on brick definition.

Discussion

Measurement Issues

In evaluating the printing results, a visual approach was necessary due to the difficulty encountered in locating repeatable, automated inspection equipment for quantifying the volume of the solder paste deposits. The majority of available inspection tools are geared for post-reflow bump inspection or for paste deposits on a surface-mount scale (length and width dimensions >300 µm). The bumping application represents an extreme challenge for inspection equipment. For ±5% accuracy on 66 µm (0.0002 mm^3) deposits, the equipment would need a resolution of better than 1 µm in x, y and z. This is coupled with the challenge represented by the specular wafer surface, though the extreme planarity is a benefit.

Verifying that the extremely low print defect rates needed for high-yield bumping processes are actually being achieved requires an exceptionally high statistical sample size. This requires that the measurement equipment be capable of accepting computer-aided design (CAD) input, as generating a program manually would be impractical. Though quantitative data collection is preferred, visual examinations are beneficial because one can easily and rapidly detect an isolated print defect in a closely spaced array of deposits.

Paste Technology Impact

The particle size distributions for Types 5 and finer are not yet well standardized. Therefore, the paste manufacturer and user should agree upon which of the manufacturer's powder types are appropriate in a given application.

Referring to Table 9, no statistical difference in blockage occurred between the Type 5 and the finer Type 6 distribution. This result was due to the large overlap in the Type 5 and Type 6 distributions. The current market demand has gravitated towards Type 6, as it fits the aperture sizes normally required for bumping and is typically more available than Type 5. Type 7 powder is normally only required for bumping extremely small apertures.

Another consideration regarding powder distribution to make an informed

Continued on pg. 56

Area Ratio Level								Least Sq Mean
2.75	A							100.00000
3	A							100.00000
2.5	A	B						97.50000
2.25		B						95.16667
2			C					75.83333
1.75				D				51.50000
1.5					E			39.83333
1.25						F		1.66667
0.75						F		0.00000
1						F		0.00000

Levels not connected by same letter are significantly different.

TABLE 7: Area ratio effect on blockage.

Area Ratio Level										Least Sq Mean
0.75	A									4.5812500
1		B								4.1250000
1.25			C							3.8750000
1.5				D						3.5729167
1.75					E					2.9583333
2						F				2.0000000
2.25							G			1.4166667
2.5								H		0.6958333
2.75									I	0.4458333
3										J 0.2583333

Levels not connected by same letter are significantly different.

TABLE 8: Area ratio effect on brick definition.

2-D or 3-D Inspection: Do You Have to Choose?

Dr. Udo E. Frank

Flexibility in x-ray inspection combines 2-D real-time imaging with 3-D axial computed tomography.

The role played by x-ray systems in the inspection of today's electronic assemblies is well understood. Unlike machine vision and optical inspection equipment, x-ray systems penetrate materials to expose hidden solder joints on area array devices. Once a need for x-ray inspection equipment has been determined, the next question is: Which is best for the application—two-dimensional (2-D) or three-dimensional (3-D) imaging?

2-D vs. 3-D Imaging

For most applications, 2-D x-ray systems serve the need, providing a top-down image of the board or package being viewed. More advanced systems also offer the ability to inspect for defects by rotating the part being inspected at oblique angles to the x-ray beam. The target area—the component or interconnect being checked for a defect—can thus be viewed from multiple orientations.

Two-dimensional (2-D) systems consist of: a) an x-ray source (sealed or open tube), b) a fixture for holding and manipulating the part being inspected (sample) and c) the radiation detector. While x-ray tubes are available in various configurations and performance capabilities, open microfocus tubes are used primarily for the high-resolution requirements of electronics assembly and packaging. Such tubes can provide a spatial resolution in the range of 1 µm, with geometrical magnifications up to 2400x.

An open tube is a stainless steel tube in which a vacuum is continuously created, while a sealed tube is generally a tube in which the vacuum is created at the time of manufacture. Sealed tubes may not offer as sharp an image as open tubes. They are also less suitable for high magnification applications because of the larger minimum distance required from the focal spot to the object and usually have a shorter life due to consumption of the electron gun (filament).

The *manipulator* is a device for x-y-z positioning and rotating/tilting of the sample with precision. The manipulator should be capable of directional and rotational speeds that can be varied for requirements ranging from quick overview searches at low magnification to very low speeds at high magnification.

The *detector* processes the information of the x-ray image in real-time into an image of visible light that can be observed and assessed by the human eye. While the most common detector is a combination of video camera and image intensifier that converts the x-rays into visible light, other types of detectors recently developed include high-dynamic cameras and flat panel direct digital detectors (DDDs).

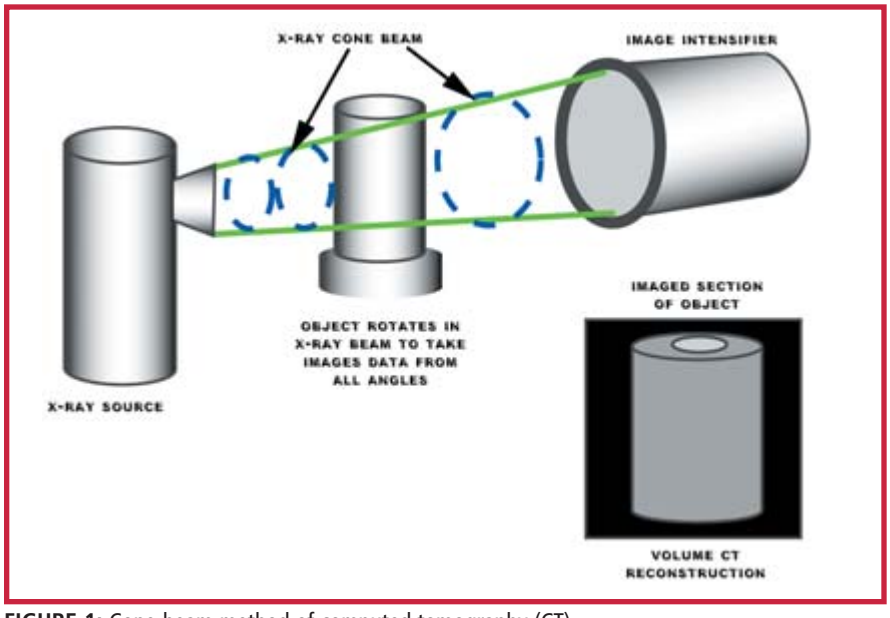

FIGURE 1: Cone-beam method of computed tomography (CT).

The primary advantage of 2-D x-ray inspection is the savings in time in viewing an image, as 3-D analysis can take twice as long, or even longer. The primary limitations of 2-D systems become apparent when imaging double-sided boards. Since x-rays penetrate through components on both sides of the board, the devices on one side can be partially obscured by devices on the other side. Oblique angle imaging can lessen, and even eliminate, the problem, depending on the x-ray system and the complexity of the assembly being inspected.

The most notable advantage of 3-D x-ray inspection is that it results in a complete picture of the area of concern. Solder balls, for instance, on the underside of ball grid arrays (BGAs) can be viewed from all sides, and defects, such as insufficiently wetted or cracked balls, can be easily identified.

So, do you need 2-D or 3-D imaging? The requirement may not always be known until the middle of the inspection procedure, or the requirement may change. An x-ray system that offers both capabilities may be the ideal solution for the majority of applications.

Combining 2-D and 3-D

An ideal system that combines 2-D and 3-D imaging would incorporate a choice of: a) a standard open microfocus tube or b) a multifocus tube, which enables the operator to select either a microfocus, nanofocus or high-power mode, depending on the requirements of the application. The system would perform high-resolution 2-D inspection for optimum processing speed, while enabling the operator to switch to 3-D for inspection of parts and interconnects that cannot be adequately viewed using 2-D.

Inspecting with 3-D

Three-dimensional capability can be achieved with a process called *axial computed tomography* (ACT) with volume rendering software. ACT is a reconstruction technology. By taking multiple 2-D views and by calculating the volume data (voxels), a 3-D image is constructed. Typically, for 3-D inspection, the region of interest (ROI) of the part or interconnect is first located. Then, a multitude of images is taken in a 360º circle by rotating the sample and the x-ray beam being projected in a cone, as can be seen in Figure 1. Using software, the images are subsequently recombined into a 3-D visualization model.

The manipulator for the 2-D/3-D x-ray system would enable movement around six axes, the movement being either programmed by computer numeric control (CNC) or controlled with a joystick. The multiple axes, thus, would provide flexibility in positioning the sample for optimum imaging. The high accuracy of the axis allows precise point-to-point measurements in 2-D mode. In 3-D mode, wall thickness or void volume measurements can be performed directly from the 3-D model due to the known size of the voxel data.

The combined 2-D/3-D system should let the operator shift from one mode to the other easily. Thus, if a BGA, for instance, is being viewed using the 2-D mode, and a 3-D image is required to examine for a possible defect, the operator could punch a certain tactile key on the keyboard and begin the 3-D operation. As the multiple images are taken in the 360º circle around the part and the 3-D image is constructed by software, the operator could begin to view the image on a second screen. Once viewing is completed, the operator could then shift back to 2-D and continue the process.

True-X-Ray Intensity

The accuracy of a 2-D/3-D x-ray system can be attributed to a unique control technology called *true x-ray intensity* (TXI). Unlike systems that measure and control the input level of the high voltage and current to the x-ray tube, TXI is a process that controls and stabilizes output intensity for x-ray emission even over a long time range of inspection (hours). The result is a sharp, consistent 2-D image and data that can be reconstructed into a complete 3-D image. Without precise control over the x-ray intensity, the reconstructed 3-D image would be degraded

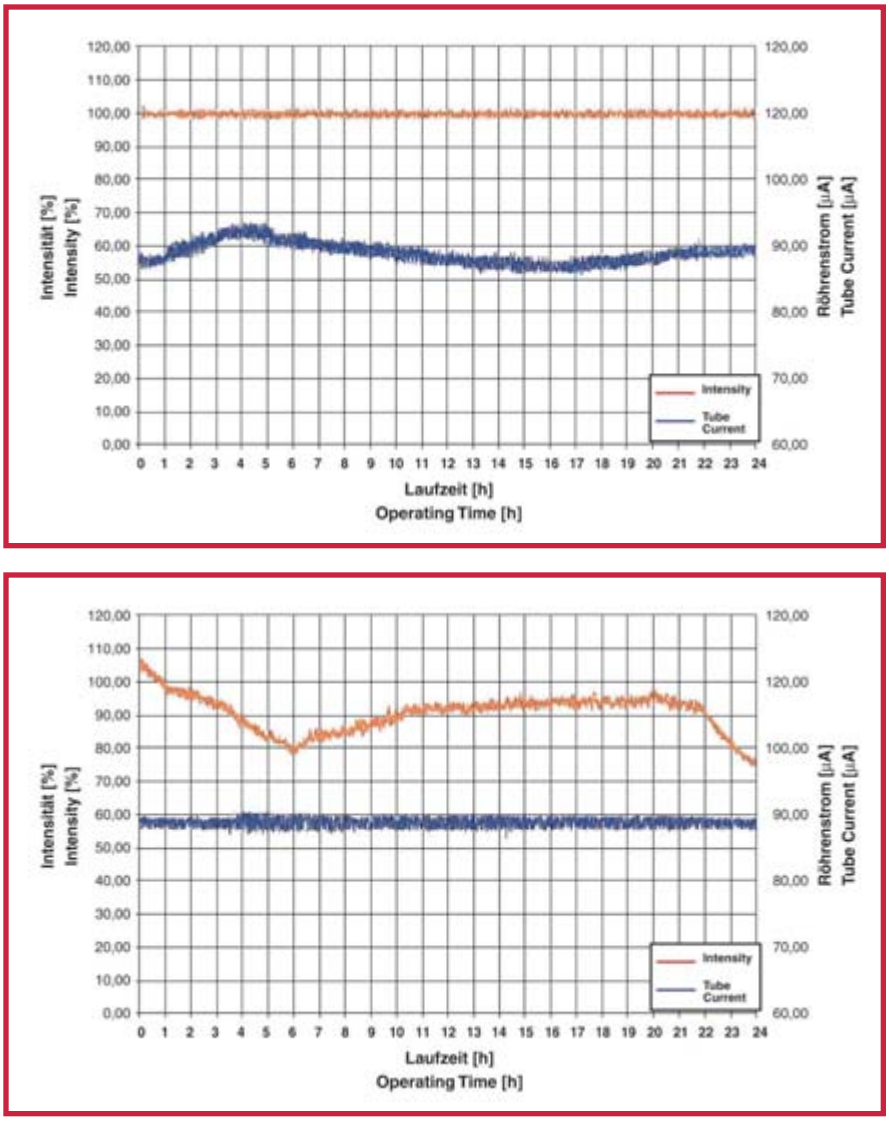

FIGURE 2: X-ray output intensity is shown in red, with TXI (top) and without TXI (bottom).

and may not even be possible to achieve (Figure 2).

