MEPTEC Report

SPRING 2012

A Quarterly Publication of The Microelectronics Packaging & Test Engineering Council

Volume 16, Number 1

Tenth Annual

MEMS Technology Symposium

Sensors: A Foundation for Accelerated MEMS Market Growth to $1 Trillion

page 18

Unisem Group – a global provider of semiconductor assembly and test services for many of the world's most successful electronics companies.

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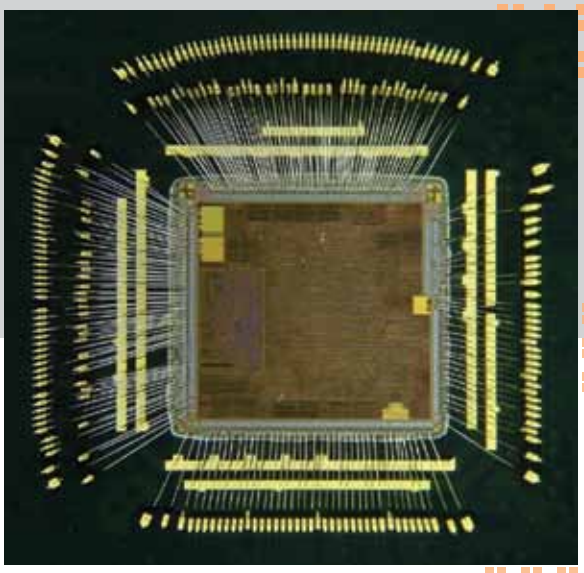
INSIDE THIS ISSUE

ASE GROUP

Copper Wire



- Cu wire bond as good as gold
- Low cost opportunity
- Wire diameters as low as 0.7 mils
- Leader in high volume production
- Quality and yield equivalent to gold
- High reliability, typically 2x JEDEC

www.aseglobal.com

2012: Politics, Olympics, and…MEPTEC?

Jim Walker, V.P. of Research for Semiconductor Manufacturing
Gartner
MEPTEC Advisory Board Member

OK. IT'S AN ELECTION YEAR. WE hear the candidates' promises. We decide who's best (or maybe least worst). We get to vote. I know. Where am I going with this?

Well, it's also an Olympics year. Candidates "run" for election or re-election. Interesting choice of words in this day…

MEPTEC has been around since the 1970's. Since that time, many politicians have come and gone, along with several economic cycles and Olympic triumphs. Initially, one could think these two topics might not have much in common; but actually, they do. During the past 50 years or so, the coinciding of the presidential election with the Olympic year has been a growth time for the semiconductor industry. This year should be no exception. After a dismal, virtually no-growth 2011, 2012 promises to be better. Single digit growth is forecast, but capital expenditures are increasing, and inventories are decreasing.

The semiconductor industry is poised for the next round. Along with this comes the ever leading quest for smaller, lighter, faster and, of course, cheaper (really lower cost… not implying lower quality here). And leading the way is the packaging and test community.

Many of us have seen the changes in semiconductor packaging over more recent times, especially since the proliferation of the cell phone and portable products. We will see even more importance for packaging as we try to stay on Moore's Law and continue the mantra stated above. Packaging is now respected as being the enabler for continuing the density improvements, while lowering cost and meeting the time-to-market/product life cycle demands of the market. And now 3D is here to advance us to the next round.

MEPTEC plays a role in achieving these market goals. Bringing together packaging and test engineers, and more recently even design and product engineers, MEPTEC serves the industry by enabling members to network and learn how to cost effectively and reliably achieve the goal of optimizing the performance of the silicon circuitry in a system. By communicating via monthly luncheon meetings and quarterly technical symposiums, MEPTEC brings the "social media" to you personally with the interaction necessary to grow one's technical competency.

Come attend the next monthly meeting or symposium. The food is always great, and the conversation will definitely enhance your day.

2012 is also the Chinese year of the Dragon. Let's hope that the industry begins to move its tail, and that carries further into a crescendo-like roar. ◆

JIM WALKER is V.P. of Research for Semiconductor Manufacturing at Gartner. Jim has been involved with semiconductor packaging for over 30 years while at Henkel, DuPont, National Semiconductor and Hana Microelectronics Group. Jim currently serves on the MEPTEC Advisory Board.

UPCOMING MEPTEC EVENTS

■ **WEDNESDAY**, APRIL 11
MEPTEC Luncheon
Biltmore Hotel & Suites
Santa Clara, CA

■ **WEDNESDAY**, MAY 23
Tenth Annual MEPTEC
MEMS Technology Symposium
The Wyndham San Jose Hotel
San Jose, CA

■ **THURSDAY**, MAY 24
MEMS Investor Journal/MEPTEC
2012 MEMS Business Forum
Biltmore Hotel & Suites
Santa Clara, CA

■ **WEDNESDAY**, JUNE 13
MEPTEC Luncheon
Biltmore Hotel & Suites
Santa Clara, CA

■ **WEDNESDAY**, SEPT 12
MEPTEC Gartner Luncheon
Biltmore Hotel & Suites
Santa Clara, CA

■ **WEDNESDAY**, SEPT 26 **& THURSDAY**, SEPT 27
2012 MEPTEC/SMTA
Medical Electronics Symposium
Arizona State University
Tempe Campus, Tempe, AZ

■ **WEDNESDAY**, OCT 10
MEPTEC Luncheon
Biltmore Hotel & Suites
Santa Clara, CA

■ **THURSDAY**, OCT 18
Fourth Annual
MEMS Investor Journal/MEPTEC
MEMS Testing & Reliability
Conference
Biltmore Hotel & Suites
Santa Clara, CA

■ **TUESDAY**, NOV 13
Q4 MEPTEC Symposium:
Multi-Die Integration – Roadmap for the Next Generation
Biltmore Hotel & Suites
Santa Clara, CA

■ **WEDNESDAY**, NOV 14
MEPTEC & SEMI Present
2012 KGD Symposium
Biltmore Hotel & Suites
Santa Clara, CA

■ **WEDNESDAY**, DEC 12
MEPTEC Holiday Luncheon
Biltmore Hotel & Suites
Santa Clara, CA

MEPTEC Report

SPRING 2012

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Volume 16, Number 1

ON THE COVER

18 TENTH ANNUAL MEMS TECHNOLOGY SYMPOSIUM – "Sensors: A Foundation for Accelerated MEMS Market Growth to $1 Trillion". MEPTEC is pleased to be holding our 10th Annual MEMS Technology Symposium. To celebrate a decade of bringing hundreds of experts and thousands of attendees together, we are going to jumpstart the next decade with a bold prediction: How to reach a $1 trillion dollar MEMS market in the next ten years.

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16 ANALYSIS – Demand for portable Internet connectivity devices such as cell phones, tablets, GPS devices, MP3 players, and more is very strong, in spite of poor economic times. What these items have in common is that they all pack an enormous amount of functionality into a very small space.

BY SANDRA WINKLER
NEW VENTURE RESEARCH CORP.

20 PROFILE – Unisem's turnkey services include design, assembly, test, failure analysis, and electrical and thermal characterization. With approximately 10,000 employees worldwide, Unisem has factory locations in Malaysia, United Kingdom, People's Republic of China, Indonesia and the U.S.

UNISEM GROUP
MEMBER COMPANY PROFILE

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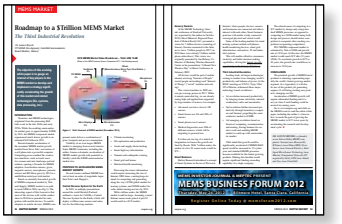
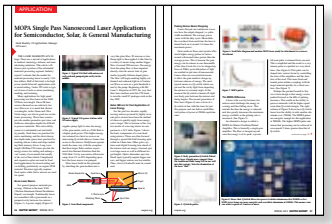
24 MEMS MARKET – The potential growth of MEMS based products is stunning, representing arguably the world's fastest growing market segment. As a byproduct, it will also be one of the greatest job generating engines. It will bring exciting new products, changing our life.

BY JANUSZ BRYZEK, PH.D.
FAIRCHILD SEMICONDUCTOR





26 APPLICATION – Lasers are now small and powerful and easy to integrate into a host of processing equipment. Laser applications benefit from the optimal mix of peak pulse power, available pulse energy, and power duration. MOPA lasers add an additional feature of front loaded power.

BY MARK BRODSKY
SPI LASERS

DEPARTMENTS

MEPTEC

THE NEXT GENERATION

The MEPTEC Report is a Publication of the Microelectronics Packaging & Test Engineering Council

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MEPTEC Report Vol. 16, No. 1. Published quarterly by MEPCOM LLC, P. O. Box 222, Medicine Park, OK 73557.

MEPTEC Report is sent without charge to members of MEPTEC. For non-members, yearly subscriptions are available for $75 in the United States, $80US in Canada and Mexico, and $95US elsewhere. For advertising rates and information contact Gina Edwards at 408-858-5493, Fax Toll Free 1-866-424-0130.

Meet the MEPTEC Advisory Board

Nikhil Kelkar
Intersil Corporation

Nick Leonardi
Premier Semiconductor

Dr. Raj Pendse
STATS ChipPAC

IN THIS ISSUE WE CONTINUE introducing our fourteen Advisory Board Members. All Board members are listed at the left.

NIKHIL KELKAR is currently Director of Worldwide Package Development and Assembly Engineering at Intersil Corporation in Milpitas, CA. He joined Intersil in 2005 and has led development of variety of package technologies ranging from optical sensors to active/passive integration. Prior to joining Intersil, Nikhil worked in Package Technology Group at National Semiconductor since 1996 where he pioneered the wafer level chip scale packaging technology. Nikhil received his M.S. in Mechanical Engineering in 1996 from the CALCE Electronic Packaging Research Center at University of Maryland at College Park.

NICK LEONARDI brings over twenty five years of electronics industry experience into his position as Director of Business Development for Premier Semiconductor Services. With current focus on new business development, previous key roles in engineering development, applications and sales management, with companies such as AMD, LSI Logic and GE. Primary areas of business development include the Counterfeit IC Detection Programs and the Lead Free Solder Conversion for BGA's and other package types. Industry affiliations and participation include; MEPTEC Advisory Board Member and Regional Co-Chairman, with support of other organizations including the FSA, SEMI, IEEE, IMAPS and SMTA. Nick received his B.S. Degree in Materials Engineering from Alfred University, New York.

DR. RAJ PENDSE is Vice President of Advanced Products and Technology Marketing at STATS ChipPAC. Prior to joining STATS ChipPAC, Raj held various positions in package engineering and R&D at National Semiconductor Corp. and Hewlett-Packard Labs. His work has spanned the gamut from packaging of high-end microprocessors, ASIC and graphics products to low-cost packaging solutions for logic and analog devices that find use in mobile phones and consumer products. His most recent focus has been on Flip Chip and 3D Wafer Level Packaging. Raj completed his B.S. in Materials Science from IIT Bombay with Top in Class honors and his Doctorate in Materials Science from UC Berkeley.

SEMI Reports 2011 Global Semiconductor Equipment Sales of $43B

SEMI has reported that worldwide sales of semiconductor manufacturing equipment totaled $43.53 billion in 2011, representing a year-over-year increase of 9 percent. The data is available in the Worldwide Semiconductor Equipment Market Statistics (SEMS) Report, now available from SEMI. The report, which includes data for seven major semiconductor producing regions and 24 product categories, shows worldwide billings totaled $43.53 billion in 2011, compared to $39.93 billion in sales posted in 2010. Categories cover wafer processing, assembly and packaging, test, and other front-end equipment. Spending rates varied for all the regions tracked, with increases reported for Europe, North America, and Japan. North America surpassed Taiwan as the region with the highest amount of spending with $9.26 billion in equipment sales. The Korea market claimed the second place for the second year in a row with $8.66 billion in sales; Taiwan fell to the third position with a regional decrease of 24 percent. For more information, visit www.semi.org. ◆

MEMBER NEWS

ALTERA CORP. AND TSMC JOINTLY DEVELOP WORLD'S FIRST HETEROGENEOUS 3D IC TEST VEHICLE USING COWOS PROCESS

Altera Corporation and TSMC announced the joint development of the world's first heterogeneous 3D IC test vehicle using TSMC's Chip-on-Wafer-on-Substrate (CoWoS) integration process. Heterogeneous 3D ICs are one of the innovations enabling the industry's move beyond Moore's Law by stacking various technologies within a single device, including analog, logic and memory. TSMC's integrated CoWoS process provides semiconductor companies developing 3D ICs an end-to-end solution that includes the front-end manufacturing process as well as back-end assembly and test solutions.
www.altera.com
www.tsmc.com

LOCTITE CHIP-BONDER NOW COMPATIBLE WITH NON-CONTACT DISPENSING TECHNOLOGY

Henkel expands its portfolio of surface-mount adhesives (SMA) with the company's new product Loctite 3621. This adhesive has been validated for use with non-contact dispensing technologies, often referred to as jetting. This capability makes the SMA even more ideal for high-volume production environments and enables higher throughput as well as more uniform dot dimensions.
www.henkel.com/electronics

PAC TECH SELLS PACLINE 300 A50 SYSTEM TO DIODES

Pac Tech – Packaging Technologies GmbH has announced that it has sold their latest PacLine 300 A50 system for electroless deposition of Ni, Pd and Au on advanced semiconductors to Diodes Incorporated in Plano, Texas. The system will be installed at Diodes wafer fabrication facility in Kansas City, Missouri.