Applications for 2-D/3-D Inspection

Combined 2-D/3-D x-ray inspection is, first and foremost, a design, production and quality control tool. For R&D requirements, a 2-D/3-D x-ray inspection system can be employed to develop and refine the manufacturing process, and it is ideal for inspecting prototypes during pre-production. It can also be used for reverse engineering of existing products.

In terms of electronic assemblies, a 2-D/3-D system could be used off-line to inspect components and packages. Cracks, voids, delamination and other component anomalies can be observed and measured in either the 2-D or 3-D mode, whichever most accurately depicts the defect. This type of system is also particularly useful in the manufacture of sensors and relays and other micro-electromechanical (MEMS) and micro-opto-electromechanical (MOEMS) devices. ■

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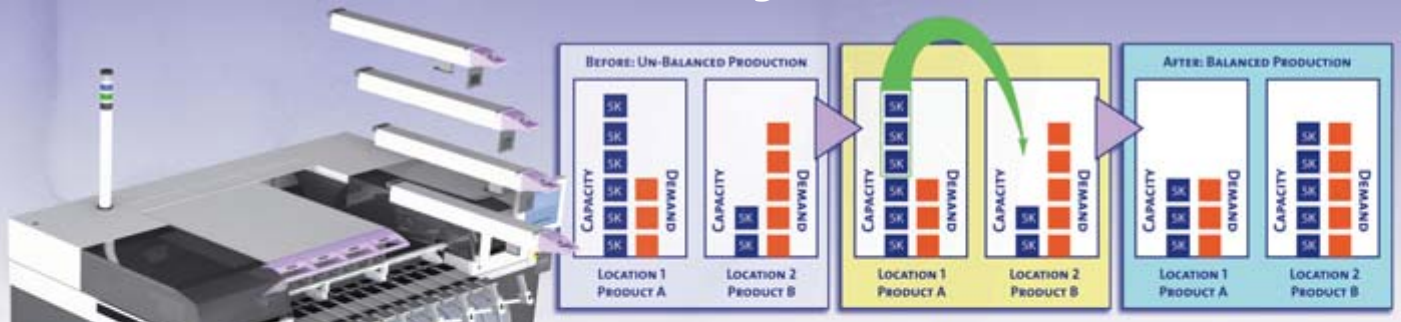

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Reliable Solder Joints for 0201s

David Geiger, Mei Wang, Dr. Dongkai Shangguan, Todd Castello and Fredrik Mattsson

A summary of the eutectic and lead-free solder reliability testing that has been performed while developing the 0201 process.

Over the past few years, numerous experiments have been conducted to design a robust process for 0201 assembly.[1-6] Optimal pad designs have been developed, stencil designs have been fine tuned, pick-and-place equipment has been evaluated, reflow profiles and atmosphere have been investigated and rework methods have been established, with both tin-lead (Sn-Pb) and lead-free solders. The reliability tests to be presented in this article include shear test, bending test, vibration test, thermal cycling, as well as cross sectioning and scanning electron microscope (SEM) analysis.

Qualification Vehicle

As shown in Figure 1, the 0201 qualification vehicle was a double-sided panel with mirror images. The outside dimension was 5 in. x 7 in. with 0.030 in. thickness. Four boards with a cell phone form factor were designed into this panel. For 0201s, two types of pad design (Pad U and Pad H) were utilized in this test vehicle; Boards A and B were designed with Pad U, while Boards C and D were designed with Pad H, for 0201s. Different spacings (6 mils, 8 mils and 10 mils) were included between 0201 and 0201, between 0201 and 0402, and between 0201 and chip-scale package (CSP) and SO8. Microvia is also included for 0201s.

With a 5 mil thick stencil, the area ratio (AR)—the ratio of the aperture opening area to the aperture wall area—was 0.60 for Pad U and 0.74 for Pad H.

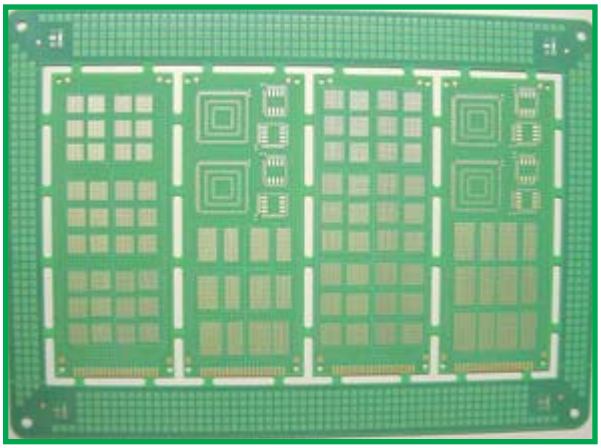

FIGURE 1: 0201 qualification vehicle.

A total of 5,728 components were on the topside of the qualification vehicle, including 5,092 locations for 0201s, 624 locations for 0402s, eight locations for SO8s and four locations for CSPs. The 0201 resistors from two different vendors and 0201 capacitors from another two vendors were distributed equally in the pick-and-place program.

Solder paste printing was carried out using a eutectic Sn-Pb, no-clean solder paste and a lead-free, no-clean, Sn/3.9Ag/0.6Cu solder paste. The stencil used was a 0.005 in. stencil with apertures designed for good printability. The minimum expected solder paste volume for Pad U was 554 mil^3 (0.009705 mm^3).

Cross Section Analysis

For cross section analysis (Figures 2 and 3), components from each pad type and each component vendor were sectioned. The solder fillets were evaluated using the IPC-A-610 Rev C guidelines, and each of the pad types investigated would meet the Class III requirements. The solder fillet wetted up the entire end termination of the components, both for the capacitors and for the resistors.

Shear Test

A lap shear test was performed on 20 samples of each component type, both with microvia in pad and no microvia in pad, on Panel A (Pad U) and Panel C (Pad H). A shear tester with a load rate of 500µm/sec. was used for all of the shear tests. For the 0201 components, each terminal was roughly 0.2 x 0.3 mm. Based on the shear strength of the solder, a minimum of 300g shear strength would be required for the Sn-Pb solder. Further, if the failure mode is due to poor assembly quality such as insufficient solder or excessive voiding, it should be considered as a failure.

All shear tests exceeded the minimum requirement of 300g (Figure 4). All shears resulted in separation at the solder-component termination interface or were mixed mode, including termi-

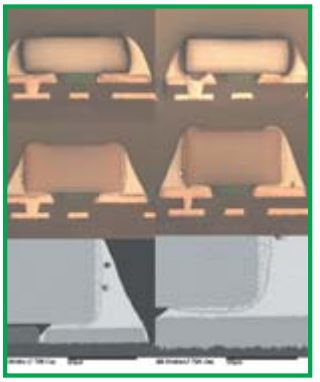

FIGURE 2: Cross sections and SEM for lead-free 0201 solder joints.

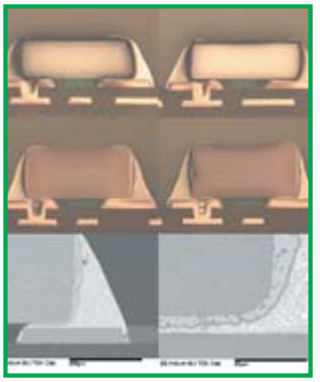

FIGURE 3: Cross sections and SEM pictures for Sn/Pb 0201 solder joints.

nation from component, solder-termination interface, within solder, or printed circuit board (PCB) pad lifting (Figure 5).

An analysis of variance on 960 shear test data points showed that the component type and the pad size have a significant effect on the shear strength of the 0201 solder joints. The presence of via-in-pad did not have a statistically significant effect (Table 1).

The shear test also showed that the 0201 solder joints assembled with the lead-free solder have higher shear strength than the Sn-Pb solder (Figure 4).

Cyclic Bending Test

The cyclic bending test was used to simulate keypad or other button pushing induced stress during the life of an electronic product. The cyclic bending test consisted of a two-point anvil structure with one moving anvil (Figure 6). The total displacement was 2 mm, and the frequency was 1.35Hz (or 81 cycles per minute). The duration of the test was 300,000 cycles. Resistance measurement data were collected every 10 seconds. The time and location of the failure was captured and recorded.

After the test to 300,000 cycles, failure analysis revealed that the failure was due to the cracking of the trace connecting between the resistors (Figure 7); no solder joint cracking was observed. The failure analysis also showed that the open nets were occurring at the same locations and orientation for both the Sn-Pb and lead-free solder boards.

Vibration Testing

For the vibration testing, to ensure that the energy would be concentrated in the areas of interest, a sine sweep was first performed on the boards to determine at what frequencies the major resonances occurred and at what frequency the board went into attenuation. The data (Figure 8) showed that the first resonant frequency occurred at about 35 Hz, the second and third resonances occurred at about 170 Hz and 190 Hz and then slowly tapered off to the attenuation frequency at about 900 Hz. This result indicates that the most effective test profile should be concentrated in the area between 5 Hz and 500 Hz. To meet this requirement, the following profile was used (Table 2).

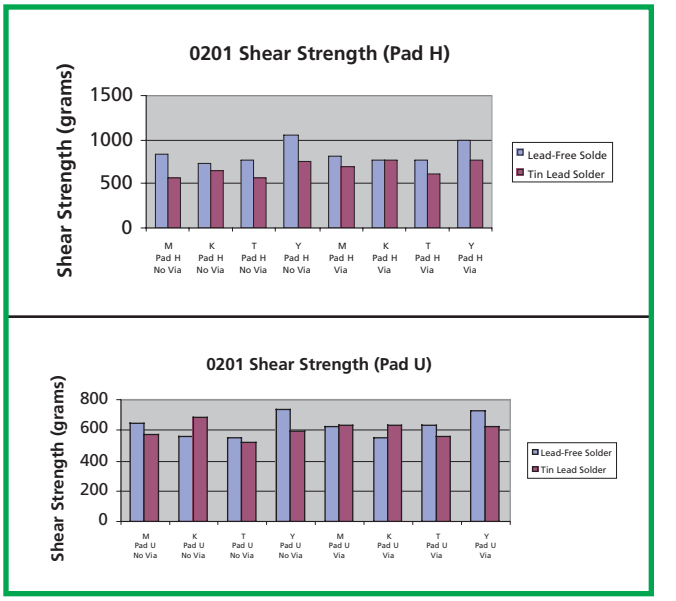

FIGURE 4: Shear test results.

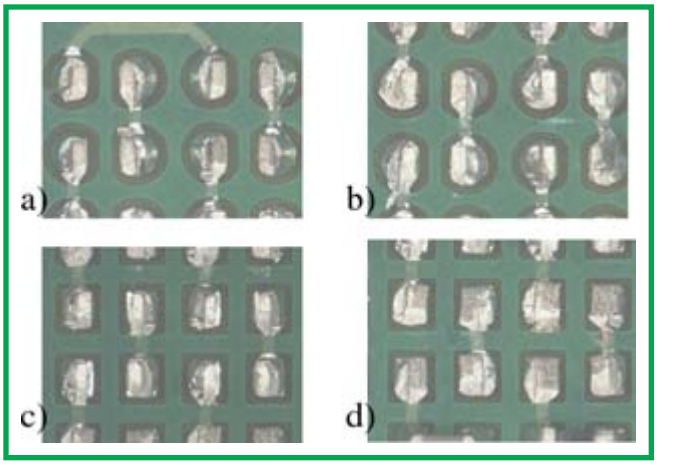

FIGURE 5: Shear test pictures a) Sn/Pb Pad H capacitor, b) Sn/Pb Pad H resistor, c) Sn/Pb Pad U capacitor, d) Sn/Pb Pad U resistor.

ANOVA Table for Pad H					
Source	**DF**	**SS**	**MS**	**F**	**P**
Paste Vendor	2	1307102	653551	8.974	0.054
Via Type	3	218473	72824	1.662	0.211
Component Vendor	18	788832	43824	4.474	0.000
Error	456	4467135	9796		
Total	479	6781542			

ANOVA Table for Pad U					
Source	**DF**	**SS**	**MS**	**F**	**P**
Paste Vendor	2	1743929	871965	8.902	0.055
Via Type	3	293857	97952	1.796	0.184
Component Vendor	18	981897	54550	4.940	0.000
Error	456	5035840	11044		
Total	479	8055524			

TABLE 1: Analysis of variance for shear testing.

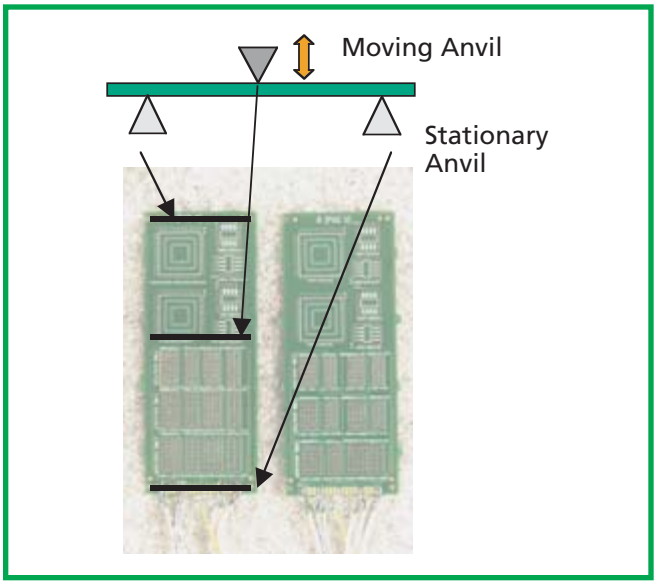

FIGURE 6: Bend test set-up.

The boards were then tested for one hour in each of the three major axes (x, y, and z). No failures were found.

Temperature Cycling

Temperature cycling (-45 to 125°C) was done using the lead-free test vehicle,[4] which has many different types of components including 0201, 0402, 0603, quad flat pack (QFP), CSP and ball grid array (BGA). A total of 52 boards with 20 0201s on each board were included. No failures were observed for the 0201 component up to 3,000 cycles. This result was the same for the 0402 and the 0603 components on these boards.

Summary

Optimized pad design and process parameters are critical to the quality and reliability of board assembly using 0201 components. Cross sections have shown that the solder joint formation meets the IPC-A-610C Class III requirements. Results of the reliability tests, including shear test, cyclic bending test, vibration test and thermal cycling test, have demonstrated the reliability of 0201 solder joints, using Sn-Pb and lead-free solders. ■

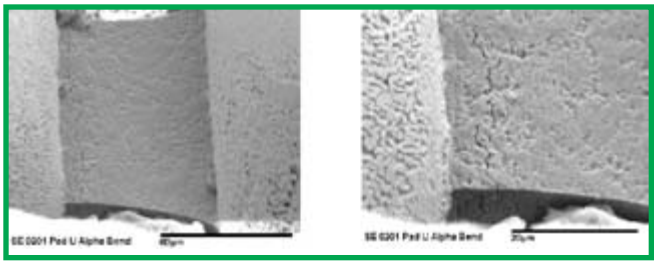

FIGURE 7: Trace cracks on PCB after bend test.

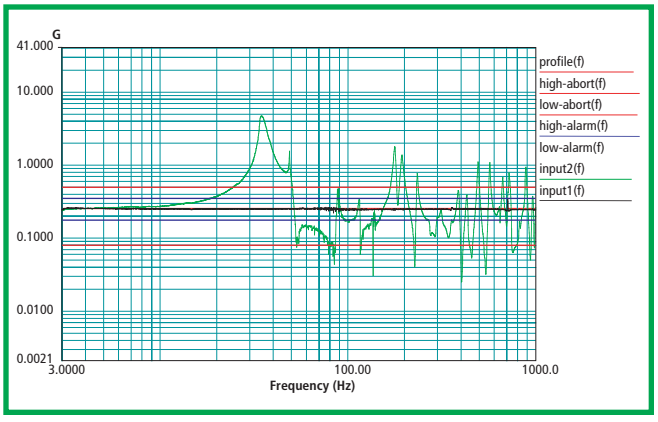

FIGURE 8: Sine sweep chart for 0201 test vehicle.

Frequency (Hz)	g^2/Hz	Slope
5	0.0029	-12dB
500	0.0029	12 dB

TABLE 2: Total Grms Level: 1.5 Grms.

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Acknowledgment

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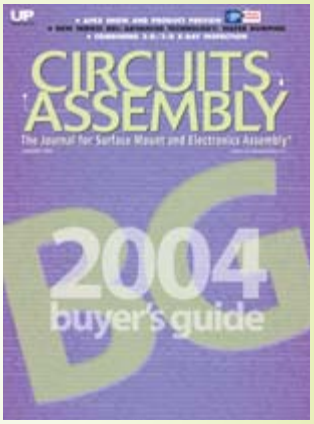
Welcome to *Circuits Assembly's* 2004 Buyer's Guide

The *Product Listings* (pg. 33-43) are ordered alphabetically, from *Adhesives* to *Wire Processing. Associations, Exhibition Companies and Training Centers* (pg. 33), *Manufacturers' Representatives* (pg. 37) and *Services* (pg. 40) are also listed in this section. An alphabetical list of suppliers follows on pages 44-52.



How to Use the Guide

1. In the *Product Listings*, you can look up a product by category and subcategory, which are listed in alphabetical order.
2. You can locate the contact information for a given supplier by referring to the alphabetical *Supplier Listings* (pg. 36-44).
3. Advertisers in this issue are listed in boldface type in the *Supplier Listings*.

NOTE: If you are an Industry Supplier and don't see your listing, don't worry! You can enter your company in our 2004 *Circuits Assembly* Online Buyer's Guide at www.circuitsassembly.com/bg_intro. Online Buyer's Guide listings are accessible year-round, and you can update your listing at any time. Once entered, you'll receive future alerts when we update our print version later this year.

Adhesives

Adhesives - Acrylic

Anorad, Rockwell Automation
Cookson Electronics
Emerson & Cuming
Epoxy Technology
Global Communications
Mouser Electronics
National Starch and Chemical Company
Pinnacle Electronics
Polyonics
3M Electronic Adhesives & Specialties Dept.
T-Tech Inc.

Adhesives - Anaerobic

National Starch and Chemical Company

Adhesives - Conductive

AI Technology Inc.
Creative Materials, Inc.
Emerson & Cuming
Epoxy Technology
Jodan Technology, Inc.
Mouser Electronics
National Starch and Chemical Company
Parker Hannifin, Chomerics Division
Polyonics
3M Electronic Adhesives & Specialties Dept.
Zymet, Inc.

Adhesives - Cyanoacrylate

National Starch and Chemical Company
OK International
Techcon Systems

Adhesives - Epoxy

AIM
Creative Materials, Inc.
Dow Chemical
Emerson & Cuming
Epoxy Technology
Henkel Loctite Corporation
Heraeus Inc. Circuit Materials Division
Kester Northrop Grumman
Mouser Electronics
National Starch and Chemical Company
OK International
3M Electronic Adhesives & Specialties Dept.
Zymet, Inc.

Adhesives - Fixatives

Dymax Corporation
Emerson & Cuming
3M Electronic and Interconnect Solutions
Zymet, Inc.

Adhesives - Hot melt

National Starch and Chemical Company
3M Electronic Adhesives & Specialties Dept.

Adhesives - Insulating

Creative Materials, Inc.
Dow Corning Corp.
Emerson & Cuming
Epoxy Technology
National Starch and Chemical Company
3M Electronic Adhesives & Specialties Dept.
3M Electronic and Interconnect Solutions
Wacker Silicones
Zymet, Inc.

Adhesives - Surface mount

Creative Materials, Inc.
Dow Corning Corp.
Emerson & Cuming
Epoxy Technology
Henkel Loctite Corporation
National Starch and Chemical Company
Smart Sonic Stencil Cleaning Systems
Tech Spray, L.P.
3M Electronic Adhesives & Specialties Dept.
Zymet, Inc.

Adhesives - Thermally conductive

Creative Materials, Inc.
Dow Corning Corp.
Dymax Corporation
Emerson & Cuming
Epoxy Technology
Henkel Loctite Corporation
National Starch and Chemical Company
3M Electronic Adhesives & Specialties Dept.
Wacker Silicones
Zymet, Inc.

Adhesives - Urethane and silicone

Creative Materials, Inc.
Dow Corning Corp.
Emerson & Cuming
National Starch and Chemical Company
3M Electronic Adhesives & Specialties Dept.
Wacker Silicones

Associations, Exhibition Cos. and Training Centers

American Electronics Association
American Hakko Products, Inc.
California Circuits Association
Center For Business & Industry
Electronic Industries Association (EIA)
ESD Association
FocalSpot, Inc.
FPC of Huntsville
IPC-Assn. Connecting Electronic Industries
NEPCON Events
PCBindia.com
Personal Computer Memory Card Int'l Assn.
Reed Exhibition Co.
Robotic Industries Assn. (RIA)
Screenprinting & Graphic Imaging Assn. Intl.
Surface Mount Technology Association
UP Media Group, Inc.
Wepco Vintek Tech Sales

Cleaning Agents

Cleaning Agents - Alcohol-based

DEK International GmbH
Enthone Inc., a Cookson Electronics Company
Kyzen Corporation
Micro Care Corporation
Mouser Electronics
Tech Spray, L.P.

Cleaning Agents - Aqueous

Aqueous Technologies
Enthone Inc., a Cookson Electronics Company
International Products Corp.
JNJ Industries, Inc.
Kyzen Corporation
Mallinckrodt Baker, Inc.
Micro Care Corporation
Smart Sonic Stencil Cleaning Systems
Tech Spray, L.P.
Zestron Corporation

Cleaning Agents - Saponifiers

Enthone Inc., a Cookson Electronics Company
Smart Sonic Stencil Cleaning Systems
Zestron Corporation

Cleaning Agents - Semiaqueous

Enthone Inc., a Cookson Electronics Company
Kyzen Corporation
Zestron Corporation

Cleaning Agents - Solvents

AGC Chemicals Americas, Inc.
CAIG Laboratories, Inc.
DEK International GmbH
Dow Corning Corp.
Enthone Inc., a Cookson Electronics Company
HumiSeal Div. of Chase Corp.
ITW Chemtronics
Kyzen Corporation
Micro Care Corporation
Mouser Electronics
Petroferm
Tech Spray, L.P.
Zestron Corporation

Cleaning Equipment

Cleaning Equipment - Aqueous

Advanced Automation, LLC
Aqueous Technologies
Austin American Technology
JNJ Industries, Inc.
Manncorp
Smart Sonic Stencil Cleaning Systems
Speedline Technologies, Inc.
Spraying Systems Co.
Stoelting
Technical Devices Company
Terra Universal, Inc.
TREK Industries
Unit Design, Inc.
Zestron Corporation

Cleaning Equipment - Batch

Aqueous Technologies
Austin American Technology
JNJ Industries, Inc.
Manncorp
NIX of America
Smart Sonic Stencil Cleaning Systems
Speedline Technologies, Inc.
TREK Industries
Unit Design, Inc.
Zestron Corporation

Cleaning Equipment - Brushes

All-Spec Industries
CAIG Laboratories, Inc.
Eraser Company, Inc.
Micro Care Corporation
Mouser Electronics
Tech Spray, L.P.

Cleaning Equipment - Degreasing

All-Spec Industries
Easy Braid Co.
TREK Industries

Cleaning Equipment - Dryers

Austin American Technology
Spraying Systems Co.

Cleaning Equipment - Filtration systems

Fumex Inc.
Impell
OK International
SERFILCO, Ltd.
Smart Sonic Stencil Cleaning Systems

Cleaning Equipment - In-line

Aqueous Technologies
Austin American Technology
Manncorp
Speedline Technologies, Inc.
Spraying Systems Co.
Stoelting
Technical Devices Company
TREK Industries
Zestron Corporation

Cleaning Equipment - Ionic testers

Aqueous Technologies
TREK Industries

Cleaning Equipment - Rinse water recycling systems

Aqueous Technologies
Smart Sonic Stencil Cleaning Systems
TREK Industries
Unit Design, Inc.

Cleaning Equipment - Semiaqueous

Austin American Technology
Spraying Systems Co.
TREK Industries
Unit Design, Inc.
Zestron Corporation

Cleaning Equipment - Solvent

Austin American Technology
Spraying Systems Co.
TREK Industries
Zestron Corporation

Cleaning Equipment - Solvent dispensers

All-Spec Industries
I&J Fisnar Inc.
Micro Care Corporation

Cleaning Equipment - Spot cleaning

Waveroom Plus

Cleaning Equipment - Spray nozzles

BETE Fog Nozzle, Inc.
Easy Braid Co.
Spraying Systems Co.

Cleaning Equipment - Ultrasonic

Aqueous Technologies
Austin American Technology
JNJ Industries, Inc.
Manncorp
Smart Sonic Stencil Cleaning Systems
Stoelting
Terra Universal, Inc.
TREK Industries
Zestron Corporation

Cleaning Equipment - Vapor recovery systems

OK International
The CMM Group, LLC
TREK Industries

Component Insertion

Component Insertion - Through-Hole - Component insertion tool

Advanced Automation, LLC
Anorad, Rockwell Automation
Mouser Electronics
Teradyne Connection Systems
Tyco Electronics

Component Insertion - Through-Hole - Eyelets and setting tools

Mouser Electronics

Component Insertion - Through-Hole - Fixtures - Autoinsertion

Advanced Automation, LLC
MB Manufacturing
S.P. Precision International

Component Insertion - Through-Hole - Insertion equipment - Automatic

Advanced Automation, LLC
Anorad, Rockwell Automation

ScanCAD International, Inc.
Tyco Electronics
Zierick Mfg. Corp.