The PacLine 300 A50 is a fully automated, self-contained, mass-production system capable of processing up to 150 wafers per hour and up to 600,000 8-inch wafers per year. *www.pactech.com*

ANADIGICS POWERS SAMSUNG GALAXY NOTE

ANADIGICS, Inc. has announced that the Company is shipping production volumes of its ALT6705, AWT6621, and AWT6624 fourth generation High-Efficiency-at-Low-Power (HELP4™) power amplifiers (PAs) and AWC6323 dual-band third generation High-Efficiency-at-Lower-Power (HELP3E™) power amplifiers (PAs) to Samsung Electronics for Samsung Galaxy Note. The AWT6621 powers the Galaxy Note I9228 (TD-SCDMA) and the AWC6323 powers the Galaxy Note I889 (CDMA), both available in the China market. The ALT6705, AWT6621, and AWT6624 power the Galaxy Note SHV-E160L available in Korea. *www.anadigics.com.*

InvenSense Announces The First Wearable Sensor SDK For Health And Fitness Applications

Developers Kit Incorporates MPU-9150, Pressure Sensor, Microcontroller, Bluetooth and Embedded MotionApps Lite™ Software

INVENSENSE, INC., THE leading provider of MotionTracking™ devices for consumer electronics, announced the availability of the MotionFit™ System Developers Kit (SDK) to accelerate design and commercialization of wearable sensor devices for the growing fitness and remote health monitoring markets. The MotionFit SDK consists of a small 40mm x 37mm development board incorporating the InvenSense MPU-9150 single chip 9-axis MotionTracking device, a pressure sensor for altitude tracking, a TI MSP430 microcontroller with external serial flash for data logging, a 110mA/hr rechargeable battery, and communication via USB or Bluetooth interfaces enabling real-time streaming of data to smartphones. The SDK also includes Embedded MotionApps Lite™ software that handles all complexities of 9-axis sensor calibration and sensor fusion providing access to calibrated raw sensor data as well as fused outputs such as 3-D orientation enabling developers to focus on the differentiating features of their application. Key sensor processing tasks are offloaded to the MPU-9150's

embedded Digital Motion Processor™ (DMP) allowing the total solution to function on small, low cost 16-bit microcontrollers.

According to ABI Research (August 2011), the market for wearable sensing devices will exceed 100 million units annually by 2016. Wireless connectivity will play a role in this growth enabling wearable sensors to become a must-have accessory to smartphones allowing for streaming of real-time data to mobile devices or the cloud. Wearable sensor products currently track user motions with basic 3-axis accelerometers which can accurately detect and track only a limited number of activities thus limiting their usefulness to consumers.

The MotionFit SDK from InvenSense addresses key accuracy and performance issues by providing a complete 10-axis MotionTracking solution to developers encompassing a 3-axis gyroscope, 3-axis accelerometer, 3-axis compass and a pressure sensor to support a wider range of motions to accurately identify and track a broad range of activities including running, swimming, hiking, and tennis. For remote health monitoring applications, the SDK can jump-start development of devices for out-patient activity monitoring and for remotely tracking range of motion improvements during physical therapy.

The MotionFit SDK became available for purchase on February 15th from the InvenSense website for $149. The associated Embedded MotionApps Lite software is available for download to registered developers on the InvenSense Developer Corner website at www.invensense.com/developers. The SDK supports TI's Code Composer Studio (CCS) Embedded Workbench compiler and debugger software which must be purchased separately. ◆

Delphon Industries Sells ProbeMax™ Product Line to International Test Solutions

DELPHON INDUSTRIES HAS ANNOUNCED the sale of their ProbeMax™ product line to International Test Solutions, the world leader in probe cleaning technology. International Test Solutions will use the ProbeMax products to enhance their existing probe cleaning and probe polishing business. The two companies, along with Complete Probe Solutions, who was the exclusive ProbeMax worldwide distributor, will work together to assure there is no disruption to the existing customer base during the transition period.

Delphon operates four divisions: Gel-Pak manufactures gel-coated boxes, trays, slides and films for the shipping, handling and processing of valuable devices; Quik-Pak provides microelectronic packaging and assembly solutions; UltraTape manufactures cleanroom tapes and labels; TouchMark provides medical device pad printing services.

For more information, please contact Jeanne Beacham at Jeanne@delphon.com. ◆

Shin-Etsu MicroSi Joins EV Group's Open Platform for Temporary Bonding Materials for 3D IC Manufacturing

EV GROUP (EVG) HAS ANNOUNCED that Shin-Etsu Chemical Co., Ltd., the world's largest supplier of semiconductor materials, has joined EVG's open platform for temporary bonding/debonding (TB/DB) materials. Shin-Etsu's advanced adhesives will be qualified with EVG's EZR® (Edge Zone Release) and EZD® (Edge Zone Debond) modules, which support the new ZoneBOND™ room temperature debonding process used in the production of 3D ICs.

Markus Wimplinger, EVG's corporate technology development and IP director, commented, "Through our open materials platform approach, we are building a strong supply chain for EVG's market-leading TB/DB technologies-unlocking another key barrier in the advancement of 3D IC commercialization. Enabling the use of a wide range of adhesives from various suppliers for our equipment gives customers the most flexible choice of bonding materials for increased flexibility during thin wafer processing."

ZoneBOND™ capable technology, in tandem with EVG's breakthrough EZR® (Edge Zone Release) and EZD® (Edge Zone Debond) modules, provides a superior approach for temporary wafer bonding, thin wafer processing, and debonding applications-overcoming the last remaining limitations associated with thin wafer processing.

For further insight into the ZoneBOND™ approach, please view the recent webcast "3D is a Reality in High-volume Manufacturing" hosted by Yole Developpement at www.i-micronews.com.

Visit www.EVGroup.com or www.microsi.com for more information. ◆

STATS ChipPAC's Scalable 3D eWLB Solutions Deliver Performance, Height and Cost Advantages

With over 200 million units shipped, eWLB proves to be a strong technological platform for next generation 2.5D and 3D solutions

STATS CHIPPAC HAS ANNOUNCED its next-generation three dimensional (3D) embedded Wafer Level Ball Grid Array (eWLB) Package-on-Package (PoP) solutions. This innovative new 3D technology provides an ultra thin package profile height below 1.0mm, a 30% height reduction over the industry standard 1.4mm total stacked package height.

Market demand for advanced, multi-functional portable electronic devices is driving the need for semiconductor packages with higher thermal and electrical performance, increased bandwidth and speed in an ultra thin package profile. PoP has been a successful 3D packaging approach by virtue of the flexibility it offers in combining individual memory and logic packages vertically into a single solution in the industry standard 1.4mm total stacked package height. While current PoP technologies are effective in integrating multiple functions in a small form factor, reaching the next level of packaging bandwidth and performance in more advanced mobile devices drive advancements in the stacked package profile height below 1.0mm as well as tighter substrate line/space capability.

STATS ChipPAC's eWLB PoP technology offers customers significant performance, cost and height advantages over traditional substrate-based PoP technology. By utilizing eWLB's fan-out wafer level packaging approach, STATS ChipPAC has been able to reduce the bottom PoP package height to less than 0.5mm. eWLB PoP is available in either a single or double-sided configuration and provides a flexible integration platform for stacking a wide range of memory packages on top with a final stacked package height below 1.0mm.

With high-performance and power-efficient capabilities in an inherently small, ultra-thin package profile, eWLB has been a technology enabler for advanced mobile applications such as smartphones, media tablets and cloud computing. STATS ChipPAC has shipped over 200 million eWLB units at a rapidly increasing run rate and is in volume production with a large number of eWLB package architectures including small die, large die, multi-die and multi-layer designs.

Further information is available at www.statschippac.com. ◆

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BGA
FO-WLP

Advances in microelectronics design bring new requirements and challenges for electronic packaging. As front-end and final manufacturing processes become more integrated, packaging is increasingly integral to the design, manufacture, and function of microelectronic devices.

SEMICON West 2012 connects contemporary and advanced packaging innovations from the world's leading technology companies with the engineers, designers, scientists, and key decision-makers needing answers and solutions that improve performance and productivity and help move products to market.

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Applied Materials and A*STAR's Institute of Microelectronics to Drive Advanced 3D Chip Packaging with World-Class R&D Lab in Singapore

APPLIED MATERIALS, INC. AND THE Institute of Microelectronics (IME), a world-renowned research institute under the Agency for Science, Technology and Research (A*STAR), has officially opened the Centre of Excellence in Advanced Packaging at Singapore's Science Park II.

The Centre of Excellence in Advanced Packaging has been built with a combined investment of over USD$100 million from Applied Materials and IME. The world-class facility features a 14,000 square foot Class-10 cleanroom and is equipped with a fully-integrated line of 300 millimetre manufacturing systems to support the research and development of 3D chip packaging, a critical growth area for the semiconductor industry.

The Centre will be the most advanced lab of its kind dedicated to wafer level packaging and will combine Applied Materials' leading-edge equipment and process technology with IME's leading research capability in 3D chip packaging. The Centre positions Singapore as a global leader in semiconductor R&D and is expected to help accelerate the development and adoption of 3D packaging technology globally.

Conceived to support research collaboration between Applied Materials and IME, the Centre will also allow both parties to pursue independent research initiatives including process engineering, integration and hardware development. For Applied Materials, this is a significant addition of new capabilities in Singapore. The Centre also serves as a demonstration of how A*STAR is able to develop and nurture a local ecosystem for advanced R&D through partnerships with leading corporations.

Learn more at www.appliedmaterials.com. For more information about IME, please visit www.ime.a-star.edu.sg. The A*STAR website is www.a-star.edu.sg. ◆

Amkor Technology Licenses Proprietary Through Mold Via Technology to SHINKO Electric Industries

AMKOR TECHNOLOGY, Inc. has announced that it has granted SHINKO Electric Industries Co., Ltd. a non-exclusive license to its proprietary Through Mold Via ("TMV®") technology. The agreement provides for the transfer of Amkor's TMV® technology to SHINKO and a license under Amkor's patents to enable SHINKO to manufacture packages based on this technology. The license also permits SHINKO to use Amkor's registered TMV® trademark in its sales and marketing activities.

"Technology innovation has always been a key component of our success, and our proprietary TMV® technology has been widely adopted in the rapidly growing smartphone and tablet markets," said Ken Joyce, Amkor's president and chief executive officer. "We are pleased to license our TMV® technology to SHINKO, a respected outsourced assembly and test provider. This engagement will provide our customers the option of having multiple sources for TMV® packaging services."

Since their introduction, package-on-package ("PoP") components have been rapidly adopted for 3D integration of logic and memory. Amkor's TMV® technology enables leading-edge PoP designs for smartphone and tablet applications, delivering increased integration, miniaturization and performance without requiring the development of new surface mount stacking infrastructure or adding cost.

Visit the Amkor website at www.amkor.com or the SHINKO web site at www.shinko.co.jp/english for more information. ◆

PLEXUS CORP. AND KONTRON AG TO ENTER STRATEGIC MANUFACTURING ARRANGEMENT

Plexus Corp. and **Kontron AG** announced their intention to enter into a strategic manufacturing arrangement. Under the arrangement Kontron AG (Kontron) will transition all manufacturing of its Kontron Design Manufacturing Services (M) Sdn. Bhd. subsidiary (KDMS) located in Penang, Malaysia to Plexus, primarily to its Penang facilities. Plexus will acquire the inventory and equipment of KDMS, hire substantially all KDMS employees and pay a modest premium; in exchange Kontron will commit to approximately $100 million of incremental revenue annually for two years.

www.plexus.com

K&S LAUNCHES CONNX PLUSPS™ WIRE BONDER

Kulicke & Soffa Industries, Inc. has announced the formal launch of its ConnX Plus High Speed Wire Bonder. ConnX Plus is a second generation ball bonder under the successful Power Series™. When compared to the previous generation, the ConnX Plus further increases net productivity in low pin count, discrete and cost performance markets.

In addition to features of the prior generation ConnXPS™ wire bonder, the ConnX Plus includes exciting new enhancements to help further increase efficiency and net productivity.

www.kns.com

TESSERA TO ACQUIRE CAMERA MODULE MANUFACTURING ASSETS

Tessera Technologies, Inc. announced that its wholly-owned subsidiary, DigitalOptics Corporation, has agreed to acquire certain assets of Vista Point Technologies, a Tier One qualified camera module manufacturing business, from Flextronics International Ltd.

DOC will pay approximately $23 million in cash for certain assets of Flextronics's camera module business located in Zhuhai, China, along with the equity interests of a wholly-owned foreign enterprise that will own those assets (together, the "Zhuhai Camera Module Business").

www.tessera.com

DFR SOLUTIONS ADDS ENHANCED MICRO-TESTING CAPABILITIES

DfR Solutions announced it is enhancing its micro testing capabilities with the installation of XYZTEC's state of the art Condor Series at DfR Solutions corporate headquarters in College Park, Maryland. The Condor Series will enable DfR to offer expansive micro-mechanical testing, including JEDEC JESD22 qualification, copper wire bond pull and shear testing, dynamic bend testing of small structures, and material characterization of Pb-free solders, to its numerous component and OEM customers.

www.dfrsolutions.com ◆

SEMI Acquires Plastic Electronics Conference and Exhibition

Establishes Plastic Electronics Special Interest Group to Promote Commercialization of Organic Electronics

SEMI HAS ACQUIRED THE PLASTICS Electronics Conference and Exhibition to enhance SEMI's member value and to advance the related industries towards successful commercialization of new products in the field of organic and inorganic large area electronics (OLAE). The Plastics Electronics Conference, organized by a prestigious committee of industry and academic leaders, has co-located with SEMICON Europa since 2010. Following the acquisition, the organizing committee will serve as a Plastic Electronics Special Interest Group, guiding SEMI activities and services worldwide.

OLAE promises a large market potential of over $50 billion by 2020 according to the Bank of America, Merrill Lynch and several other research organizations. The technology is an answer to many challenges in our society with regard to renewable energy, environment protection, information, entertainment, communication, e-mobility, health and more. OLAE covers five important areas — OLED Lighting, Organic and Inorganic Photovoltaic, OLED Displays, Organic Electronics and Integrated Smart Systems — which all have a similar disruptive technology in common.

The Plastic Electronics Special Interest Group (PE-SIG) will be governed by distinguished board members from leading industry corporations, research institutes and academia, including executives from BASF, Merck, Technical University of Dresden, VTT Technical Research Centre of Finland, and others. The PE-SIG of SEMI will focus its activities on Roadmaps, Standardization, Industry Research and Statistics, Conferences, Exhibitions and Public Policy worldwide. The 8th edition of the Electronic Conference and Exhibition will be held in conjunction with SEMICON Europa in Dresden (9-11 October 2012) and will be extended to other regions in the future.

"The SEMI track record of using global industry collaboration, advocacy and standards to expand and optimize major industries such as semiconductors, displays, solar PV, and related technologies will greatly help the emerging OLAE industry to move from lab to fab," says Dr. Karl Hahn, senior vice-president of BASF and board member of the newly established PE-SIG. "There are substantial synergies between technologies, equipment, materials, and services among SEMI member companies and the rapidly developing OLAE industry," says Thomas Morrow, head of Emerging Markets at SEMI Headquarters.

For more information visit www.semi.org/en/industries/plasticelectronics. ◆

High Tg, Reworkable Underfill from Henkel Ideal for High Value, Fine-Pitch Area Array Devices

EXPANDING ON THEIR portfolio of advanced underfill materials, Henkel has developed LOCTITE UF3810, a new underfill technology that provides extremely high reliability while also allowing for easier reworkability as compared to previous generation products.

Designed to deliver superior performance and ease-of-use, LOCTITE UF3810 addresses many of the complex requirements associated with today's high value devices, but does so in a formulation that has excellent processability. The material is halogen-free, completely reworkable and has a high glass transition (Tg) temperature of 100°C, thereby delivering robust thermal cycling reliability for next-generation wafer-level CSP (WLCSP) and PoP devices.

As Dr. Brian Toleno, Henkel's Global Product Manager for Liquids, explains, LOCTITE UF3810 is the go-to product for manufacturers seeking high reliability in a cost-conscious formulation. "With increasing device complexity comes increasing cost," says Toleno. "Assembly specialists want to reliably protect these devices but also have the option to rework them should any issues arise. LOCTITE UF3810 provides high reliability and reworkability – a balance not readily available with traditional, low Tg formulas."

For more information on LOCTITE UF3810 or any of Henkel's next-generation underfills, go to www.henkel.com/electronics or call the company headquarters at 714-368-8000. ◆

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ITEM MEDIA

MEMS TECHNOLOGY

By Mike Pinelis, Ph.D.

BioMEMS: Emerging Technologies and Applications

ONE OF THE MOST PROMISING market segments for MEMS technologies is the biomedical industry. The biomedical MEMS market size is currently approximately $1.7 billion and is projected to at least double in size by 2015. In BioMEMS applications, it is advantageous to miniaturize currently available components and systems due to form factor and cost considerations. Furthermore, many applications are newly enabled by MEMS technologies and would not be possible at all without miniaturization.

The scope of biomedical MEMS applications includes sensors, diagnostics and health screening, individualized treatment, drug delivery systems, tissue engineering and organ prosthesis, R&D tools, as well as surgery and minimally invasive procedures. To promote the discussion around these BioMEMS topics, MEMS Investor Journal and SMART Commercialization Center for Microsystems have organized a conference on the topic. The event will take place in Cleveland, Ohio on March 21-22, 2012. In this article, we highlight some of the participating speakers and their presentations.

Dr. Gregory Galvin, Chairman and CEO of Rheonix, will discuss how molecular diagnostics can be made easy and practical through MEMS technology. Rheonix has been developing polymer based microfluidic technology that has enabled automated tools capable of carrying out complex molecular diagnostics. According to Dr. Galvin, the economics of this technology allows for test pricing well below that of conventional benchtop molecular diagnostics tools. With companies such as Rheonix, MEMS is now delivering on its potential for medical diagnostics and several companies have, or will soon have, products in this market.

MEMS technology is coming to a neuron near you – this is the main topic of Dr. Peter Gilgunn's talk on neural interfaces enabled by MEMS and microelectrodes. According to Dr. Gilgunn, Microsystems Research Fellow at The Institute for Complex Engineered Systems, people already rely on the "cognitive extensions" provided by technologies such as smart phones and other wirelessly connected computing devices. Dr. Gilgunn believes that this trend will drive greater, more intimate integration with our technology and "naturalistic" interaction with it – for example, consider the impact of Siri on the iPhone4. Research on neural and other tissue interfaces promises to bridge the final gap between us and our technology and, by doing so, will enable applications in physical, cognitive and sensory enhancement. MEMS design, fabrication and assembly techniques are key to realizing the robust, high channel-count neural interfaces necessary to make these connections stable and reliable over decades-long service periods.

The future for BioMEMS is bright – emerging technologies will bring many innovative products to the market and biomedical device makers need to capitalize on these opportunities.

Dr. Daniel Irimia, Assistant Professor in Surgery and Bioengineering at the Harvard Medical School, will discuss cellular motility in health and disease. According to Dr. Irimia, all cells in our body have the ability to move, and their motility is rarely random. Most often, cells follow directional cues in the form of biochemical and mechanical stimuli, to participate in critical processes during health and disease conditions. To better understand the role of cell motility in situations such as trauma or cancer, Dr. Irimia's group is designing microfluidic tools to measure the directionality and speed characteristics of moving inflammatory and epithelial cells with unprecedented precision. Using such tools, they were able, for example, to define a set of "normal values" for directional decisions and speed in neutrophils from healthy people. In patients with burn injuries, they measured transient alterations of neutrophil motility, favoring infections and other complications. In pancreatic cancer patients, they uncovered some surprising abilities of the cancer cells to efficiently navigate complex microenvironments and respond to conditions of mechanical and chemical confinement. Ultimately, Dr. Irimia's engineered tools and the unexpected findings enabled by his research group could lead to new therapeutic approaches for conditions that span from acute to chronic inflammation, and from cancer to tissue regeneration.

This two-day BioMEMS 2012 event also includes exciting talks by Paul Rubel on micropump technologies and applications, Dr. Nena Golubovic on MEMS and nano hybrid systems for topical and transdermal delivery of drugs, Dr. Saju Nettikadan on advances in tip based lithography for BioMEMS applications, and Louis Ross on MEMS and sensors for sports applications. In addition, the event will include commercialization and venture capital panels.

The future for BioMEMS is bright – emerging technologies will bring many innovative products to the market and biomedical device makers need to capitalize on these opportunities. ◆

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DR. MIKE PINELIS (mike@memsjournal.com) is the President and CEO of MEMS Investor Journal. This article is a part of MEMS Investor Journal's ongoing market research project on MEMS activity in China. Currently they have developed a report that lists 140+ of the key MEMS companies and organizations in China. If you would like to receive this report, please contact them at research@memsjournal.com for more information about rates and report contents.

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INDUSTRY INSIGHTS

By Ron Jones

Gorillas and Other Great Apes

ACCORDING TO WIKIPEDIA, Great Apes include Gorillas, Orangutans, Chimpanzees and Humans ... yes Virginia, you are a great ape. The premise for using great apes as a backdrop for my article is weak at best, so I'm going to drop any referral to humans being in the mix. By the way, the largest gorillas weight around 400 pounds in the wild and may reach 600 pounds in captivity, not 800 pounds. Another myth busted.

We constantly hear referrals to 800 pound gorillas. The implication is that the 800 pound gorilla sets the rules and gets whatever he wants. While the 800 pound gorilla may make a huge impact in some areas, he doesn't get his way in all things. He can brute force with his strengths, but may get outmaneuvered by the more nimble orangutans and chimpanzees.

This New Year keeps striking me as different from most in the past. According to Dataquest, the revenues and growth will be as shown below.

2011 was near zero growth and 2012 isn't forecasted to be much better. So where's the excitement in that? As I mentioned in my previous article, the excitement comes when you peel the onion and see the makeup of the growth.

David Pogue is one of my favorite writers, especially his weekly article on Personal Tech in the NY Times. In his blog during CES, he said "If you just peek into the huge International Consumer Electronics Show, you might think that it's mostly a deafening showcase for tablets, thin TV screens, superthin laptops and Android phones. But if you really take the time to look — if you walk all 15 miles of exhibit halls — you'll discover that, in fact, you were right. C.E.S. really is primarily a deafening showcase for tablets, thin TV screens, superthin laptops and Android phones."

These are the products that are driving explosive growth in the semiconductor industry, which is sadly being masked by shrinkages in other semiconductor sectors. These products require high volumes of very sophistical IC's. Many technologies which have been gestating over the past few years, such as 2.5 and 3D packaging, are being thrust to the forefront in order to support high volumes of advanced packages. There are certainly many different approaches being put forward, but there is not, nor is there likely to be, a clear winner. There will be multiple approaches used depending on the final package needs.

TSMC has decided to jump in and offer turnkey solutions to clients who need interposers in their final xD solution. It is still somewhat unclear what this really means. TSMC, along with UMC and Global Foundries/Chartered, have specifically not entered into the assembly market over the years. They have partnered with companies to do turnkey in the past, but they have not added their own capabilities. Companies that have coupled fab and assembly (e.g. Amkor and ASAT) have been sorry and the experiments were not pretty.

So can the 800 pound gorilla of foundry become a major turnkey supplier for high tech products? Maybe yes, maybe no. They may be able to use their massive resources to develop leadership solutions and they certainly possess the capital backing to implement those solutions. Or they may be outmaneuvered by the orangutan assembly houses that have been doing the work for decades, coupled with the IP chimpanzees that control a significant portion of the 2.5 and 3D IP. With the number of different technologies that can be brought to bear and the breadth of package requirements, I don't think that TSMC will have massive success, but may do well on some specific high volume products. Start to pay attention if they begin buying IP companies and OSAT providers.

There is already a lot of crowding in the Application Processor market. AP's by Qualcomm, NVIDIA, TI, Apple, Renesas, Marvell and others are supplying the SOC platforms that are the heart of SmartPhones, tablets and smart TVs. They include multicore CPU's and scads of other functional blocks that support all the things that smartphones and tablets do. Intel, the 800 pound gorilla of microprocessors, has not been a major supplier to this market. While they have certainly had their Atom processor for several years, it is not the basis of these processors. As a matter of fact, most of the AP processors, save Qualcomm are based on ARM cores.

Intel has now announced that they are going to jump into the nascent AP market. The question is whether the 800 pound gorilla of CPU's can port this success over to AP's, or whether the orangutan AP vendors that currently supply the market, coupled with the chimpanzee CPU core providers like ARM, will outmaneuver them and continue to own the market. Things are moving at light speed, so stay tuned. ◆

Year	2010	2011	2012	2013	2014	2015
Revenue $B	299.4	302.1	308.8	338.8	348.2	375.1
Growth %	30.9	0.9	2.2	9.7	2.8	7.7

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MEDICAL ELECTRONICS

By Jim McElroy

Closing Technology Gaps

EVERY TWO YEARS, INEMI brings together industry leaders to create a series of technology roadmaps that look out ten years. In addition to roadmapping twenty one technologies, the roadmap also describes the unique requirements of six market segments of the electronics industry – including medical electronics. From this knowledge base, iNEMI develops a collaborative agenda that brings segments of the industry together to work on common challenges that are best addressed cooperatively. Industry workshops are also organized to help focus the industry on which identified gaps offer the best opportunities for collaborative development. Over the past 18 months, two medical electronics workshops were conducted.

Medical Electronics Roadmap

Demographics in many countries are shifting as birth rates decline and the overall population growth slows. Globally the 65+ population will grow from 516M in 2009 to 1.53B in 2050. Healthcare spending will inevitably grow significantly over this time horizon. However, there is growing pressure to make healthcare delivery more efficient, cost effective and with reduced error rates. The iNEMI roadmap tracks technology trends and gaps in 3 market sectors: implanted products, portable products, and diagnostic imaging systems – each having unique requirements and challenges.