Component Insertion - Through-Hole - Insertion equipment - Semiautomatic

Advanced Automation, LLC
Anorad, Rockwell Automation
Contact Systems
RoyonicUSA
Zierick Mfg. Corp.

Component Insertion - Through-Hole - Pinning machines - Automatic

Tyco Electronics

Component Insertion - Through-Hole - Robotic

Advanced Automation, LLC
Anorad, Rockwell Automation
GPAX, Ltd.
I&J Fisnar Inc.
Tyco Electronics

Component Insertion - Through-Hole - Sequencing equipment

Advanced Automation, LLC

Component Insertion - Through-Hole - Spray fluxing equipment

Advanced Automation, LLC
AIC Technologies, Inc.
Ultrasonic Systems Inc.

Component Prep

Component Prep - Component counters

Automated Production Systems, Inc.
Ismeca USA
Manix Manufacturing, Inc.
Q Corporation
Tomken Industries

Component Prep - Component delivery

Autosplice Inc.
Data I/O Corp.
GPAX, Ltd.
Manix Manufacturing, Inc.
3M Electronic and Interconnect Solutions

Component Prep - Component weighing systems

Tomken Industries

Component Prep - Handlers

Bliss Industries Inc.
Ismeca USA

Component Prep - Lead cutting and trimming

Anorad, Rockwell Automation
HEPCO Inc.
Manix Manufacturing, Inc.
Mid America Taping and Reeling Inc.
Plato Products Inc.
Q Corporation
Tomken Industries

Component Prep - Lead forming and bending equipment

Automated Production Systems, Inc.
Autosplice Inc.
Fancort Industries, Inc.
HEPCO Inc.
Manix Manufacturing, Inc.
Manncorp
Tomken Industries
Waveroom Plus

Component Prep - Lead tinning equipment

Unit Design, Inc.

Component Prep - Programmers

BP Microsystems
Data I/O Corp.

Component Prep - Tape and reel equipment

Autosplice Inc.
Bliss Industries Inc.
GPAX, Ltd.
Ismeca USA
Manix Manufacturing, Inc.
Q Corporation

Components

Components - Leaded - Active

Fairchild Semiconductor
Lumex, Inc
Mouser Electronics

Components - Leaded - Connectors

Advanced Interconnections Corp.
Mouser Electronics
Teradyne Connection Systems
3M Electronic and Interconnect Solutions
Zierick Mfg. Corp.

Components - Leaded - Passive

Fairchild Semiconductor
Mouser Electronics
Raychem Circuit Protection
Teradyne Connection Systems
Wilbrecht Electronics, Inc.

Components - Leaded - Sockets

Advanced Interconnections Corp.
Mouser Electronics
3M Electronic and Interconnect Solutions
Zierick Mfg. Corp.

Components - Surface Mount - Active

Fairchild Semiconductor
Mouser Electronics
Sanyo/Hitachi High Technologies America

Components - Surface Mount - BGA

Digi-Key
Fairchild Semiconductor
Teradyne Connection Systems

Components - Surface Mount - Chip scale

Fairchild Semiconductor

Components - Surface Mount - Connectors

3M Electronic and Interconnect Solutions
Advanced Interconnections Corp.
AVX Corporation
Mouser Electronics
Sinbon Technologies
Teradyne Connection Systems
Zierick Mfg. Corp.

Components - Surface Mount - Flip chip

Waterfall Technologies

Components - Surface Mount - Leadless

AVX Corporation
Fairchild Semiconductor
Raychem Circuit Protection

Components - Surface Mount - Micro BGA

AVX Corporation
Plasma Etch, Inc.

Components - Surface Mount - Passive

AVX Corporation
AXTAL Products
Fairchild Semiconductor
Mouser Electronics
Nu-Way Electronics, Inc.
Raychem Circuit Protection
SMEC, Inc.
Taiyo Yuden (U.S.A.), Inc.

Components - Surface Mount - Sockets

Advanced Interconnections Corp.
Mouser Electronics
Synergetix
3M Electronic and Interconnect Solutions
Zierick Mfg. Corp.

Conformal Coating

Conformal Coating Encapsulants - Underfill - Application equipment

Anorad, Rockwell Automation
ASYS Automation LLC
ESSEMTEC (USA) LLC
I&J Fisnar Inc.
PVA
Spraying Systems Co.
Ultrasonic Systems Inc.

Conformal Coating Encapsulants - Underfill - Chemicals and equipment

Anorad, Rockwell Automation
CAIG Laboratories, Inc.
Concoat Limited
Dow Chemical
Dow Corning Corp.
Dymax Corporation
Mouser Electronics
National Starch and Chemical Company
W. M. Hague Co., Inc.
Wacker Silicones

Conformal Coating Encapsulants - Underfill - Coating thickness measurement

Veeco Instruments Inc.

Conformal Coating Encapsulants - Underfill - Encapsulants - Underfill

HumiSeal Div. of Chase Corp.
Paratronix Inc
Ultrasonic Systems Inc.
Wacker Silicones
Zymet, Inc.

Conformal Coating Encapsulants - Underfill - Removal equipment

Micro Care Corporation

Curing

Curing - Curing systems - IR

Enthone Inc., a Cookson Electronics Company
ESSEMTEC (USA) LLC
Rehm USA, LLC

Curing - Curing systems - Thermal

Conceptronic Inc.
Enthone Inc., a Cookson Electronics Company
Heller Industries Inc.
Rehm USA, LLC

Curing - Curing systems - UV

ASYS Automation LLC
Dow Chemical
Dymax Corporation
Enthone Inc., a Cookson Electronics Company
EXFO Photonic Solutions Inc.
Hamamatsu Corporation
I&J Fisnar Inc.
Pro-mation, Inc.
Ultrasonic Systems Inc.

Curing - Heaters

Rehm USA, LLC

Curing - Ovens

Conceptronic Inc.
Heller Industries Inc.
Manix Manufacturing, Inc.
Rehm USA, LLC
Sun Electronic Systems, Inc
Vitronics Soltec Inc.

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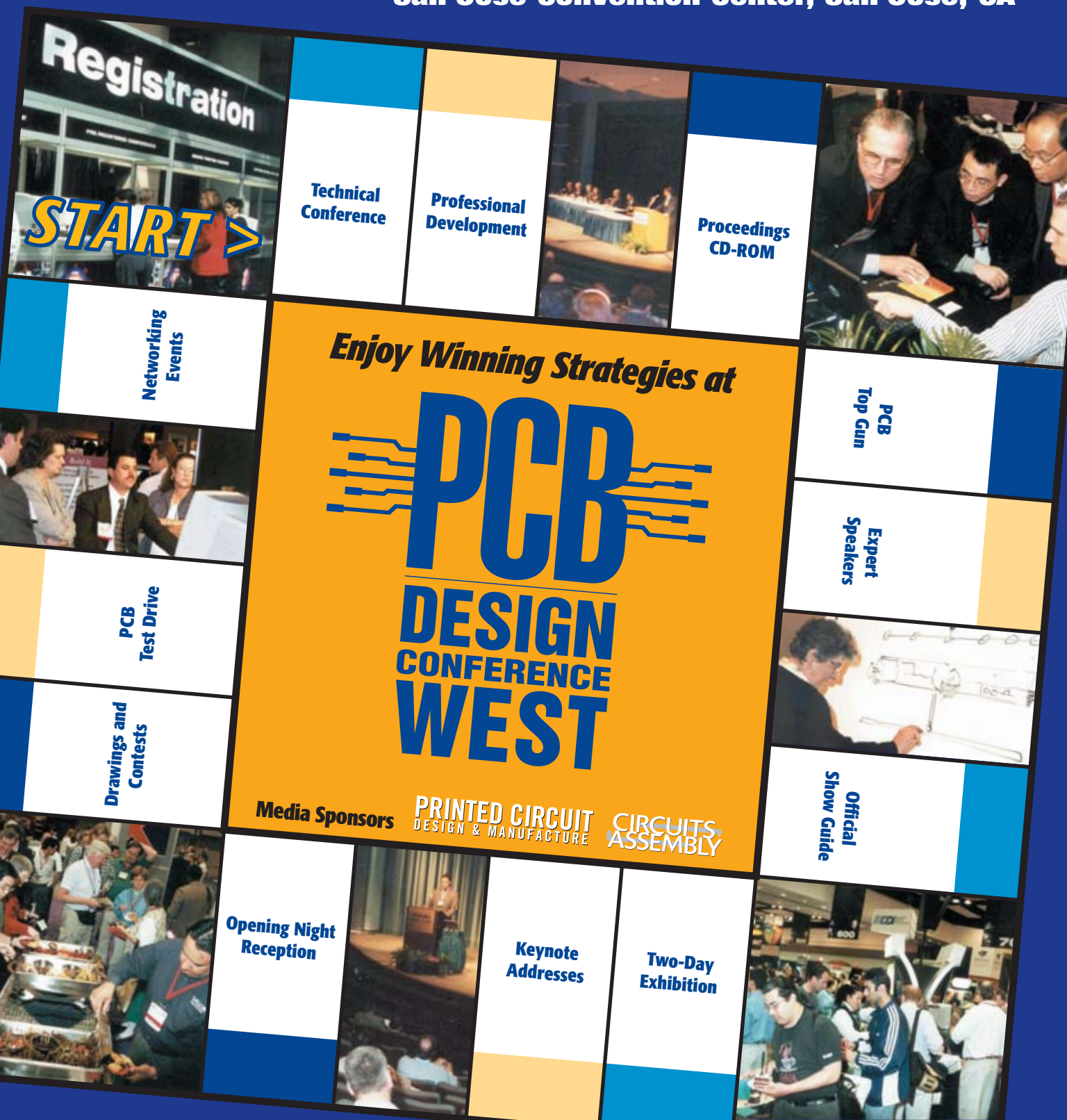

Curing - UV lamps

Advanced Radiation Corporation
Dymax Corporation

Depaneling Equipment

Depaneling Equipment - Automated

AIC Technologies, Inc.
Anorad, Rockwell Automation
ASYS Automation LLC
CAB Technology Inc.

Fancort Industries, Inc.

PCB depaneling equipment for scored and tab routed boards; PCB handling racks; PCB assembly fixtures; Pulse bonders for flex circuits; Robotic point and line soldering systems; SM Lead Forming Equipment.

PMJ Automec
Radoll Designs
Tyco Electronics

Depaneling Equipment - Mechanical

AIC Technologies, Inc.
American Hakko Products, Inc.
Fancort Industries, Inc.
HEPCO Inc.
NIX of America
Radoll Designs
T-Tech, Inc.
Tyco Electronics
Waveroom Plus

Depaneling Equipment - Scoring

Fancort Industries, Inc.
Radoll Designs
Tyco Electronics

Discrete Wiring Production Systems

Palomar Technologies

Dispensing

Dispensing - Automatic

Air-Vac Engineering
Anorad, Rockwell Automation

Asymtek

Asymtek is a world leader in the design and manufacture of automated fluid dispensing systems. Products range from benchtop dispensers and stand-alone dispensing workstations to fully automated, in-line conveyorized systems for semiconductor package assembly and printed circuit board packaging. Asymtek also manufactures dispensing systems for medical and industrial manufacturing.

ASYS Automation LLC
Component Express Corporation
ESSEMTEC (USA) LLC
GPD Global
Manncorp
Newport Corporation
OK International
Palomar Technologies
Sealant Equipment & Engineering, Inc.
Speedline Technologies, Inc.
Start International
Techcon Systems
Tyco Electronics
Ultrasonic Systems Inc.

Dispensing - Dispensers - Manual

ERSA Inc.
Manncorp
OK International
Semiconductor Equipment Corp.

Dispensing - Dispensers - Positive displacement

Anorad, Rockwell Automation
Creative Automation Company
DL Technology
ESSEMTEC (USA) LLC
GPD Global
Manncorp
MIMOT
OK International
Sealant Equipment & Engineering, Inc.
Ultrasonic Systems Inc.
Universal Instruments
Waveroom Plus

Dispensing - Dispensers - Pressure

Ultrasonic Systems Inc.

Dispensing - Dispensers - Semiautomatic

Anorad, Rockwell Automation
ASYS Automation LLC
Speedline Technologies, Inc.
Ultrasonic Systems Inc.

ID Systems

ID Systems - Barcode

CIMCIS, Ltd.
Identco

Polyonics

Polyonics manufactures kapton and polyimide labels for bar code identification of PCBs. Thermogard 555, 562, 565, and 570 can be used in direct contact with solder in wave soldering manufacturing processes. Anti-static Thermogard polyimide labels resist buildup of ESD. Polyonics' materials can be used with most industrial thermal transfer printers and with a variety of thermal transfer ribbons.