Through advances in electronics technologies, major improvements are being seen in patient monitoring, wireless data transfer and patient-centric diagnostic imaging. More advanced technologies are being explored that make use of MEMS, bio-chemical sensors, high density batteries, and very small scale systems (e.g. artificial retina). These advancements will help resolve complex challenges related to energy constraints, data security, mission critical reliability, and patient safety. The iNEMI roadmap is available to all in the industry at www.inemi.org/2011-inemi-roadmap.

Industry Collaboration

From roadmapping and workshop results, iNEMI has developed a list of high priority technology gaps that require collaborative projects to meet the business and technology needs of the medical electronics segment. We are now in the process of forming collaborative teams for those topics having the highest interest.

Topics being addressed include:

1) Defining Reliability Requirements for implantable Medical Devices
2) Qualification Methods for Portable Medical Products
3) Component Specifications for Medical Electronics Products
4) Supply Chain Support for Medical Products
5) Product design requirements that address MRI/XRAY & implantable compatibility challenges
6) Qualification Methods for Medical Electronics Packaging

For the first 3 of these areas, formation teams have completed project planning and they are now in their project sign-up periods (i.e. companies are making the commitment to participate).

For the balance of these areas, a team will develop an appropriate scope of work and determine the critical links of the supply chain that must participate to ensure success. Based on gaining the required industry players, a project launch will follow.

Project Descriptions

Further details are provided on the first 3 mentioned efforts:

Defining Reliability Requirements for Implantable Medical Devices

The proposed focus of the program is to identify the product testing that is required to ensure reliability of implantable medical electronic products. The reliability testing standards used for the development of implants are derived from the harsh environment operation standards applied to military, automotive or avionics products. However, these standards may overstress the implants, leading to over-engineered products, and do not reflect the specific requirements of

implantable electronic products potentially leading to underestimation of specific failure modes.

Although a manufacturer may have knowledge about a specific product for a given use case, this know-how is typically not shared among OEMs. Greater sharing of this information and agreement on industry-standard testing requirements could help mitigate several problems.

Qualification Methods for Portable Medical Products

The rapid growth of the use of electronics in medical devices and the recent market-driven need to shorten time to market for new products has revealed the lack of a consistent approach to determining the reliability performance of devices. As a result, time-consuming and redundant testing occurs at many stages of the product development and qualification cycle. A standard methodology and qualification procedure would enable the industry to enact changes more quickly and to bring products to the market in a shorter time.

This project will develop a reliability qualification method for portable electronic medical equipment, including the peripheral products of implantable systems.

Component Specifications for Medical Electronics Products

There are no medical industry specifications for the qualification of components or their suppliers. Thus every component that is purchased for high-reliability medical products today must be individually qualified.

This situation increases costs for component manufacturers since every medical device OEM can have different requirements. This high cost of business can make the component manufacturers unresponsive to the medical device market.

This project will define a set of component-level reliability qualification methods for electronic components used in implantable and wearable medical devices. The goal is to develop specifications that can be supported by device OEMs as well as component suppliers. These tests and screens will be identified from relevant existing test methodologies and standards available in the electronics industry at large.

In summary, Medical Electronics represents a growing segment of the industry with significant quality-of-life benefits to the global population. iNEMI is committed to driving industry-led initiatives that will accelerate the deployment of enabling technologies and associated products. For the latest information on these efforts go to: www.inemi.org/focus/medical-electronics. ◆

JIM MCELROY served as iNEMI's CEO from 1996 to 2009. He retired in August 2009, but continues to work part-time for the consortium, assisting with new program development. Mr. McElroy came to iNEMI from MicroModule Systems, a 1992 spin-off from Digital Equipment Corporation. Mr. McElroy has authored several papers and articles in the area of interconnect/packaging and holds one patent for the design of the VAX9000 Multi-chip Module. He is an active member of IMAPS and IEEE. He received a B.S.M.E. and an M.S.M.E. from Northeastern University in Boston, Massachusetts.

Advanced IC Packages Needed for Handheld Electronics

Sandra Winkler, Senior Analyst for IC Packaging
New Venture Research Corp.

THE DEMAND FOR PORTABLE Internet connectivity devices such as cell phones, tablets, GPS devices, MP3 players, and more is very strong, in spite of poor economic times. What these items have in common is that they all pack an enormous amount of functionality into a very small space. To achieve this feat, these products must utilize more advanced packaging methods for the ICs inside the products, as it is the IC packages that hold the footprint to the PCB and thus determine the size of the PCB and, ultimately, the size of the final product. The packaging method of the chip also determines the speed and performance of that chip, as well as its battery consumption.

These devices are fueling demand for advanced IC packaging technologies such as system in package (SiP), stacked packages, fan-in QFNs, fan-out WLPs, interconnection styles of 3-D and 2.5-D through-silicon vias (TSVs), and flip chip.

Stacked Packages

Stacked packages are essentially a vertical multichip package. They come in many forms, including die stacks, package on package (PoP), package in package (PiP), TSOP stacks, QFNs, MCMs, and WLPs. Now found in all cell phones, stacked packages are enjoying a high-demand market. Stacked package revenue will experience a 10 percent CAGR through 2015.

Through-Silicon Vias (TSVs) / 3-D Interconnect

Using 3-D interconnection with TSVs creates a die stack with the shortest interconnection distance, enhancing the characteristics of high speed, low power consumption, reduced parasitics, and small form factor. This interconnection style utilizes vias that go through the silicon to electrically connect one die to the next in a vertical stack, in place of wire bonds or other forms of connection.

In a world in which small mobile devices connected to the Internet are in high demand, these are important features. By moving to 3-D interconnection, the device can achieve 100 times the connectivity or bandwidth, with less power consumption. With lines and traces on the silicon die moving to 45-, 32-, and 22-nm lithographies, utilizing TSVs is a way for the back-end interconnection to keep pace with the front-end manufacturing.

The notion of 2.5-D was born in early 2010, as a variation of 3-D integration. Three-dimensional integration stacks devices vertically using TSVs for electrical connection, and possibly an RDL (redistribution layer) created with a dielectric material as a layer to reroute the electrical connections between chips to allow the vias to travel to the lower substrate.

2.5-D replaces the RDL with a silicon (or glass) interposer as the routing layer, so that the through-vias run through the interposer or substrate rather than through the active die. This interposer can be used to fan out or reroute the electrical traces of a device while routing the traces to another vehicle in a vertical dimension, such as the package substrate. These layers utilize microbumps on the interface to electrically connect to the next layer in the stack. Silicon interposers accommodate the CTE mismatch between the layers in a stack, acting as a stress reducer, thus improving reliability.

The identified potential markets for TSVs will climb from 35 billion units in 2010 to over 54 billion in 2015.

System in Package (SiP)

SiPs are a functional block, a system of electronics that combines functional units together onto a single substrate to enable the shortest electrical distance between parts for superior performance. This reduces the number of traces going into and out of the package, enabling a more simplistic PCB for the final product and potentially reducing system costs. Revenue for SiPs will expand at a 5.4 percent CAGR through 2015.

Fan-In QFNs

To increase the reach of the QFN package, this involves extending the number of rows of leads from the usual one to two or three rows of leads. The leadframe is stamped or etched as in any other leadframe solution, but the leads

are of various lengths, either two or three different lengths. When bent downward for connection to the PCB by trim and form equipment, the result is a multirow, array-patterned package solution, know as a fan-in QFN. This allows the number of package leads to extend into the hundreds, up from generally fewer than 50. This includes extending its reach to higher bit MCUs and both logic and analog communications chips, largely bound for RF handheld gadgets that require a small-form-factor package. Though the number of fan-in QFNs assembled currently is quite small, the potential is huge, with a projected CAGR of 63.1 percent through 2015.

Fan-Out WLPs

Reconfigured or fan-out wafer-level packages (WLPs) were introduced in 2006. After devices are manufactured on a wafer, the devices are sawn and transferred on a carrier to another larger wafer that has gaps between die, which are filled with overmold material that also coats the back side of the devices for protection. This allows for a larger surface on which to extend a redistribution layer, thus allowing for far more I/Os than would be possible on the original smaller WLP surface. Solder balls or bumps can be added to this surface for interconnection to a printed circuit board. Fan-Out WLPs have a CAGR of 15.9 percent for revenue through 2015.

Advanced IC Packages

All these packages are advanced forms of IC packages, which add performance and/or reduced form factor to the mix. These attributes make them suitable for the handheld electronic gadgets that are in great demand currently.

Cellular handsets are the primary handheld electronic gadget that everyone wants to own. Their use is spreading around the world, especially in territories too vast to support wired communication lines. Cellular handsets are growing at an 8.5 percent CAGR between 2011 and 2015, and the smart phone subset of this market is growing at a 15.2 percent CAGR. These rates are far greater than for the economy as a whole.

More information can be found on these topics and others in the new report, *Advanced IC Packaging Technologies, Materials, and Markets, 2011 Edition*, available from New Venture Research. Visit www.newventureresearch.com to order your report today. ◆

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- The Next Large Market Opportunity: Motion Interface
- Realizing the Full Potential of MEMS Design Automation Software
- Awareness Through a Trillion MEMS Sensors
- MEMS Integration of the Accelerometer: The First Step of the MEMS Revolution
- MEMS R&D Prototyping to Manufacturing in Singapore
- Evolution of MEMS Packaging Supporting High Volumes
- Requirements to Launch Roadmap Funding
- New Markets Enabled by MEMS

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Tenth Annual MEPTEC MEMS Technology Symposium

Wednesday, May 23, 2012
Wyndham Hotel, San Jose, California

MEPTEC IS PLEASED TO be holding our 10th Annual MEMS Technology Symposium. To celebrate a decade of bringing hundreds of experts and thousands of attendees together, we are going to jumpstart the next decade with a bold prediction: How to reach $1 trillion dollars MEMS market in the next ten years. We hope you can join us as we bring together speakers who will support the idea that this accelerated growth is possible.

Truly new technologies have historically changed civilizations, productivity, and the balance of power.

Maxim Integrated Products recently described a 3rd industrial revolution... a fusion of sensing, computing, and communication based on MEMS integration. Maxim predicts the MEMS market will match the $300B IC market. This will be significantly accelerated by increasing MEMS R&D cycles to 15/year (vs ~3/year now), and by standardized MEMS processes. This will require significant funding, beyond a single company's capability. Much better to compete in a $1T market using best-practice shared designs and processes that accelerate market growth, than to tackle a $10B market, going it alone. Funding a MEMS partnership ("coopetitors") based on that vision should be feasible.

At the 2010 MEMS Technology Summit at Stanford, Bosch envisioned 7 trillion Sensory Swarm sensors serving 7 billion people by 2017. MEMS-based systems already enable smart automobiles, phones, and homes, as well as personal entertainment, medical diagnostic and industrial applications. Hewlett-Packard outlined a vision for CeNSE, a Central Nervous System for the Earth, deploying a trillion nano-sensors and actuators. This will generate, by 2013, a $360B global market for MEMS-based sensing systems.

Clearly, the MEMS market is entering an explosive growth phase. Various analysts have estimated a growth of 12-15% per year, translating to a MEMS market of ~$1 trillion in 35 years (2046). To reach that market in only 10 years, growth must accelerate to 54% a year. This conference will feature visionary speakers who are convinced this growth is possible. ◆

The Wyndham Hotel is conveniently located at 1350 North First Street in San Jose, CA in close proximity to the San Jose Airport.

Special Showcase Session: *MEMS for All of Us*

At the post-symposium reception a special session called **MEMS for All of Us** will be held to showcase selected products driven by sensors and sensor software. During the reception, attendees will have an opportunity to see hands on demonstrations of the products. The technology behind the products will be presented in the last session of the symposium.

MEMS for All of Us will be open to symposium attendees, outside industry groups, media and the public.

Companies who have accepted to-date include:

- **CSR** – www.csr.com
- **HillCrest Labs** – www.hillcrestlabs.com
- **Movea** – www.movea.com
- **Sensor Platforms, Inc.** – www.sensorplatforms.com
- **Syride** – www.syride.com
- **VectorNav** – www.vectornav.com
- **Xsens** – www.xsens.com

On the day following this event, **MEPTEC** and **MEMS Investor Journal** are co-presenting the first annual **MEMS Business Forum**. The Forum will continue the theme of tremendous MEMS growth by inviting business, academic and technology experts to discuss the key issues that will help enable and drive the growth. Discounted attendance and exhibiting opportunities are available to those who wish to attend both events. Contact bcooper@meptec.org or go to **www.memsforum2012.com** for pricing details.

KEYNOTE

Steve Nasiri

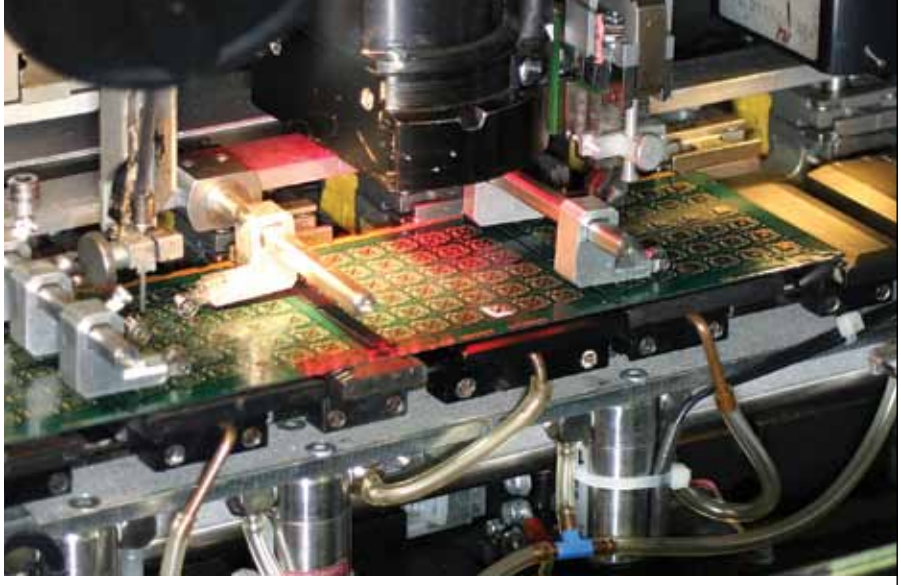
Motion Interface the Next Large Market Opportunity

Steve Nasiri, Founder, President, CEO and Chairman, InvenSense

Every now and then, some new technology surfaces as the next Must-Have function that transforms the consumer products landscape; Bluetooth, Camera Modules, WiFi, and Touch Screens, to name just a few. Motion Interface rapidly has become that next Must-Have function in all mobile consumer products. At the outset within the Nintendo Wii and now found in all high-end Smart Phones and Tablets, and expected to be penetrating many other consumer products, such as, Smart TV's remote controllers, Wearable Devices, Ski Goggles, Power Screwdrivers, Golf Putters, Sporting Shoes, Quadhelicopters, and many more. This presentation will discuss the key fundamental technologies, challenges, benefits, and overview of various use cases.

Steven Nasiri is the founder of InvenSense and has served as President, CEO and Chairman since 2003. Prior to founding InvenSense, Mr. Nasiri held various positions as a co-founder and executive of several MEMS companies, including SenSym (acquired by Honeywell), NovaSensor (acquired by General Electric), Integrated Sensor Solutions (acquired by Texas Instruments) and ISS-Nagano GmbH. ◆

Unisem Group is a global provider of semiconductor assembly and test services for many of the world's most successful electronics companies. Unisem offers an integrated suite of packaging and test services such as wafer bumping, wafer probing, wafer grinding, a wide range of leadframe and substrate IC packaging including leaded, QFN, BGA and FlipChip packages, and high-end RF and mix-signal test services.



Array Package Assembly - Die Attach.

Final Test.

UNISEM'S TURNKEY SERVICES include design, assembly, test, failure analysis, and electrical and thermal characterization. With approximately 10,000 employees worldwide, Unisem has factory locations in Ipoh, Malaysia; Wales, United Kingdom; Chengdu, People's Republic of China; Batam, Indonesia and Sunnyvale, California, USA. The company is headquartered in Kuala Lumpur, Malaysia.

Assembly

Unisem assembles a broad range of standard and custom leadframe, leadless and array packages with pin counts ranging from 3 to 700+. They also offer WLCSPs or Wafer-Level Chip-Scale Packages which are a low cost solution that enables direct connectivity at the substrate or board level.

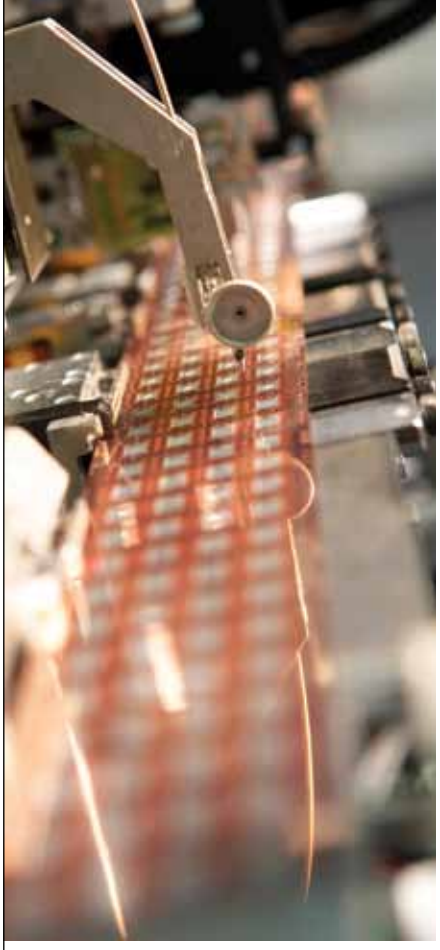
Test

In addition to package assembly services, Unisem provides a full range of package testing services. Capabilities include analog, digital and mixed signal testing, with over 100 test systems. To further reduce their customer's time-to-market, Unisem also offers the following post-test services: Lead Scan, Lead Conditioning, Tape and Reel, Vacuum Packing, Burn-in, Dry-bake, Final Pack/Stock and Drop Shipping.

Wafer Bumping

Unisem offers wafer bumping services through its wafer bumping fab in Ipoh (UAT) and its factory in Chengdu, China. Located at the same location as their assembly and test factories, customers receive seamless integration of a wide variety of services under one roof covering wafer bumping, wafer backgrinding, wafer probe, dicing, final test and flip-chip assembly.

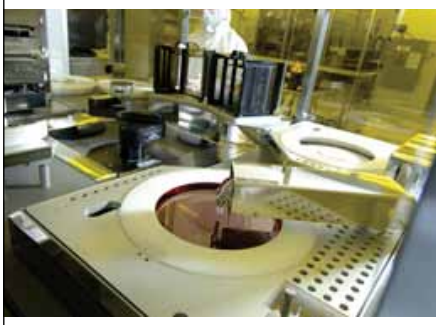
These two wafer bumping fabs offer gold bumps, copper pillar bumps and solder bumps (through ball drop, plating and solder paste printing). Additionally, they provide repassivation and bond pad redistribution services.



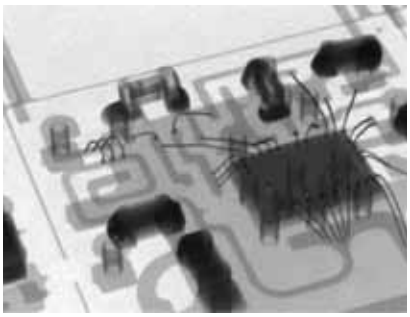
Leadframe Package Assembly - Die attach.

Unisem has both development and high volume production semiconductor assembly and test facilities in Asia, Europe and the United States. And with their new wafer bumping fab in Chengdu, they now have two high volume factories with full turnkey wafer level packaging capability.

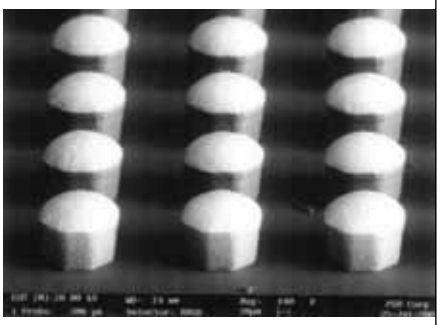
Package Assembly - Wirebond.



UAT Wafer Bumping Fab in Ipoh.



QFN System-in-package.



Copper Pillar Bumping for WLCSP.

PACKAGE OFFERINGS

Array Packages

Unisem has vast experience with BGA assembly and manufacturing. In fact, they have developed several in-house manufacturing capabilities that give them the flexibility needed to for quick design and manufacture of Array products. So any manufacturing hurdles are quickly cleared, and any specialized needs are soundly addressed by their competent design and manufacturing crew which provides optimized cost and yield for a variety of package designs.

Leadframe Packages

Unisem's leadframe package assembly and manufacturing systems provide for lower costs and higher yields of the industry's most sought-after packages. Their process innovations in these proven technologies have kept them at the forefront of the industry.

Leadless Packages

The small size of these packages, coupled with excellent thermal and electrical performance, make leadless leadframe packages such as the QFN and ELP ideal for hand held and portable communications applications including cellular phones, personal digital assistants (PDAs) and other applications where small, high performance packages are required. Their QFN packages are also available in 2 and 3 Die configurations in Stacked Die, MCM and SIP (System-In-Package) versions which bring enhanced functionality, package performance and integration perfectly suited for wireless and other applications needing system integration in a single package format.

Wafer Level Packaging

Unisem offers a Wafer Level CSP low cost solution that enables direct connectivity at the substrate or board level. To

help provide this service, they are also equipped with latest state-of-the art Laser Mark, Rudolph Wafer 2D/3D inspection station and high speed Muhlbauer Die Sorter. Unisem offers a full turnkey solution for Wafer Level CSP from WAFER BUMPING, PACKAGING, TEST SOLUTION (probing) and full wafer map integration to handle die size from 0.5 mm2 to 7 mm2 in both their Ipoh and Chengdu factories.

MEMS Packaging

Unisem builds custom MEMS packaging for a number of applications that require unique cavity environments, including solutions for pressure sensors and microphones. Much of their MEMS package development takes place in their development facility in Wales and are then transferred to Unisem's high volume factories in Asia.

UNISEM FACTORIES

Batam

Unisem's factory in Batam Island, Indonesia, is a one stop shop facility, which provides Wafer Probe, Wafer Backgrinding, Assembly Packaging, Final Test, and Drop Shipment.

Unisem Batam assembles and tests leaded and array packages on a high volume basis in this 345,000 square feet facility. Located approximately 10 miles from Singapore, Batam is an island that benefits from free trade zone incentives provided by the Indonesian government.

Chengdu

Unisem Chengdu Co., Ltd. ("Unisem Chengdu"), Unisem Group's latest state-of-the-art Semiconductor Assembly and Test facility in Chengdu, China, began mass production in July of 2006 in the current total production floorspace of 320,000 square feet. Recently Unisem's second 320,000 square foot building was fully facilitated and is now running production volumes for wafer bumping and wafer level packaging.

Unisem Chengdu offers full turnkey semiconductor assembly and test services including wafer bumping, wafer probe, wafer backgrinding, assembly, test, and drop-shipping of finished goods to customers' designated locations. Unisem Chengdu provides assembly service for a wide range of advanced leadframe, substrate and wafer level packages and the testing of analog, mixed signal and radio frequency devices.

Ipoh

Unisem Ipoh is Unisem Groups full turnkey assembly and test operations located in Malaysia. Unisem Ipoh offers an integrated suite of packaging and test services for semiconductor companies such as wafer bump, wafer probe, wafer grinding, a wide range of leadframe and substrate IC packaging, high-end radio frequency and mix-signal test, tape & reel and drop-shipment services.

UAT

Unisem Advanced Technologies Sdn Bhd ("UAT") (Formerly known as Unisem-Advanpack Technologies Sdn Bhd), is one of the first independent wafer bumping service providers in Malaysia. UAT is located at Unisem's Ipoh facility and commenced operations in 2006. This 22,000 square feet facility with a class 1K clean-room supports wafer sizes of 100mm, 150mm and 200mm diameters.

Sunnyvale

Unisem's test services facility in Sunnyvale, CA provides a full range of test, engineering and other test related services. This 22,000 square foot facility operates 24 hours a day, seven days a week.

Sunnyvale serves as their North American test hub providing expertise in test engineering services. They offer pre-production capacity on a wide range of test platforms for analog, digital, mixed signal and RF devices. Other test related services available in this location are burn-in, wafer probe, final test, marking, dry bake, lead scan and lead conditioning, tape and reel, dry pack and seal and bar code labeling.

Europe

Unisem Europe, part of the Unisem Group, is the region's leading contract manufacturing IC Assembly and Test Facility. This full-turnkey assembly and test factory in Wales has developed a strong reputation in supporting the development of emerging technology companies during the critical start-up and preproduction phases, and is recognized throughout the industry for its expertise in packaging, test and failure/reliability analysis.

Unisem Europe is focused on offering fast prototyping services and low to medium volume assembly and test of QFN, laminate and MEMS packaging. Unisem Europe offers new emerging and fabless semiconductor companies the support vital to developing their products and the strength of Unisem Group's Asia-based assembly factories once their product ramp to high volumes.

Summary

Unisem has both development and high volume production semiconductor assembly and test facilities in Asia, Europe and the United States. These facilities offer a wide variety of packaging solutions that range from mature leadframe and substrate packages to newer package technologies for the unique needs of multi-die and MEMS applications. And with their new wafer bumping fab in Chengdu, they now have two high volume factories with full turnkey wafer level packaging capability. ◆

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Roadmap to a $Trillion MEMS Market

The Third Industrial Revolution

Dr. Janusz Bryzek
VP MEMS Development, Fairchild Semiconductor
Board Member, Mancef

The objective of this evolving white paper is to gauge an interest of key players in the MEMS market to develop and implement a strategy significantly accelerating the growth of this market and related technologies (ICs, systems, data processing, etc.).

INTRODUCTION

Transistor and MEMS technologies originated from the pioneering Bell Labs work in the late 1940s and early 1950s. While the resulting semiconductor market grew to approximately $300B by 2011, the MEMS component market experienced much slower growth to an estimated $10 billion in 2011.