ID Systems - Barcode labels

Computype, Inc.
Identco

Polyonics

Polyonics manufactures kapton and polyimide labels for bar code identification of PCBs. Thermogard 555, 562, 565, and 570 can be used in direct contact with solder in wave soldering manufacturing processes. Anti-static Thermogard polyimide labels resist buildup of ESD. Polyonics' materials can be used with most industrial thermal transfer printers and with a variety of thermal transfer ribbons.

Zebra Technologies

ID Systems - Barcode printers

CAB Technology Inc.
CIMCIS, Ltd.
Identco
Zebra Technologies

ID Systems - Barcode scanners

CIMCIS, Ltd.
Identco

Microscan

Microscan fixed position bar code scanners and 2-D readers are compact, high speed, and ideal for automated tracking.

ID Systems - Barcode software

CAB Technology Inc.
CIMCIS, Ltd.
Coreco Imaging
Identco
Zebra Technologies

ID Systems - Component marking

American Coding & Marking Ink Co., Inc.
Identco
Polyonics
Sprinter Marking, Inc.

ID Systems - Label application systems

ASYS Automation LLC
CAB Technology Inc.
Identco
Polyonics
Tyco Electronics

ID Systems - Laser marking inks

Polyonics

ID Systems - Laser marking systems

AIC Technologies, Inc.
ASYS Automation LLC
CAB Technology Inc.
Unitek Miyachi Corp.

Inspection

Inspection - Accessories

Airline/Ovation Products
RVSI

Inspection - Automatic solder joint - IR

Anorad, Rockwell Automation

Inspection - Automatic solder joint - Laser

Anorad, Rockwell Automation

Inspection - Automatic solder joint - Optical/vision

Agilent Technologies
Cognex Corp.
CyberOptics Corp.
Machine Vision Products, Inc.
OK International
Omron Electronics LLC
Orbotech Inc.
Qualectron Systems Corp.
Smart Sonic Stencil Cleaning Systems
Teradyne, Assembly Test Division
Testronics
Tyco Electronics
Vectron Inc.
Viscom Inc.
ViTechnology

Inspection - Automatic solder joint - X-ray

Agilent Technologies
Anorad, Rockwell Automation
Dage Precision Industries
FocalSpot, Inc.
phoenix | x-ray Systems + Services Inc.
Teradyne, Assembly Test Division
V.J. ElectroniX
YESTech, Inc.

Inspection - Coplanarity equipment

Anorad, Rockwell Automation
ERSA Inc.
Orbotech Inc.
RVSI
Smart Sonic Stencil Cleaning Systems

Inspection - Loaded board systems

Agilent Technologies
Anorad, Rockwell Automation
CyberOptics Corp.
DiagnoSYS, Inc.
Orbotech Inc.
Qualectron Systems Corp.
Teradyne, Assembly Test Division
Testronics

Inspection - Magnifiers and accessories

All-Spec Industries
ERSA Inc.
ESD MagEyes magnifiers
OC White Company
Qualectron Systems Corp.
Sunnex, Inc.
Vision Engineering, Inc.
Waveroom Plus

Inspection - Manual solder tooling - X-ray

ERSA Inc.
Glenbrook Technologies, Inc.
PACE Inc.
phoenix | x-ray Systems + Services Inc.
V.J. ElectroniX

Inspection - Microphotography equipment

ERSA Inc.

Inspection - Microscope - Acoustic - Electronic

Qualectron Systems Corp.

Inspection - Microscope lights and accessories

All-Spec Industries
Anorad, Rockwell Automation
Luxo Corporation
Meiji Techno America
OC White Company

Inspection - Semiautomatic solder joint

CyberOptics Corp.
Qualectron Systems Corp.

Inspection - Solder paste equipment

Airline/Ovation Products
Anorad, Rockwell Automation
LPKF Laser & Electronics, North America
Manix Manufacturing, Inc.
Omron Electronics LLC

Panasonic Factory Automation Company

Panasonic Factory Automation Company is a premier equipment supplier for electronics and advanced microelectronics assemblies. Our core competencies include software, training and full service support solutions. Our sales and service facilities span throughout North America to support our customers.

Tyco Electronics

Inspection - Solder paste inspection

Agilent Technologies
Airline/Ovation Products
Anorad, Rockwell Automation
ASC Intrernational
Cognex Corp.
CyberOptics Corp.
DEK International GmbH
ERSA Inc.
Orbotech Inc.
Smart Sonic Stencil Cleaning Systems
Testronics
ViTechnology

Inspection - Stations - Manual

CyberOptics Corp.
ERSA Inc.
FocalSpot, Inc.
JOT Automation Inc.
Manncorp
PACE Inc.
Qualectron Systems Corp.
RVSI
Terra Universal, Inc.
Unit Design, Inc.
ViTechnology

Inspection - Stations - Semiautomatic

Airline/Ovation Products
CyberOptics Corp.
FeinFocus USA, Inc.
FocalSpot, Inc.
Qualectron Systems Corp.
RVSI
ViTechnology

Inspection - Stereo viewers - Microscope

Leica Microsystems Inc.
Meiji Techno America
OC White Company

Inspection - Vision systems

Anorad, Rockwell Automation
Christopher Group Inc.
Cognex Corp.
CyberOptics Corp.
DEK International GmbH
ERSA Inc.
Europlacer
Meiji Techno America
Metcal
OC White Company
OK International
Omron Electronics LLC
Optical Gaging Products, Inc.
Orbotech Inc.
Q Corporation
Qualectron Systems Corp.
RVSI
Technology Information Corporation
Teradyne, Assembly Test Division
Tyco Electronics
Vectron Inc.
View Engineering Inc
ViTechnology

Manual Assembly

Manual Assembly - Hand lotion

All-Spec Industries
Mouser Electronics

Manual Assembly - Hand tools

All-Spec Industries
Beau Tech, Inc
Cooper Tools
Manix Manufacturing, Inc.
Micro Care Corporation
Mouser Electronics
T-Tech, Inc.

Manual Assembly - Modular workstations

All-Spec Industries

Finetech
InterMetro Industries Corp.
JOT Automation Inc.
Pro-mation, Inc.
T-Tech, Inc.

Manual Assembly - Progressive assembly systems

Fancort Industries, Inc.
JOT Automation Inc.
SCHMIDT Feintechnik Corp.
T-Tech, Inc.

Manufacturers' Representatives

All-Spec Industries
ARi Industries, Inc.
Assembly Resource
BesTech, Inc.
Contact East Inc.
CR Tech, LLC
De Armond Enterprises
Elite Industrial Group
Hadden Assoc. Inc.
Hartman Associates
Hitech
Ibars Electronics Corporation
Industrial Indexing Systems Inc.
JMW Enterprises, Inc.
Kasion Automation Ltd.
Kirby & Demarest
Matthew Associates, Inc.
MDI Corp.
Pacothane Technologies
Partners in Technology Inc.
Petlock, Inc.
Products International Inc.
Qualmax
Technical Resources Corp.
Techsystems International, Inc.
Techsystems NW
The ECM Group, LLC
Transtechnology Pte Ltd
Waveroom Plus
West Tech Inc.
WittcoSales, Inc.

Material Handling

Material Handling - Automatic guided vehicles

SICK, Inc.

Material Handling - Automatic storage and retrieval systems

Cogiscan Inc.
NIX of America
SICK, Inc.
Terra Universal, Inc.

Material Handling - Boxes and racks

3M Electronic and Interconnect Solutions
All-Spec Industries
CAB Technology Inc.
Fancort Industries, Inc.
InterMetro Industries Corp.
NIX of America
Waveroom Plus

Material Handling - Carts

All-Spec Industries
DEK International GmbH
InterMetro Industries Corp.
Manix Manufacturing, Inc.
NIX of America
Terra Universal, Inc.

Material Handling - Computerized

Cogiscan Inc.
JOT Automation Inc.

Material Handling - Conveyors - Production line

AIC Technologies, Inc.
ASYS Automation LLC
JOT Automation Inc.
Manncorp
Pro-mation, Inc.
SICK, Inc.

Siemens Dematic Material Handling Automation
Tyco Electronics

Material Handling - Magazine loaders/ unloaders

AIC Technologies, Inc.
ASYS Automation LLC
ESSEMTEC (USA) LLC
JOT Automation Inc.
NIX of America
Pro-mation, Inc.
Q Corporation

Material Handling - Robots

JOT Automation Inc.
NIX of America
SICK, Inc.

Material Handling - Shipping containers

All-Spec Industries

Material Handling - Systems

Cogiscan Inc.
JOT Automation Inc.
PIAB Vacuum Products
Pro-mation, Inc.
SICK, Inc.
Tyco Electronics

Pick-and-Place Equipment

Pick-and-Place Equipment - Assembly robots

Adept Technology Inc.
Advanced Automation, LLC
Air-Vac Engineering
Anorad, Rockwell Automation
JOT Automation Inc.
Technology Information Corporation
Tyco Electronics

Pick-and-Place Equipment - Component placement tools

Airline/Ovation Products
Anorad, Rockwell Automation
Hover-Davis, Inc.
Newport Corporation
Palomar Technologies
Production Solutions, Inc.
T-Tech, Inc.
Technology Information Corporation
Tyco Electronics

Pick-and-Place Equipment - Fine pitch

Advanced Automation, LLC
AIC Technologies.com
Anorad, Rockwell Automation
Contact Systems
Datacon North America, Inc.
Dynatech-Samsung
Europlacer
Finetech
Fuji America Corporation
Manix Manufacturing, Inc.
Manncorp
Palomar Technologies

Samsung Technology, Inc.
Siemens Dematic
Technology Information Corporation
Tyco Electronics
Universal Instruments

Pick-and-Place Equipment - High volume

Advanced Automation, LLC
Anorad, Rockwell Automation
Dynatech-Samsung
Europlacer
Fuji America Corporation
Juki Automation Systems
K3 Equipment LLC
Manix Manufacturing, Inc.
Newport Corporation
Palomar Technologies

Samsung Technology, Inc.

Technology Information Corporation
Transtechnology Pte Ltd
Universal Instruments

Pick-and-Place Equipment - Low volume

Advanced Automation, LLC
AIC Technologies.com
Air-Vac Engineering
Anorad, Rockwell Automation
Contact Systems
Dynatech-Samsung
ESSEMTEC (USA) LLC
Europlacer
Manix Manufacturing, Inc.
Manncorp
Samsung Technology, Inc.
Semiconductor Equipment Corp.
Technology Information Corporation
Tyco Electronics
Universal Instruments

Pick-and-Place Equipment - Manual

Advanced Automation, LLC
AIC Technologies, Inc.
Anorad, Rockwell Automation
ESSEMTEC (USA) LLC
Finetech
LPKF Laser & Electronics, North America
Manncorp
Semiconductor Equipment Corp.
T-Tech, Inc.
Technology Information Corporation

Pick-and-Place Equipment - Medium volume

Advanced Automation, LLC
AIC Technologies, Inc.
Anorad, Rockwell Automation
Automated Production Systems, Inc.
Contact Systems
Dynatech-Samsung
ESSEMTEC (USA) LLC
Europlacer
Fuji America Corporation
Manix Manufacturing, Inc.
Manncorp

MYDATA Automation, Inc.
Samsung Technology, Inc.
Siemens Dematic
Technology Information Corporation
Tyco Electronics
Universal Instruments

Pick-and-Place Equipment - Odd form

3M Electronic and Interconnect Solutions
Advanced Automation, LLC
Anorad, Rockwell Automation
Assembléon America
Component Express Corporation
Contact Systems
Dynatech-Samsung
Europlacer
GPAX, Ltd.
Palomar Technologies

Samsung Technology, Inc.
Technology Information Corporation
Tyco Electronics
Universal Instruments

Reflow Soldering Equipment

Reflow Soldering Equipment - Computer controlled reflow

Advanced Automation, LLC
AIC Technologies, Inc.
Conceptronic Inc.
ECD Inc.
ESSEMTEC (USA) LLC
Heller Industries Inc.
Manix Manufacturing, Inc.
Rehm USA, LLC
SEHO USA Inc.
T-Tech, Inc.
Technology Information Corporation
Tyco Electronics
Vitronics Soltec Inc.

Reflow Soldering Equipment - Conduction

Sikama International Inc.
Technology Information Corporation

Reflow Soldering Equipment - Convection

A.P.E.
Advanced Automation, LLC
AIC Technologies, Inc.
Automated Production Systems, Inc.
BTU International
Conceptronic Inc.
ESSEMTEC (USA) LLC
Heller Industries Inc.
LPKF Laser & Electronics, North America
Manix Manufacturing, Inc.
Manncorp
Novastar Technologies, Inc.
Rehm USA, LLC
SEHO USA Inc.
Speedline Technologies, Inc.
T-Tech, Inc.
Technology Information Corporation
Tomken Industries
Tyco Electronics
Vitronics Soltec Inc.

Reflow Soldering Equipment - Fixtures

Airline/Ovation Products
MB Manufacturing
S.P. Precision International
Technology Information Corporation

Reflow Soldering Equipment - Hot bar

A.P.E.
Fancort Industries, Inc.
Technology Information Corporation
Unitek Miyachi Corp.

Reflow Soldering Equipment - Inert gas

SEHO USA Inc.
Technology Information Corporation
Tomken Industries
Vitronics Soltec Inc.

Reflow Soldering Equipment - Inert gas atmosphere

AIC Technologies, Inc.
Air Liquide
BTU International
Heller Industries Inc.
SEHO USA Inc.
Technology Information Corporation
Vitronics Soltec Inc.

Reflow Soldering Equipment - Infrared

SEHO USA Inc.
Technology Information Corporation
Tomken Industries
Vitronics Soltec Inc.

Reflow Soldering Equipment - Infrared - Panel

Technology Information Corporation

Reflow Soldering Equipment - Laser

Technology Information Corporation

Reflow Soldering Equipment - Oven profiling equipment

ECD Inc.
ESSEMTEC (USA) LLC
Manncorp
Sun Electronic Systems, Inc
T-Tech, Inc.
Technology Information Corporation
Vitronics Soltec Inc.

Reflow Soldering Equipment - Single-point soldering

Fancort Industries, Inc.
Technology Information Corporation
Vitronics Soltec Inc.

Reflow Soldering Equipment - Thermal profiling equipment

Datapaq, Inc.
ECD Inc.
KIC
Manncorp
Sun Electronic Systems, Inc
Technology Information Corporation
Vitronics Soltec Inc.

Reflow Soldering Equipment - Vapor phase

AIC Technologies, Inc.
R&D Technical Services
Technology Information Corporation

Reflow Soldering Equipment - Vapor phase filtration system

Impell
OK International
Technology Information Corporation

Rework and Repair

Rework and Repair - Component removal tools

A.P.E.
AIC Technologies, Inc.
All-Spec Industries
American Hakko Products, Inc.
FocalSpot, Inc.
LPKF Laser & Electronics, North America
Mouser Electronics
PACE Inc.
Technology Information Corporation
ViTechnology

Rework and Repair - Computerized repair systems

A.P.E.
Air-Vac Engineering
Conceptronic Inc.
Manix Manufacturing, Inc.
Manncorp
T-Tech, Inc.
Technology Information Corporation
Tyco Electronics

Rework and Repair - Desoldering tools and workstations

A.P.E.
All-Spec Industries
American Hakko Products, Inc.
Finetech
FocalSpot, Inc.
LPKF Laser & Electronics, North America
Metcal
Mouser Electronics
PACE Inc.
Plato Products Inc.
Technology Information Corporation

Rework and Repair - Rework and repair stations

A.P.E.
AIC Technologies, Inc.
Air-Vac Engineering
All-Spec Industries
American Hakko Products, Inc.
ASYS Automation LLC
Conceptronic Inc.
Finetech
FocalSpot, Inc.
Integral Automation
Manix Manufacturing, Inc.
Manncorp
OK International
PACE Inc.
PDR
Plato Products Inc.
Semiconductor Equipment Corp.
Technology Information Corporation
ViTechnology
Waveroom Plus

Rework and Repair - Rework and repair tools

A.P.E.
AIC Technologies, Inc.
All-Spec Industries
American Hakko Products, Inc.
Beau Tech, Inc
Crystal Mark, Inc.
Easy Braid Co.
HEPCO Inc.
Metcal
Micro Care Corporation
OK International
PACE Inc.
Plato Products Inc.
Technology Information Corporation
Tecnomatix Unicam
ViTechnology

Rework and Repair - Soldering braid

All-Spec Industries
Brim Electronics Inc.
Easy Braid Co.
Mouser Electronics
PACE Inc.
Technology Information Corporation

Screen Printing

Screen Printing - Emulsions

Beam On Technology
DEK USA Inc

Screen Printing - Frames

Beam On Technology
Cookson Electronics
DEK International GmbH
LPKF Laser & Electronics, North America

Screen Printing - Screen cleaning equipment

Advanced Automation, LLC
DEK International GmbH
Easy Braid Co.
JNJ Industries, Inc.
Manncorp
Micro Care Corporation
Smart Sonic Stencil Cleaning Systems
Spraying Systems Co.
T-Tech, Inc.
Tyco Electronics

Screen Printing - Screen printers - Adhesives

ASYS Automation LLC
DEK International GmbH
EKRA America
Epoxy Technology
Milara Inc.

Screen Printing - Screen printers - Automatic

Advanced Automation, LLC
Affiliated Manufacturers, Inc.
Anorad, Rockwell Automation
ASYS Automation LLC
DEK International GmbH

EKRA
Material Deposition Technology

EKRA America

A market leader in Europe for over 50 years, EKRA designs and manufactures screen printing solutions for the SMT, Hybrid, Semiconductor Packaging, and Solar industries. EKRA focuses on useful technology development that provides real benefit to customer processes. Efficiency, ease of use, and reliability are characteristics designed into every EKRA product.

ESSEMTEC (USA) LLC
K3 Equipment LLC
Milara Inc.
Minami America Inc.
Ovation Products

Panasonic
ideas for life

Panasonic Factory Automation Company

Panasonic Factory Automation Company is a premier equipment supplier for electronics and advanced microelectronics assemblies. Our core competencies include software, training and full service support solutions. Our sales and service facilities span throughout North America to support our customers.

Speedline Technologies, Inc.
Surface Mount Techniques

Screen Printing - Screen printers - Semiautomatic

Advanced Automation, LLC
Anorad, Rockwell Automation
ASYS Automation LLC
Automated Production Systems, Inc.
DEK International GmbH
EKRA America
ESSEMTEC (USA) LLC
LPKF Laser & Electronics, North America
Manncorp
Milara Inc.
Minami America Inc.
RPAmericas
Speedline Technologies, Inc.
Tyco Electronics

Screen Printing - Screen printers- Manual

Advanced Automation, LLC
AIC Technologies, Inc.
EKRA America
ESSEMTEC (USA) LLC
LPKF Laser & Electronics, North America
Manix Manufacturing, Inc.
Manncorp
Milara Inc.
T-Tech, Inc.

Screen Printing - Screens

Beam On Technology
DEK International GmbH
Minami America Inc.

Screen Printing - Screens - Imaged

DEK International GmbH

Screen Printing - Squeegees

DEK International GmbH
Easy Braid Co.
EKRA America
JNJ Industries, Inc.
Minami America Inc.
Transition Automation, Inc.

Screen Printing - Stencils

A-Laser, Inc.
Beam On Technology
Cookson Electronics
DEK International GmbH
LPKF Laser & Electronics, North America
Minami America Inc.
Tecan Ltd

Tech-Source International, Inc.

Tech-Source offers the *T3* Series Solder Stencil Cutting Systems.

T3 is the next generation of laser based stencil cutting machines.

Designed by and for stencil manufacturers, T3 Series machines provide the precision and performance needed in today's competitive environment.

Ease of use and efficiency in operation characterize the T3.

Screen Printing - Stripping equipment

Spraying Systems Co.

Screen Printing - Tension meters

Beam On Technology

Services

Services - Board fabrication

Ace Tech Circuit (ATC) - Americas Sales

Ace Tech Circuit (ATC) is a Korean PCB manufacturer specializing in:
* Impedance Controlled Boards (Probe Cards)
* Burn-in Boards
* Multilayer Boards
* Back Plane Boards
* Build Up Boards

We emphasize long-lasting customer relationships and our commitment to:
* Quality
* Supplying lower prices
* On-time delivery

Advanced Circuits
Pacothane Technologies
PD Circuits, Inc.
Sierra Proto Express
Teradyne Connection Systems
Tracewell Systems
Tyco Electronics
Vitel Technologies, Inc.

Services - Component engineering

Centron Industries, Inc.
Pinnacle Electronics
Signus Radiancy Ltd
Sinbon Technologies

Services - Component preparation

Fancort Industries, Inc.
GPAX, Ltd.
Pinnacle Electronics
Sinbon Technologies
Vitel Technologies, Inc.

Services - Conformal coating

Vitel Technologies, Inc.

Services - Consulting

Agilent Technologies
Asian High Technology Group, Inc.
Ceeris International Inc.
CIMCIS, Ltd.
Circuit Search
Engelmaier Assoc., L.C.
FocalSpot, Inc.
Foresite, Inc.
GE Global Electronics Solutions
ITM Consulting
Les Hymes Associates -The Complete Connection
Matthew Associates, Inc.
Pacothane Technologies
Pinnacle Electronics
Soldering Technology Intl.
Sonoscan, Inc.
Speedline Technologies, Inc.
Technology Information Corporation
Vitel Technologies, Inc.
Waterfall Technologies

Services - Depaneling

Fancort Industries, Inc.
Vitel Technologies, Inc.

Services - Design bureau

C&B PWB Design Services, Inc.
Engelmaier Assoc., L.C.
Nelson Design Services, Inc.
PCB Design Express
Pinnacle Electronics
Vitel Technologies, Inc.

Services - Education and training

Agilent Technologies
DMG Engineering
Engelmaier Assoc., L.C.
Excel Enterprises LP
Festo Corporation
GOEPEL ELectronics LLC
Surface Mount Technology Association
Soldering Technology Intl.
Sonoscan, Inc.
Speedline Technologies, Inc.
Technology Information Corporation
Vitronics Soltec Inc.
Waterfall Technologies

Services - Flip chip assembly services

ASAT Inc.
Pinnacle Electronics

Services - Laser repair and service

CCT Laser Services, Inc.
Unitek Miyachi Corp.

Services - Lead preparation

GPAX, Ltd.

Services - Panel scoring

Radoll Designs

Services - PCB assembly

Alpha Circuits
Amistar Corp.
ANC Technology
Electrical Insulation Suppliers
Express Manufacturing, Inc.
Global Communications
IEC Electronics
Key Electronics
MB Manufacturing
Milara Inc.
Pinnacle Electronics
Preco Electronics, Inc.
Qual-Pro Corporation
Qualcon
Reptron Electronics, Inc.
Sinbon Technologies
Teltronics, Inc.
Teradyne Connection Systems
The Morey Corporation
Tracewell Systems
Vitel Technologies, Inc.

Services - PCB repair and modification

FinePoint, Inc.
FocalSpot, Inc.
Pinnacle Electronics
Quality Circuits, Inc.
Vitel Technologies, Inc.

Services - Screen and stencil manufacturing

DEK International GmbH
Integrated Ideas & Technologies, Inc.
LPKF Laser & Electronics, North America

Services - Systems integration

Agilent Technologies
Anorad, Rockwell Automation
FocalSpot, Inc.
Pinnacle Electronics
Teradyne Connection Systems
Tracewell Systems
Tyco Electronics
Unitek Miyachi Corp.

Services - Test labs

DiagnoSYS, Inc.
ESSC Test Laboratory
FocalSpot, Inc.
Foresite, Inc.
phoenix | x-ray Systems + Services Inc.
Pinnacle Electronics
SCOPE Laboratory
Sonoscan, Inc.
Waterfall Technologies

Services - Testing

DiagnoSYS, Inc.
Engelmaier Assoc., L.C.
FocalSpot, Inc.
phoenix | x-ray Systems + Services Inc.
Pinnacle Electronics
Reptron Electronics, Inc.
Sonoscan, Inc.
TestCrafters Inc.
Vitel Technologies, Inc.
W. M. Hague Co., Inc.

Services - Used and refurbished equipment

Agilent Technologies
DoveBid, Inc.
GE Global Electronics Solutions
Henry Butcher International Ltd.
Hi-Tech Sources
Lewis and Clark, Inc.
phoenix | x-ray Systems + Services Inc.
Pinnacle Electronics
Smart Sonic Stencil Cleaning Systems
Sun Electronic Systems, Inc

Software

Software - CAD interface

Aegis Industrial Software Corp.
Agilent Technologies
LPKF Laser & Electronics, North America
Tecnomatix Unicam
Tyco Electronics

Software - CIM linking software

Aegis Industrial Software Corp.
CIMCIS, Ltd.
GraphiCode

Tecnomatix Unicam

The award-winning eM-Assembly Expert is the industry-leading tool for improving electronics manufacturers' New Product Introduction processes. A completely integrated, single solution for assembly and test programming, documentation creation and parametric optimization, the new release also integrates with an exclusive vendor part library, providing the only complete electronics NPI solution on the market.

Software - Enterprise Resource Planning (ERP)

Motorola, Mfg Software Strategic Bus Unit

Software - Manufacturing Execution System (MES)

Aegis Industrial Software Corp.
Arena Solutions
CIMCIS, Ltd.
ESSEMTEC (USA) LLC
Motorola, Mfg Software Strategic Bus Unit

Tecnomatix Unicam

eMPower Execution Systems comprise an end-to-end Web-based solution set for real-time collecting, sharing, and analyzing of manufacturing process data, and the managing of assembly operations performance across the extended enterprise. The applications provide drill-down capabilities with real-time access to shop-floor information for proactive, data-driven visibility and knowledge management.