Recent dramatic acceleration of the consumer MEMS market growth resulted from Steve Jobs' conversion of a cell phone into a powerful computer. Computing power enabled the creative user interfaces, such as touch sensitive screens and auto landscape-portrait rotation, opening a Tornado for MEMS adoption. Acceleration sensors, gyros, magnetic sensors, microphones, pressure sensors and RF filters grew by 2011 to a multibillion units/year total market.

Based on currently forecasted growth of MEMS component market by Yole and iSupply, the MEMS market is on path to reach $20B in 2016 (see Fig.1). The interesting aspect of this forecast is that most of the devices with visible market share in 2016 have potential for integration with mobile devices. To enable adoption in mobile devices, MEMS components must deliver a combination of price, footprint and power consumption.

2016 MEMS Market Value Breakdown – Total: US$ 19.6B

(Status of the MEMS Industry Report, September 2011, Yole Développement)

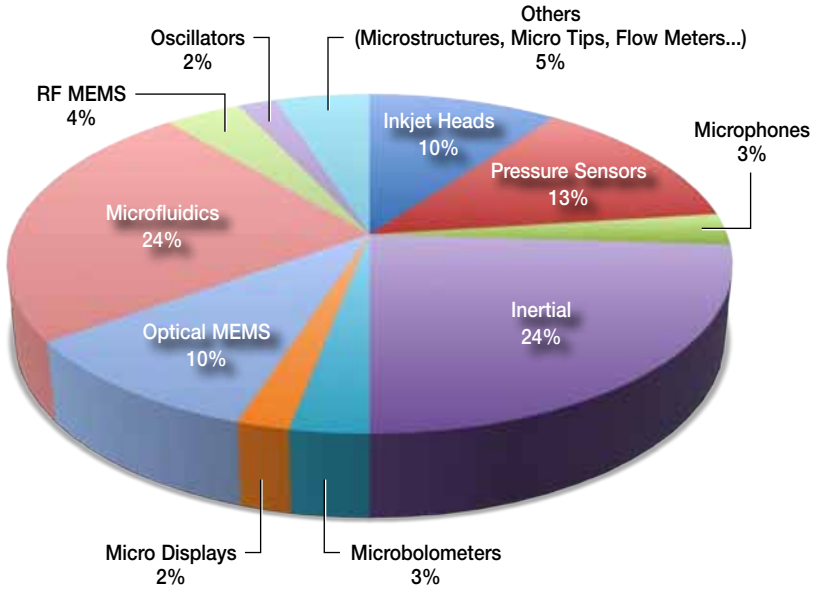

Figure 1. Yole's forecast of MEMS market (December 2011),

Visibility of an even larger MEMS market is emerging from several sources. Some MEMS visionaries, including the author, foresee a dramatic acceleration of MEMS market growth with potential to (finally) catch the $300B semiconductor market size.

POINTERS TO ACCELERATED MEMS MARKET GROWTH

Several sources outlined MEMS forecast at least an order of magnitude larger than Yole's and iSupply's.

Central Nervous System for the Earth

In 2010, in multiple presentations around the world Hewlett-Packard outlined a vision for CeNSE, a Central Nervous System for the Earth, which will deploy a trillion nano sensors and actuators for the following markets:

- Climate monitoring
- Oil exploration and production
- Assets and supply chain tracking
- Smart highway infrastructure
- Tsunami and earthquake warning
- Smart grid and homes
- Structural health monitoring

Processing the sensor information would require increasing the size of Internet 1000 times, creating huge demand for computing and generating along the way a $70B global market for sensing systems, and $290B market for value added sensing services by 2013.

With a trillion nodes, the MEMS market would be huge. Assuming a smart Internet sensor node priced at just $1 would result in a $1T market…

Sensory Swarms

At the MEMS Technology Summit conference at Stanford University (co-organized by the author in October 2010), Horst Muenzel, Regional President of Robert Bosch LLC, presented a vision for 7 trillion devices consisting of Sensory Swarms connected to the Internet to serve 7 billion people in 2017 (in 2010 there were already 5 billion mobile phone subscribers). This vision was originally presented by Jan Rabaey, Co-Director of Berkeley Wireless Research Center in his presentation "A Brand New Wireless Day" at Bears Conference in February 2009.

All devices would be part of mobile internet servicing "Internet of People" (social people networking) and "Internet of Things" ("social" machine networking).

This vision translates to 1000 sensors per average person in 2017. While it sounds somewhat big, we are already seeing high end applications supported by large number of sensors, for example:

- Advanced cars have close to 100 sensors.
- Smart homes use 10s and 100s of sensors.
- Smart phones use 6 sensors.
- Medical diagnostics uses 100s of different sensors, which will be migrating to personal use.

It is thus not too big of a stretch of imagination to foresee the growth outlined by Bosch. With 7 trillion nodes, the market at a low $1 sensor node would be $7T…

Smart Business

Harbor Research introduced a concept of Smart Systems in the era of Pervasive Internet, where people, devices, sensors and businesses are connected and able to interact with each other. Smart business practices will enable a truly connected converged physical and virtual world.

Some of the leading markets for smart sensing systems include cell phones, health monitoring devices, smart grid infrastructure, automotive, IT and industrial systems.

This will enable collective awareness, creativity and better decision making capabilities, driving the largest growth opportunity in the history of business.

Third Industrial Revolution

Looking back, all major technologies coming to market were changing the world's productivity and balance of power. At the BSAC meeting on 9/22/11, Vijay Ullal, VP of Maxim, referenced three major technology based revolutions:

- 1st revolution increased productivity by bringing steam, electricity, internal combustion, radio and aeronautics.
- 2nd revolution further increased productivity through transistors, computers and the Internet, propelling the semiconductor market to $300B.
- 3rd emerging revolution based on fusion of computing, communication and sensing, freeing humans for creative work and enabling MEMS market to catch-up with semiconductor market.

Ullal stated that growth could be significantly accelerated if MEMS R&D speed would be increased to 15 cycles/year, and standard MEMS processes become available for the fastest growing products. Making this feasible would require significant funding exceeding the capability of a single company.

The attractiveness of competing in a $1T market by design only using standard MEMS processes, as opposed to competing in a $10B market using both design and process, should entice competitors to cooperate, thus creating coopetition (cooperating competitors).

2011 MEMS component market is estimated by Yole at $10B and growth rate at 14%/year. At this rate, the MEMS market would reach $1T after 35 years (2046). To accelerate growth to $1T to 10 years, the growth rate would have to increase to 54%/year.

CONCLUSION

The potential growth of MEMS based products is stunning, representing arguably the world's fastest growing market segment. As a byproduct, it will also be one of the greatest job generating engines. It will bring exciting new products, changing our life.

Acceleration of MEMS growth will require substantial funding and it is not yet clear if such funding could be secured in coming years.

Go to www.meptec.org and click on the MEMS event to read the entire white paper, including the author's vision on how to reach the goal of growing the MEMS market to $1T in ten years by accelerating the research and development cycle. ◆

DR. JANUSZ BRYZEK co-founded seven Silicon Valley MEMS companies: Sensym (now Honeywell), ICSensors (now Elmos/MSI), NovaSensor (now General Electric), Intelligent MicroSensor Technology (now Maxim), Transparent Networks (IP acquired by Intel), LVSI (now Atmel) and Jyve (now Fairchild).

MOPA Single Pass Nanosecond Laser Applications for Semiconductor, Solar, & General Manufacturing

Mark Brodsky, US Applications Manager
SPI Lasers

THE LASER MARKETPLACE IS huge. There are a myriad of applications in medical, metrology, defense, and manufacturing industries. This article will discuss just a portion of the substantial materials processing segment. Industry experts[1] estimate that the market for material processing lasers is nearly 3 billion dollars. Half of that total is for high power (multi-kilowatt) applications such as metal cutting. Under 120 watts is typical of uses of such as micro machining, marking, and texturing.

Many applications for high speed processing use fiber lasers in the 1060-1070nm wavelength. These IR laser sources themselves are relatively low cost. However, it is noted that shorter wavelengths, in the Green and Ultra-Violet range, are also in great use in electronic processing. Those laser sources provide smaller geometric spot sizes, and shallower absorption depths for difficult to process materials. This extra ability comes at a substantial cost and stability penalty. Such lasers are practical for micro machining, and the short absorption depth make green laser practical for marking silicon wafers and chips including flash memory drives. Long wave length 10640nm CO_2 lasers provide the energy source for cutting and etching a vast variety of non-metals but usually at the cost of finer detail. Complicated and expensive optics are used in fixed head applications for stencil cutting and via drilling, particularly on organic PCB material. Precision typically requires fixed optics while Galvo mirrors are used for speed.

Some Laser Basics

For general purpose materials processing, 1064nm is the basic YAG (Yttrium Aluminum Garnet Neodinium Doped) wavelength. Traditionally lasers are assembled with a gain media in a pumped cavity between two mirrors (Figure 1). A power supply (Figure 2)

Figure 1. Typical YAG Rail with mirrors at each end and pumped gain cavity in the middle.

Figure 2. Typical YAG power station with DI water supply.

supplies pump light to raise the energy of the gain media, such as a YAG Rod to a higher peak-power. This higher energy was released in a burst as soon as an intervening Q-switch allows a beam clear access to the mirrors. DisQ lasers operate much the same way with the exception that their larger flatter surface experienced less thermal distortion than the YAG Rod. Cavity conversion efficiencies range from 1% to 40% depending upon how the laser source was pumped.

Fiber lasers build on this principle by stretching the gain medium into a very thin glass fiber, 20 microns or less. Pump light is then applied to this fiber by a variety of means using another bigger fiber of around 200 microns. The energy from the pump fiber is then imparted directly onto the narrow hair of gain media (typically Erbium doped glass). The fiber will begin emitting highly collimated and coherent light in a Continuous Wave as soon as a gain threshold is met by the pump. Beginning with Mr. Laser's Flogiston in 1997, the very first fiber laser markers used this CW beam to inscribe small IC packages such as the tiny SOT.

Galvo Mirrors for Fast Application of Laser Energy

For the past two decades, rapidly moving mirrors powered by highly accurate galvo motors have been the method of choice to quickly apply laser energy onto a target. This is because of the very low inertia of a moving mirror in comparison to a X-Y table. Figure 3 shows the basic components of a scan-head using mirrors. These are often focused through a special flat field focusing optic called an f-theta lens. Other galvo systems used digital focusing lens ahead of the mirrors and can image a focused spot over large areas as well as different target heights. Optics determine spot size. Small spots typically require bigger mirrors, and bigger mirrors are less nimble. Thus, a host of tradeoffs must be considered.

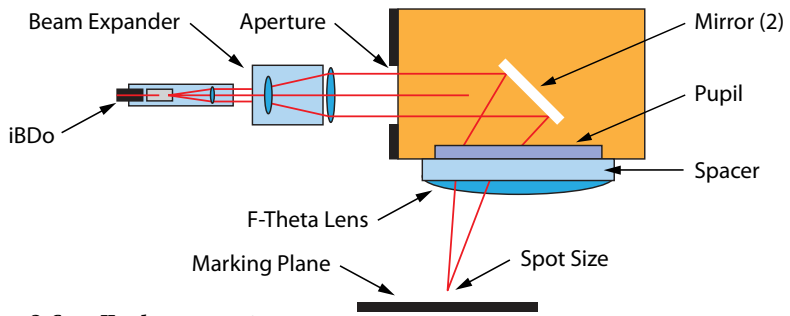

Figure 3. Scan Head components.

Pulsing Versus Beam Chopping

Lasers that put out continuous waves can have the output chopped, i.e. pulse width modulated. The average power varies with the duty cycle. Meanwhile, the overshoot from each time the laser is turned back on is around 3-6 times the maximum power.

Gain media in fibers and crystals offer much higher energy pulses in factors around a thousand times greater than the average power. This is because the gain energy can be release in one thousandth of the time it took for it to be charged up. Even at 20khz, powerful pulses of light are emitted in just tens of nanoseconds. Lasers often use an acoustical means to allow the gain media to charge up between releases of energy. The most typical means is a Q-switch which can prevent the cavity light from impacting the mirrors at a normal angle. At the moment the Q-switch is turned off, light can freely pass between the mirrors and lasing begins. The second generation of fiber laser (Figure 4) uses a form of a Q-switch in line with the laser for just this purpose and can deliver multi Kilowatt pulses of power at 20kHz repetition rates.

Figure 4. Early generation Q-Switch Pulsed Fiber Laser. Already more compact than the traditional Flash Lamp YAG in use well into this century. Note the elimination of the laser "Rail".

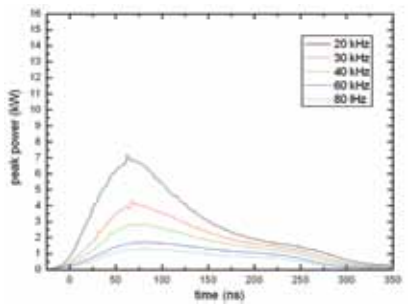

Figure 5. Q-Switch pulses.