Valor Computerized Systems, Inc.

Valor Computerized Systems' powerful software tools based on ODB++ ensure the rapid transfer of optimized data from design to manufacture. Enterprise 3000 DFM system for physical design verification, Trilogy 5000 for assembly and test engineering, and the Valor Parts Library 24/7 on-line data service deliver enhanced productivity, higher yields, shorter cycle times and increased product quality.

Visiprise

Software - Materials Resource Planning (MRP)

Motorola, Mfg Software Strategic Bus Unit

Software - Supply Chain Management (SCM)

ASAP, Inc.
SupplyWorks, Inc.

Solder Mask

Solder Mask - Dry film

DuPont Co.
Enthone Inc., a Cookson Electronics Company

Solder Mask - Liquid photoimageable

Enthone Inc., a Cookson Electronics Company

Solder Mask - Screenable

Enthone Inc., a Cookson Electronics Company

Solder Mask - Wet/dry

HumiSeal Div. of Chase Corp.

Soldering Equipment

Soldering Equipment - Hand - Flux dispensers - Bubble

Technology Information Corporation

Soldering Equipment - Hand - Flux dispensers - Spray

Spraying Systems Co.
Technology Information Corporation
Ultrasonic Systems Inc.

Soldering Equipment - Hand - Flux dispensers - Ultrasonic

Sono-Tek Corporation
Technology Information Corporation
Ultrasonic Systems Inc.

Soldering Equipment - Hand - Fume control

All-Spec Industries
American Hakko Products, Inc.
Impell
Metcal
OC White Company
OK International
PACE Inc.
Terra Universal, Inc.
Waveroom Plus

Soldering Equipment - Hand - Solder dispensers

All-Spec Industries
Plato Products Inc.

Soldering Equipment - Hand - Soldering iron holders

American Hakko Products, Inc.
Mouser Electronics
PACE Inc.

Soldering Equipment - Hand - Soldering irons - Temperature control

A.P.E.

HAKKO®

American Hakko Products, Inc.

American Hakko provides superior quality products for the electronics, industrial and consumer electronics industry, inclucing temperature controlled soldering, desoldering and rework systems for through-hole and surface-mount, smoke and fume extraction systems, CHP brand hand tools, and technical training.

Metcal
Mouser Electronics
OK International
PACE Inc.
Waveroom Plus

Soldering Equipment - Hand - Soldering irons and guns

A.P.E.
All-Spec Industries
American Hakko Products, Inc.
Easy Braid Co.
Metcal
Mouser Electronics
PACE Inc.

Soldering Equipment - Hand - Tip cleaning equipment

Mouser Electronics
PACE Inc.
Plato Products Inc.

Soldering Equipment - Hand - Tips

A.P.E.
All-Spec Industries
American Hakko Products, Inc.
Metcal
Mouser Electronics
OK International
PACE Inc.
Plato Products Inc.

Soldering Equipment - Through-Hole - Dip

PACE Inc.
Technology Information Corporation
Tyco Electronics
Unit Design, Inc.
Vitronics Soltec Inc.

Soldering Equipment - Through-Hole - Drag

PACE Inc.
Technology Information Corporation
Unit Design, Inc.

Soldering Equipment - Through-Hole - Dual Wave

Advanced Automation, LLC
AIC Technologies, Inc.
Manncorp
Novastar Technologies, Inc.
SEHO USA Inc.
Sensbey, Inc.
Six Sigma
Technical Devices Company
Technology Information Corporation
Tomken Industries

Soldering Equipment - Through-Hole - Flux hydrometers

Sensbey, Inc.
Technology Information Corporation
Waveroom Plus

Soldering Equipment - Through-Hole - Inert gas

Technology Information Corporation
Vitronics Soltec Inc.

Soldering Equipment - Through-Hole - Inert gas atmosphere

AIC Technologies, Inc.
Air Liquide

SEHO USA Inc.
Sensbey, Inc.
Technology Information Corporation
Vitronics Soltec Inc.

Soldering Equipment - Through-Hole - Laser

Applied Thermal Solutions
LPKF Laser & Electronics, North America
Pro-mation, Inc.
Technology Information Corporation

Soldering Equipment - Through-Hole - Lead stabilizing equipment

Technology Information Corporation

Soldering Equipment - Through-Hole - Modified Wave

AIC Technologies, Inc.
Technology Information Corporation
Tyco Electronics
Vitronics Soltec Inc.

Soldering Equipment - Through-Hole - Single point soldering

A.P.E.
AIC Technologies, Inc.
Automated Production Systems, Inc.
ECD Inc.
Exselect Engineering
Fancort Industries, Inc.
Global Automation, Inc.
SEHO USA Inc.
Technology Information Corporation
Tyco Electronics
Unit Design, Inc.

Soldering Equipment - Through-Hole - Solder cut systems

Sensbey, Inc.
Technology Information Corporation

Soldering Equipment - Through-Hole - Solder pots

Air-Vac Engineering
American Hakko Products, Inc.
Plato Products Inc.
Sensbey, Inc.
Technology Information Corporation
Waveroom Plus

Soldering Equipment - Through-Hole - Thermal profiling equipment

Technology Information Corporation
Vitronics Soltec Inc.

Soldering Equipment - Through-Hole - Wave

Advanced Automation, LLC
Manncorp
SEHO USA Inc.
Speedline Technologies, Inc.
Tamura H.A. System Inc.
Technical Devices Company
Technology Information Corporation
Tomken Industries
Vitronics Soltec Inc.

Soldering Equipment - Through-Hole - Wave - Computer Controlled

AIC Technologies, Inc.
Novastar Technologies, Inc.
SEHO USA Inc.
Sensbey, Inc.
Technical Devices Company
Technology Information Corporation
Vitronics Soltec Inc.

Soldering Equipment - Through-Hole - Wave - Fixtures

EMC Global Technologies, Inc.
MB Manufacturing
S.P. Precision International
Sono-Tek Corporation
Technology Information Corporation
Waveroom Plus

Soldering Equipment - Through-Hole - Wave - Inert gas

AIC Technologies, Inc.
Air Liquide
SEHO USA Inc.
Technical Devices Company
Technology Information Corporation
Vitronics Soltec Inc.

Soldering Equipment - Through-Hole - Wave - Retrofit controls

Technology Information Corporation

Soldering Masks

Soldering Masks - Temporary - Dispensing equipment

GPD Global
Spraying Systems Co.
Waveroom Plus

Soldering Masks - Temporary - Peelable materials

HumiSeal Div. of Chase Corp.
Waveroom Plus

Soldering Masks - Temporary - Tab protectors

Dynamic Technologies

Soldering Masks - Temporary - Tape

HumiSeal Div. of Chase Corp.

Soldering Masks - Temporary - Water-soluble materials

Mouser Electronics

Soldering Materials

Soldering Materials - Dross reducing agents

AIM
Amtech, Inc.
Enthone Inc., a Cookson Electronics Company
Qualitek International Inc.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Fluxes

A.P.E.
AIM
All-Spec Industries
Amtech, Inc.
Cookson Electronics

EFD, a Nordson Company

EFD provides FluxPlus paste flux for clean, controlled electronic rework applications. FluxPlus may be printed or dispensed and is a fluxing solution for BGA re-balling and pre-bumping applications. FluxPlus is the controlled, cost effective alternative to messy, liquid fluxes.

Henkel Loctite Corporation
Kester Northrop Grumman
Mouser Electronics
Qualitek International Inc.
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Ultrasonic Systems Inc.
Waveroom Plus

Soldering Materials - Fluxes - Low solids

AIM
Amtech, Inc.
Mouser Electronics
Qualitek International Inc.
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Ultrasonic Systems Inc.
Waveroom Plus

Soldering Materials - Solder - Bar

AIM
All-Spec Industries
Cookson Electronics
Enthone Inc., a Cookson Electronics Company
Kester Northrop Grumman
Mouser Electronics
P. Kay Metal, Inc.
Qualitek International Inc.
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Solder - Lead-free

AIM
Amtech, Inc.
Asahi Technologies America, Inc.
Cookson Electronics

EFD, a Nordson Company

EFD provides a full range of printable and dispensable lead-free solder pastes including tin/silver, tin/silver/copper, tin/antimony and tin/bismuth compositions addressing a temperature range from 138 to 245 degrees C.

Enthone Inc., a Cookson Electronics Company
Henkel Loctite Corporation
Kester Northrop Grumman
Qualitek International Inc.
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Solder - Wire

AIM
Cookson Electronics
Kester Northrop Grumman
Mouser Electronics
Qualitek International Inc.
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Solder paste - Aqueous

AIM
Kester Northrop Grumman
Mouser Electronics
Qualitek International Inc.
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Solder paste - No clean

A.P.E.
AIM
All-Spec Industries
Amtech, Inc.
Cookson Electronics

EFD, a Nordson Company

EFD provides SolderPlus and PrintPlus solder paste for dispensing and printing applications. Both are available with a no-clean (NC), low-residue flux system. The clear, hard, non-tack residue is non-corrosive and non-conductive and is designed to be left in place on the part. NC residue may be removed with a solvent if required.

Heraeus Inc. Circuit Materials Division
Kester Northrop Grumman
Mouser Electronics
Qualitek International Inc.
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Solder paste - Rosin-based

AIM
All-Spec Industries
Amtech, Inc.

EFD, a Nordson Company

EFD provides SolderPlus and PrintPlus solder paste for dispensing and printing applications. Both are available with RMA (rosin mildly activated) flux systems. Suited for easily solderable surfaces, RMA flux residue is clear, soft, non-conductive and non-corrosive. Solvent cleaning is optional.

Kester Northrop Grumman
Mouser Electronics
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Solder paste - Viscosity tester

Tamura Kaken Corp. USA
Technology Information Corporation

Soldering Materials - Solder paste - Water-soluble

AIM
All-Spec Industries
Amtech, Inc.

EFD, a Nordson Company

EFD provides SolderPlus and PrintPlus solder paste for dispensing and printing applications requiring water removal of flux residues. EFD water-soluble flux washes easily and completely and is available with all EFD solder alloy compositions.

Indium Corporation of America
Kester Northrop Grumman
Mouser Electronics
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Soldering oils

Enthone Inc., a Cookson Electronics Company
Qualitek International Inc.

Soldering Materials - Soldering preforms

AIM
Cookson Electronics
Enthone Inc., a Cookson Electronics Company
Kester Northrop Grumman
Senju/Mitsui Comtek Corp.
Technology Information Corporation
Waveroom Plus

Soldering Materials - Vapor phase liquids

Enthone Inc., a Cookson Electronics Company
Micro Care Corporation
Qualitek International Inc.
Technology Information Corporation

Static Protection

Static Protection - Bags

All-Spec Industries
DESCO
KNF FLEXPAK Corporation
Waveroom Plus

Static Protection - Carriers and tape

All-Spec Industries
KEACO INC.
Klöckner Pentaplast of America, Inc.
Polyonics

Static Protection - Chemicals

ACL/Staticide

An ISO 9001:2000 registered company, ACL/STATICIDE® is the leading manufacturer and marketer of cleanroom products, topical antistats, static dissipative floor finishes, floor coatings, static detection meters, monitors, IDP's (inherently dissipative plastics) and computer cleaning products.

All-Spec Industries
CAIG Laboratories, Inc.
Micro Care Corporation
Wacker Silicones

Static Protection - Clothing/shoes/gloves

All-Spec Industries
DESCO
Terra Universal, Inc.
Vidaro Corporation
Waveroom Plus

Static Protection - Electrostatic shielding

CAIG Laboratories, Inc.
Klöckner Pentaplast of America, Inc.
W.L. Gore & Associates
Wacker Silicones

Static Protection - Floor treatments

ACL/Staticide
All-Spec Industries
DEK International GmbH
DESCO
Waveroom Plus

Static Protection - Flooring and floor mats

All-Spec Industries
DESCO
Klöckner Pentaplast of America, Inc.
Terra Universal, Inc.
Waveroom Plus

Static Protection - Foam and packing materials

All-Spec Industries
DESCO
HMS Compounds, Inc.
Klöckner Pentaplast of America, Inc.
Waveroom Plus

Static Protection - Furniture/cabinets/dessicators

All-Spec Industries
BioFit Engineered Products
Terra Universal, Inc.
Waveroom Plus

Static Protection - Ionizers

All-Spec Industries
DESCO
ElectroStatics, Inc.
SIMCO
Terra Universal, Inc.
Waveroom Plus

Static Protection - Measurement/monitoring equipment

ACL/Staticide
All-Spec Industries
DESCO
Terra Universal, Inc.
TREK, Inc.
Waveroom Plus

Static Protection - Totes/bins/boxes/storage and shipping containers

All-Spec Industries
DESCO
Fancort Industries, Inc.
InterMetro Industries Corp.
Klöckner Pentaplast of America, Inc.
Terra Universal, Inc.
Waveroom Plus

Static Protection - Workstations and work surfaces

All-Spec Industries
CAIG Laboratories, Inc.
DESCO
InterMetro Industries Corp.
Production Basics
Terra Universal, Inc.
Waveroom Plus

Static Protection - Wrist and heel straps

AESOPS Inc.
All-Spec Industries
DEK International GmbH
DESCO
Terra Universal, Inc.
Waveroom Plus

Tape Automated Bonding

National Starch and Chemical Company
3M Electronic and Interconnect Solutions

Test

Test - ATE Systems - Bare board testers

Everett Charles Technologies
FinePoint, Inc.
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X-Ray Inspection System

The Dual-VU is a real-time x-ray inspection system with added vision image display. Unlike other x-ray inspection systems, this one provides simultaneous and congruent images of the device under inspection. The system provides both vision and x-ray inspection in a small footprint system. It has been particularly useful in ball grid array (BGA) applications having components on both sides, which can confuse the interpretation of the BGA x-ray image.