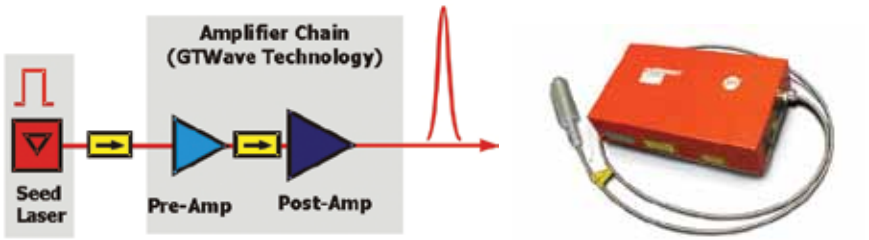

Figure 6. Seed Pulse diagram and modern MOPA Laser ready for attachment to a scan or fixed head.

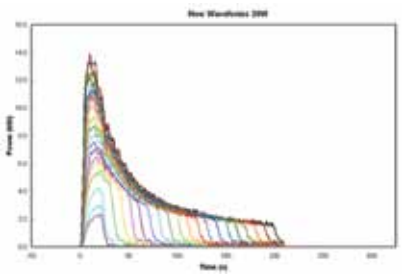

Figure 7. MOPA pulses.

The MOPA Difference

A laser with a cavity between two mirrors must discharge the energy in a rising and then falling curve. This extends the time the energy is released and also greatly decreases the maximum energy available as the pulsing rate is increased. (See Figure 5)

An alternative design is called a MOPA for Master Oscillator/Pulsed Amplifier. This is basically a single pass amplifier. The fiber is charged up and once the energy is at its peak, a powerful seed pulse is released from one end. This is amplified and the result is a very intense pulse is expelled in a very short time. (See Figure 6) This pulse can be shaped into various forms by controlling the state of the amplifiers and the duration of the seed. This more front-end loaded pulse initiates coupling with the target material quickly for a short reaction. (See Figure 7)

Perhaps the greatest benefit to this wave form design is that energy can be pushed forward as the kHz of pulsing increases. This results in the ability to process materials with far higher speed scans than Q-switch designs. The right column of Figure 8 shows how Q-switch lasers lose the ability to etch anodize aluminum over 150kHz. The MOPA pulses are energetic enough for this application at 500kHz. The higher MOPA pulse rate means that processing can be achieved at scan speeds 5 times greater than that of Q-switch.

continued on page 28

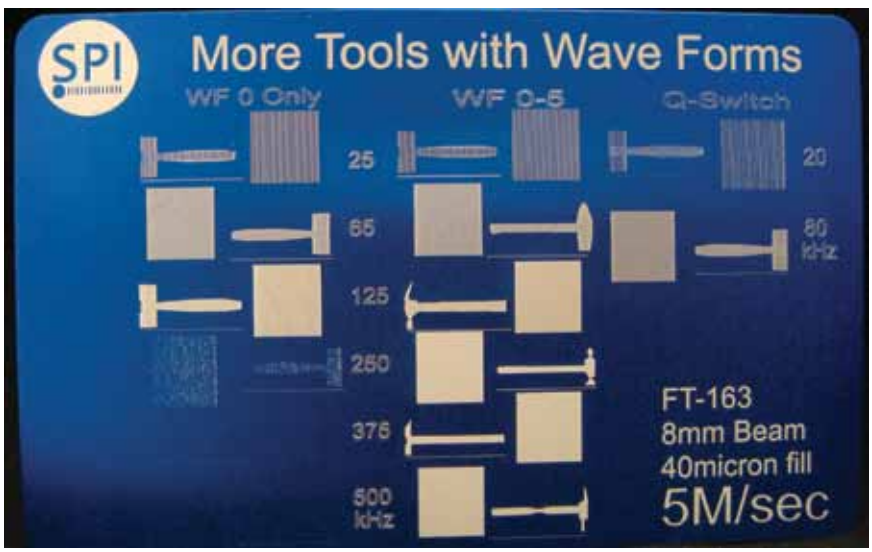

Figure 8. Shows that Q-Switch fibers lose power to ablate aluminum after 200kHz or less. MOPA wave forms are more energetic and can ablate aluminum at 500kHz. This means scans can achieve speeds of 5 meters or more.

continued from page 27

High kHz Processing

Figure 9 shows how higher kHz and less ablative pulses can provide a softer mark on IC packaging materials. Different wave form pulses can be combined to both ablate and burn text and graphics onto packages. Of greater value is how higher kHz can provide high speed and smooth ablation of Transmissive Conducting Oxide (TCO). Figure 10 shows this effect. Here, Wave Form 2 provides sufficient pulse energy to cleanly ablate the surface of TCO coated plastic while still pulsing at 125kHz. Scan rates of 2 meter/second are easily achievable and the high kHz from new MOPA designs are able to achieve 5 meter speeds and excellent pulse overlap.

Spot Shape Considerations

Laser output is greatly affected by optics. However, without special beam shaping, the natural mode of the laser determines the shape of the energy density. A typical way laser beams are compared is by what factor they are worse than ideal. This is called the M2 factor where 1.0 is a perfect diffraction limited beam. From left to right, Figure 11 demonstrates three outputs from fiber laser at M2 of 1.1, 1.8, and 3.2. While smaller M2 are appropriate for many uses, for this ceramic snapping application, the "worst" beam profile is the best fit for the job. There is no one best laser for all applications.

Final Considerations

Lasers are now small and powerful and easy to integrate into a host of processing equipment. Laser applications benefit from the optimal mix of peak pulse power, available pulse energy, and power duration. MOPA lasers add an additional feature of front loaded power with different wave forms allowing for very high speed processing using fast Galvo heads. Depending upon target material, pulse shape, and optics, low cost MOPA lasers become a tremendously flexible tool for material processing. ◆

[1] *Industrial Laser Solutions, Optech Consulting*

Figure 9. Variation of pulses on IC plastic.

Figure 10. High kHz High Speed TCO removal.

MARK BRODSKY is the Manager of the US Applications Laboratories for SPI Lasers. He received a BS in Industrial and Systems Engineering from California State University, San Jose in 1973. He was the founder of Mr Laser Inc. and owns Laser Mark's Company. He worked at National, Zilog and AMD in semiconductor packaging engineering, and at SDL and JDSU in laser applications. Mark is also active in local politics as the former Mayor of Monte Sereno, California.

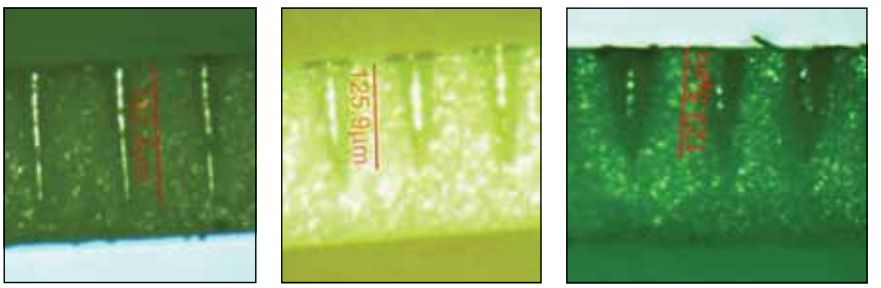

Figure 11. Different Spot Shapes effect materials differently. Here the larger mode pulse shape provides the best architecture for ceramic scribing.

HENKEL NEWS continued from page 30

kel has developed a suite of NCP materials to address flip chip underfill requirements. These include HYSOL FP5000, HYSOL FP5001, HYSOL FP5200 and, the most recent material, HYSOL FP5201. Designed for compatibility with both gold bumps and copper pillar technology, HYSOL FP5201 enables production of modern, finer-pitched flip chip designs. Other benefits of HYSOL FP5201 include its fast cure in less than five seconds using wide bonding temperature range, with no voiding, excellent electrical performance and its outstanding reliability performance of MSL3, thermal cycling testing up to 1,000 hours, HAST testing up to 96 hours and proven performance when tested for 1,000 hours of temperature storage and temperature/humidity exposure. NCP technology is most certainly enabling next-generation flip chip devices that are currently limited by wirebonding techniques and traditional capillary underfill materials. And, Henkel is advancing NCP technology with novel state-of-the-art technologies that are compatible with smaller form factors and ultra-fine pitches, again reconfirming the company's innovation leadership position.

For more information on Henkel's HYSOL FP5201 or any of its advanced NCP products, log onto www.henkel.com/electronics or call 714-368-8000. ◆

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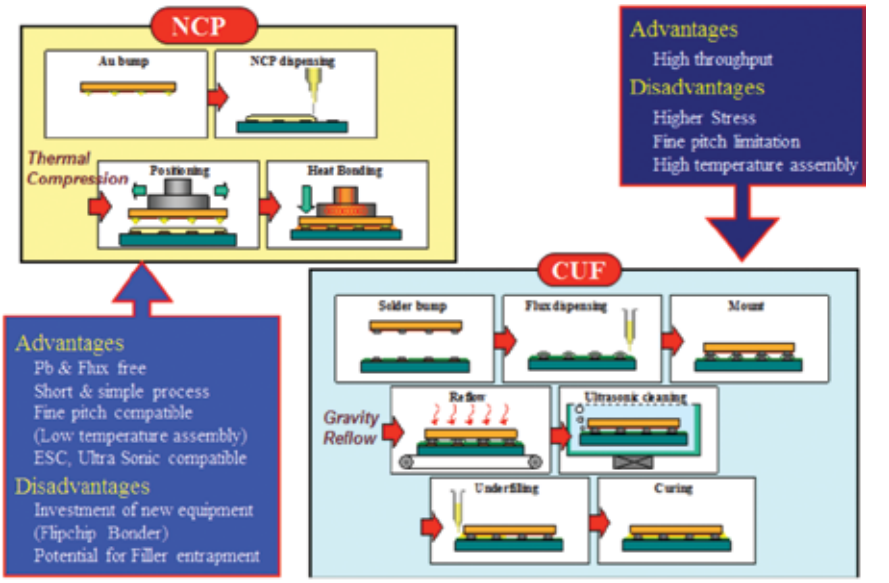
NCP Technology Paves the Way for Integrated, Advanced Packages

Tadashi Takano and Rose Guino, Henkel Electronic Materials, LLC
Mieko Sano, Kenichiro Sato and Shigeo Harada, Henkel Japan Ltd.
Kail Shim, Henkel Technologies Korea

UNDERFILLS HAVE BEEN PART OF the electronics landscape for decades, offering protection for numerous devices inside a variety of electronic products. Different types of applications – everything from automotive to smart phones to computers – use various package designs such as PoPs, BGAs and stacked packages, whereby all of the electronic interconnects are protected by some sort of underfill material.

In the late '90's and early in the 21st Century, the majority of high performance logic devices like FPGAs, QFPs, SiPs and QFNs used and still use architectures which rely on wirebonding to form the device interconnections. As greater functionality and miniaturization drivers persist, however, the trend is quickly moving toward higher I/O counts, package integration, and greater performance and flexibility. For these reasons, many new package designs are using flip chip as the preferred and more high-density interconnect method. What's more, as logic and memory begin to converge, 3D integrated packages using through-silicon vias (TSVs) will become more prevalent.

Flip chip designs are also numerous, with some incorporating gold stud bumps, some using stacked bumps, gold plated studs or copper pillars with solder caps. As devices become smaller, thinner and stacked, we will see the emergence of micro-bumps with TSV. Unlike wirebonded packages, flip chip packages use underfill for protection of the interconnected bumps. Traditional capillary underfills (CUF), however, can present some challenges with narrow gap and fine pitch flip chip devices, which is why many packaging specialists are turning to non-conductive pastes (NCPs) as a viable and more streamlined alternative. The chart below shows a comparison between the NCP process and the standard CUF technique. As is evident from the diagram below, using NCP eliminates several steps as compared to CUF, effectively shortening the underfill process by as many as three process stages and also reducing materials costs due to the elimination of fluxing and cleaning. In addition, NCP is pre-applied onto the substrate, thus interconnection and bump protection are achieved in a single step. This is the key advantage of NCP since CUF is applied after bump formation. That's not to say CUF doesn't have its advantages; it does. It is a higher UPH process than NCP method, but that is its primary benefit as compared to NCP.



Comparison of Assembly Processes.

	NCP	Flux-less CUF
Gap filling Fine pitch (<50um) narrow gap (<25um)	○	Might need vacuum
Form factor, Fillet control	○	depends on design
Thin wafer support, low k protection	○	⊗
Filler entrapment risk	⊗	○
Bump reliability Warpage	○	⊗
High UPH Skip cure	○ 1000 UPH	○ > 2000 UPH
Simpler process	○	⊗

NCP vs CUF for Cu Pillar Technology.

Using copper (Cu) pillar technology as a means of evaluation, we can compare NCP versus CUF processes. For gap filling with fine-pitches of less than 50 μm and gaps less than 25μm, NCP completely fills the spaces. With CUF, it is likely that a vacuum or pressure-assisted process may be required to pull the underfill and fill the gaps without any voids. Form factors also benefit from NCP use, as the material fillet can be controlled. When using CUF, the fillet is generally wider so limits the potential to place two chips side by side. There are multiple other advantages, all which are outlined in the table below.