Glenbrook Technologies Inc., Randolph, NJ

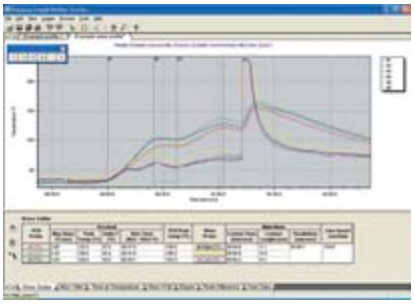
Booth 2029

Miniature Magnetic Rotary Encoders

The new line of frictionless 9-bit (512 count) miniature magnetic encoders is available in industry-standard absolute, incremental or linear output formats. Speeds of over 30,000 rpm can be achieved with measurement accuracy better than 0.7°. Non-contact design provides reliable long-term operation by eliminating the need for seals or bearings. For harsh environments, compact sealed versions are also available with immunity to IP68. The mini mag encoders come in component, modular and packaged versions. Incremental output options include digital (128 ppr), analog, linear voltage and linear current modes.

Renishaw Inc., Hoffman Estates, IL

Booth 1300



Wave Solder Probe Kit

The low-cost wave solder probe kit can now adapt your Reflow Tracker Thermal Profiling System for monitoring the wave soldering process. Users can view all the critical wave process parameters in one easy-to-read table. The Insight software will then analyze data from both processes, ensuring compatibility of data throughout the factory and minimizing operator-training needs.

Datapaq Inc., Wilmington, MA

Booth 1471

Robotic Soldering Systems

The ECHO benchtop selective robotic solder system with Geyan solder feeder eliminates the possibility of solder balls or spattering. Fixturing capabilities securely hold even the most difficult parts, multiple wires or unusual configurations in place for accurate soldering. Point-to-point speed is up to 800 mm/sec. with repeatability of ±0.01mm (x, y and z axes) and ±0.02° (r axis). Work areas range from 8 x 8 in. to 20x 20 in. Each system has a fully programmable iron tip cleaning cycle and a standard sponge cleaner or optional air blow cleaner.

Fancort Industries Inc., West Caldwell, NJ

Booth 1409

Placement Head

The Lightning placement head has a radial array of 30 modular, individually controlled spindles. The head has a duty cycle of 60 ms–a pick-to-pick or place-to-place performance that delivers chipshooting speeds in a platform system that maintains commonality of feeders, vision, heads and software with other platform equipment. Dual on-the-head optics allow the head to address a range of components, from 01005 to 30 x 30 mm, and supports component pre-orientation as well as on-the-head rejection for small parts. The plug-in spindle modules can be quickly and easily replaced and each contains a tiny Airkiss venturi vacuum generator to maintain a short and low maintenance vacuum path.

Universal Instruments Co., Binghamton, NY

Booth 355

Lead-Free Solder Paste

To help electronic assemblers meet the rapidly growing global initiatives requiring the removal of lead from their processes, ALPHA OM-338 lead-free solder paste provides soldering performance and a low cost of ownership. In addition, the solder paste has a wide reflow process.

Cookson Electronics, Foxborough, MA

Booth 1965

Tape Dispenser

The TDA080 electronic heavy-duty tape dispenser automatically dispenses and cuts virtually any tape, including duct tape. The dispenser is designed for continuous industrial use, accepts tape widths from 0.375 in. (9.5 mm) to 3.15 in. (80 mm) and cuts lengths from 3.15 in. (80 mm) to 394 in. (9999 mm). It comes with a standard 3 in. (76.2 mm) core, adjustable feed intervals and safety interlock and can be modified to dispense non-adhesive materials.

Start International, Addison, TX

Booth 1077

Lead-Free Solder Paste

NC-SMQ230 is an air reflow, no-clean solder paste specifically formulated to accommodate the high processing temperatures required by Sn/Ag/Cu and Sn/Ag lead-free alloy systems. The paste features extended stencil life and tack time.

Indium Corp. of America, Utica, NY

Booth 1351

Reworkable Underfill Encapsulant

CN-1453 is a new, silica-filled reworkable underfill encapsulant used to underfill flip chips, wafer level chip-scale packages (CSPs), CSPs and ball grid array (BGAs). Removal of defective components is accomplished by heating the component and the underfill encapsulant to 220°C. Underfill encapsulant residues are then easily scraped or brushed off. The encapsulant has a viscosity of 7500 cps at room temperature and is capable of flowing 18 mm, with a single-side dispense, in as little as 20 seconds. The encapsulant self-fillets, eliminating the need for seal passes to create complete and symmetrical fillets.

Zymet Inc., East Hanover, NJ

Booth 1363

X-Ray Inspection System

The TIGER (FXS-160.40) x-ray system now offers proprietary True X-Ray Intensity (TXI) control to assist operators in identifying production anomalies with consistent x-ray images. Unlike conventional techniques for maintaining image consistency that control the input level of high-voltage and x-ray tube current, TXI controls the output level of x-ray intensity during the image acquisition process, producing stable, permanent image quality. It also provides steady x-ray intensity after auto-start; long-term stability of x-ray intensity; and constant image contrast and brightness for recurring inspection tasks.

FEINFOCUS, Garbsen, Germany

Booth 1197

Manufacturing Software

The Navipoint Enterprise Performance Suite provides original equipment manufacturers (OEMs) with real-time visibility to operational information so that employees, customers and suppliers can be more responsive. It analyzes and presents enterprise, plant and departmental views of key performance indicators in a personalized portal. The software allows users to take actions through industry specific applications that streamline quoting, schedule sharing and order status tracking. It provides real-time information on product genealogy and supplier performance through a Web browser.

Cimnet Systems Inc., Downers Grove, IL

Booth 2041

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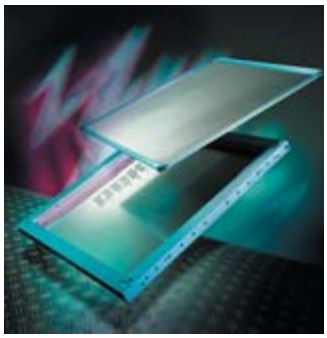
Stencil System



VectorGuard is an advanced stencil technology that is easier to handle than conventional stencils. It is surrounded by a thin aluminum extrusion that makes it lighter, and, with the risks from sharp edges eliminated, it enhances operator safety. Its variable foils guarantee print performance and operator safety. The stencil's rigid construction protects the stencil body during handling and, because it does not use an aluminum frame like mesh mounted stencils, offers cost-savings and minimized storage capacity requirements.

DEK International GmbH, Flemington, NJ

Booth 1215

Split Vision Rework Station

The Marksman Intruder offers placement and reflow for all types of boards and components, including ball grid array (BGA) and lead-free applications. The station features a convection panel preheat system available in 900 W, 1600 W and 2400 W heater configurations that can duplicate original manufacturing temperature parameters. The system incorporates the P-300 controller with each profile containing up to 16 segments of ramp/soak combined with four integrated real-time thermocouples for profile development.

A.P.E., Key Largo, FL

Booth 1909

Tape Feeders

The fast-loading Agilis feeder is now available for 12 and 16 mm tapes. In addition to the new feeder sizes, MYDATA is introducing a new magazine with linear motion, which offer smooth, high speed and precision feeding, for 0201s or smaller components. In place of a traditional feeder wheel to pull the tape, the new drive features a solenoid tape-grabbing mechanism with auto adjust capability.

MYDATA Automation Inc., Rowley, MA

Booth 857

Lead-Free Solder Paste

Multicore LF320 is a lead-free solder paste optimized for reflow in air on a range of printed circuit board (PCB) assembly applications. Reflow profiles may also be extended with nitrogen. The paste requires a minimum peak reflow temperature of only 229°C. With a print speed range of 25 to 100 mm. (1.0 to 4.0 in.) and an abandon time of up to two hours, the paste offers excellent wetting on a range of surface finishes. The solder paste has been formulated to provide high resistance to slump and solder balling.

Henkel Loctite Corp., Industry, CA

Booth 1826

Continued from pg. 25

mesh size selection is that the surface area to mass ratio (SAM), expressed in units of m^2/gram, varies inversely with the square of the particle size. In other words, halving the particle size increases the area per unit mass by a factor of four, assuming that the particle size distribution shapes are similar. This assumption is violated for small powders, as they often contain many fines, which raise the surface area even further. The amount of solder surface area in contact with the acidic flux vehicle that is designed to reduce metal and solder oxides is directly related to the difficulty of maintaining adequate shelf life and viscosity stability of the paste.

Conclusions

Paste bumping is a viable, capable and low cost technology for most of today's moderate and large pitches such as wafer-level packages (WLP) and many FCs. Automated process monitoring via volumetric data collection is an area of great opportunity to further facilitate this low cost bumping technology.

The flux chemistry as it impacts the rheology has a significant effect on the ability to release completely from the stencil as well as the deposit definition. The test results state that lower viscosity materials have improved release properties in comparison to higher viscosity paste. However, an inverse relationship to the deposit definition exists. Also from this testing, Type 6 distribution has proven to be a reliable defacto starting point for most bumping applications. The widely varying bumping application requirements demand close collaboration between suppliers and users to achieve the high yielding, low cost production of which paste bumping is capable. ■

Mesh Level			Least Sq Mean
6	A		57.300000
5	A		57.150000
7		B	54.000000

Levels not connected by same letter are significantly different.

TABLE 9: Powder mesh effect on blockage.

Mesh Level			Least Sq Mean
7	A		2.7425000
6	A		2.5443750
5		B	1.8918750

Levels not connected by same letter are significantly different.

TABLE 10: Powder mesh effect on wall definition.

Flux/Mesh Level					Least Sq Mean
D-T5	A				58.800000
D-T6	A	B			58.000000
A-T6	A	B	C		56.600000
D-T7		B	C		56.000000
A-T5			C		55.500000
A-T7				D	52.000000

Note: Levels not connected by same letter are significantly different.

TABLE 11: Viscosity effect on blockage.

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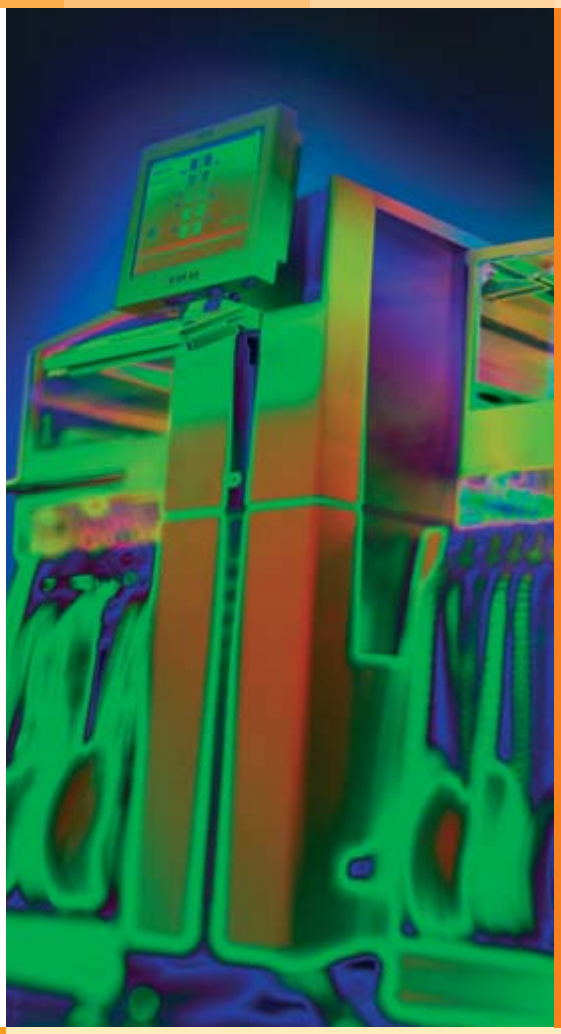

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