Understanding the market dynamics and the growth of flip chip packages, Hen-

continued on page 28

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New Aqueous-developable Dielectric Offers Multi-stack Capability with Reliability

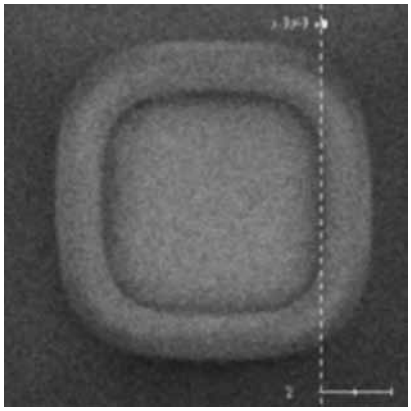
Richard Chen
Dow Electronic Materials

THE DEMAND FOR SMALLER, thinner and more powerful mobile devices with increased and more integrated functionality is a central driver for advanced semiconductor packaging designs. Consumers are demanding a wide variety of functions in a single device and the traditional lines between mobility and computing power have been blurred. Devices such as smartphones, tablets and ultrabooks offer much of the same functionality delivered in different form.

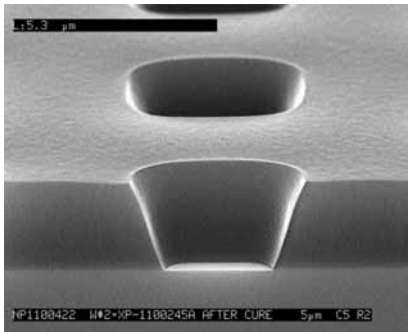
Whatever the form it comes in, the need for more power, speed and function in a smaller footprint poses a fundamental challenge – meeting these consumer demands while delivering reliable devices at affordable prices. The complexities of advanced packaging schemes have increased dramatically and materials play an important role in the success or failure of a device. And, clearly, a material's performance is measured not only on its individual merits but also on how well it or its processing impacts adjacent materials.

Inherent in the latest packaging schemes is a high density of structures and the need for higher speed interconnectivity, which require the use of redistribution layers to re-route I/Os for wafer level chip scale packaging (WLCSP), system-in-package, 3D packaging, and others. The need for permanent dielectrics to electrically isolate these copper redistribution layers comes with its challenges. Dielectric materials must process without impacting surrounding layers and they must maintain their integrity during subsequent processing.

To meet the need for an aqueous-base developable version of its benzocyclobutene (BCB) chemistry, Dow Electronic Materials is offering CYCLOTENE™ 6500 Photodielectric. This positive-tone material for i-line and broadband exposure is capable of imaging features as small as 3 μm vias with either a mask aligner or i-line stepper. Because the material is not cross-linked when exposed, CYCLOTENE 6500 Photodielectric is capable of high-resolution images with repeatability, and it delivers superior aerial image quality. Additionally, the chemistry is advantageous for manipulating the sidewalls of the features through the bake process, providing users the ability to control the profile to obtain desired slope or straightness. Using standard lithographic processing, desired features can be achieved without the need for a plasma step or other related steps.



1:2 pitch 5 µm Via at 5 µm film thickness, post cure (top view).



1:2 pitch 5 µm Vias at 5 µm film thickness, post cure.

Processing with an aqueous-base developable photodielectric has its advantages from a cost perspective. Because CYCLOTENE 6500 Photodielectric can use common drain lines and equipment used for photoresist processing, the material has a lower cost of ownership versus competitive materials. It also eliminates the need for solvent develop processing and maintaining separate systems.

CYCLOTENE 6500 Photodielectric is also an ideal material to be used in redistribution layers because it has minimal impact on other materials. Most notably, the material has a low-temperature cure with a range between 180-210°C, and it exhibits a smooth surface with no residues post cure while meeting customers' requirement for low-thermal budget materials. In addition, CYCLOTENE 6500 Photodielectric does not outgas during processing, which could potentially cause reliability issues or failure. Consequences of dielectric outgassing include impact or damage to adjacent materials and delamination during the bonding step or early failure.

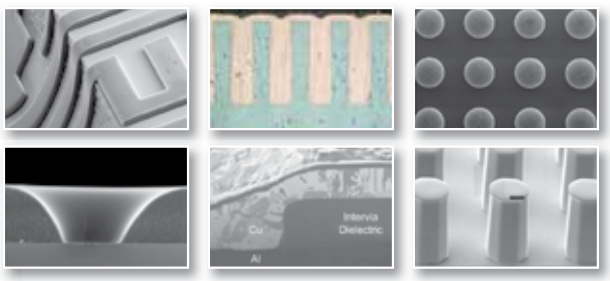
Despite its minimal impact of adjacent materials, CYCLOTENE 6500 Photodielectric provides excellent adhesion on many widely used substrates, including Si, SiO_2, Si_3N_4, Cu, BCB and organic polymers, and this adhesion is maintained during subsequent processing. The material is resistant to chemical attack by common solvents and removers used for packaging applications. Additionally, CYCLOTENE 6500 Photodielectric has good thermal stability up to 350°C if needed. This stability is particularly beneficial if the material is subjected to subsequent processing that is heat intensive, such as CVD deposition of barrier layers, solder reflow and copper-copper bonding. These characteristics are critical to eliminating delamination failure, which can potentially lead to failure of the package. Finally, copper migration into CYCLOTENE 6500 Photodielectric is very low, which is exceptionally critical given the need for the material to maintain its insulating integrity within the copper redistribution layer structures. The material has industry-leading copper drift values for polymers used in dielectric applications.

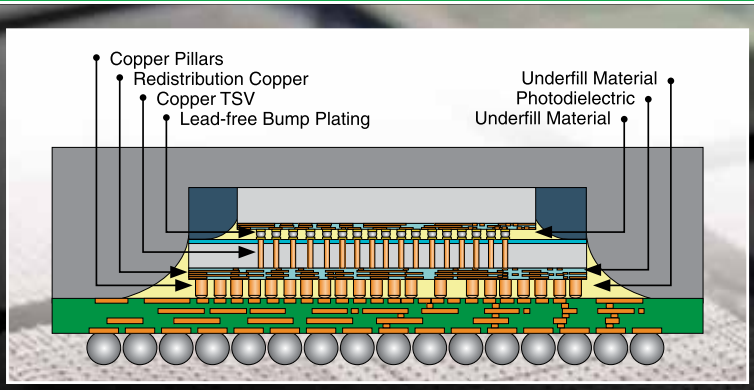
CYCLOTENE 6500 Photodielectric's properties also make the material ideal for multi-stack builds. Not only does the material bond well to other layers of CYCLOTENE 6500 Photodielectric, but also it is capable of bonding other substrates, such as Si to Si and Si to glass. From a reliability standpoint, the material's lower cure temperature capability results in reduced film stress – approximately 28 MPa.

For packaging fabs looking for a cost-effective photodielectric for redistribution layers that performs reliably and has excellent resolution with smooth, residue-free features, CYCLOTENE 6500 Photodielectric may be the ideal choice. For information regarding this material or any of Dow's advanced packaging materials, visit www.dow.com or call 508-481-7950. ◆

With Innovation Comes Revolution

Leading-edge packaging schemes are spurring a revolution in electronics. Dow Electronic Materials is there with a wide range of innovative metallization, dielectric, lithography and assembly materials – all delivered with global support from technical labs positioned close to customers. These are the innovations that drive the revolution.





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Where is the Diversity? Where are the Women?

Jeanne Beacham, President and CEO
Delphon Industries, LLC

OF COURSE MOST OF YOU reading this article are men since most of the engineers, managers and technologists in the semiconductor industry, especially in packaging, are men. I have been in the industry since 1980 and the number of women just isn't growing. Engineering in our industry has long been 90+ percent male and it has remained this way. The United States still has numbers in the range of only 5-7% women in the working engineering population. Other countries are doing better: Europe employs 25-35% of the world's women engineers, and India has a much stronger presence than the United States which heavily leans toward software.

We do seem to making strides in the world of academia, albeit slowly. It was recently reported that women faculty members in engineering at MIT went from 6% in 1990 to 17% in 2011 – some progress, but not nearly enough. A personal example (one of many) is a good friend of mine in the semiconductor industry in field applications and sales is one of only two women out of 141. Not even 2%!!

But progress at the university level can only be forwarded when women engineering students see women professors excited about the sciences. Even more importantly the elementary, middle and high school students need to have women science teachers that encourage girls to pursue careers in engineering. It seems that it takes women to help the growth of other women in technology careers, but we have a long way to go.

At a recent visit to a University campus where I was speaking to a Commercialization / Entrepreneur class, I was pleased to see a few women present, but they were definitely not planning on going into our industry. They are headed to companies like Google, Garmin, start ups with new Apple Apps or off to get an MBA or medical school. They are even choosing a career in Law over our fine industry!

The reasons they gave for not going into semiconductor engineering were clearly not about money; one concern was that there are very few women in the semiconductor industry. They were right. Not to mention most had no idea what semiconductor packaging and assembly was – even though I had referred to it lovingly as the Back End! The more distressing part was that most of them didn't even realize that the advancement of the Apps, Google and many medical device breakthroughs will depend on creative and innovative semiconductor packaging.

The perception from the women students to whom I spoke, where the entire class is only 15% female, was that engineering jobs in general are not "engaging". One of the top students present said "If I go into Computer Science all I will do is stare at a computer screen all day". So she has decided to get an MBA to go into Marketing in the Telecommunications area.

I believe that in order to attract the top technical engineers and scientists we need to revitalize the packaging industry by better communicating that it is an exciting field, and to attract the diversification needed to continue to bring new ideas and different approaches to the industry. I believe that women and men approach and address problem solving and management differently and in a complementary manner, and it is also my belief that women will help considerably to bring the innovation, creativity and team work which is clearly the critical for the next millennium.

Engineering jobs are also perceived to be better suited for introverts; yet when you think about it engineering offers a lot: exciting emerging technology to work on, and working with teams and interfacing with other engineers all over the world to solve problems. If only we could attract the creative, outgoing, strong communicators and good team players to our industry needed to solve problems and drive innovation to lead to amazing breakthroughs.

Also, there is still little progress in the number of women running technology companies, and as a CEO in the high tech industry I struggle to find women peers. But I continue to strive to find young women to mentor and encourage. As those of us who have been in the industry for over 30 years know, there are upsides to being the only woman, and it has been fun and exciting. After all, there is only one Jan, one Jeanne, one Stephie, one Karey and of course there is only one Bette! We get to stand out, we get to make a difference and everyone always knows our name. Now, it also means we need to work with all of our peers to put the excitement back into actually making a product and not just linking another million people to talk about what they had for lunch!

In summary, our industry needs an influx of the best and brightest young engineers, and it is my belief that the semiconductor industry needs more women, for the many reasons listed above. We need to change how we market our own industry not only to Wall Street but to prospective students. Even the Intel's struggle to compete with the FaceBook's and Google's. People forget, or don't realize, that they need the chips and the packaging to run all that cool social media stuff!

If you have any ideas about how to excite all students about our industry, men and women alike, drop me a line at jeanne@delphon.com. ◆

JEANNE BEACHAM is President and CEO of Delphon Industries, LLC, a materials manufacturing and service company to the Semiconductor and Medical Device Industries. Delphon has Divisions Gel-Pak, Quik-Pak, TouchMark and UltraTape, with offices in Hayward and San Diego, CA, Salem, Oregon and St. Albans, Vermont. Recently Jeanne was given the Diamond Leadership Award and East Bay Women of Distinction Award.

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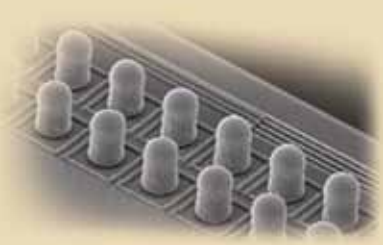

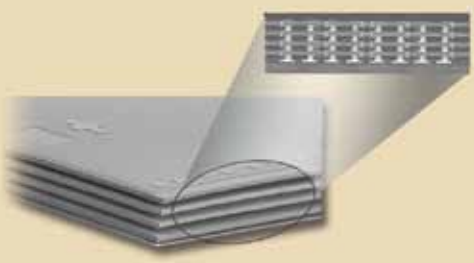

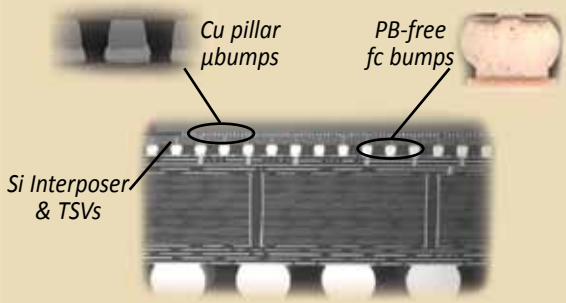

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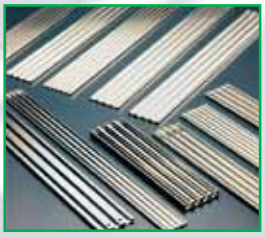
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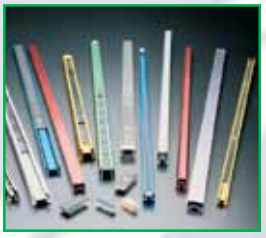
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