TWELFTH ANNUAL MEPTEC

MEPTEC
THE NEXT GENERATION

MEMS TECHNOLOGY SYMPOSIUM

ADVANCES IN MEMS -
Foundations of Design, Process, Packaging, and Test

PARTICIPATING COMPANIES:

- ASE SINGAPORE PTE LTD.
- BAND OF ANGELS
- CASEY ENGINEERING
- CHIRP MICROSYSTEMS, INC.
- GENERAL VISION, INC.
- HT MICRO
- INVENSAS CORPORATION
- MAXIM INTEGRATED PRODUCTS
- MICROGEN SYSTEMS INC.
- PLASMA-THERM LLC
- ROGER GRACE ASSOCIATES
- SITIME CORPORATION
- SIWARE SYSTEMS

Gold Sponsor

ASE GROUP

Silver Sponsor

Amkor Technology®

Association Sponsor

MEMS INDUSTRY GROUP®

Thursday, May 22, 2014 • San Jose, California

MEDIA SPONSORS

3DInCites.com · Chip Scale Review · Circuits Assembly · Electronic Engineering Journal · Global SMT & Packaging · MEMS and NanoTechnology Exchange · MEMS Journal · Micronews · Roger Grace Associates Marketing Counsel · semiconductor packaging news · TAP TIMES Test, Assembly & Packaging TIMES

CONTENTS

Twelfth Annual MEPTEC

MEMS TECHNOLOGY SYMPOSIUM

Advances in MEMS - Foundations of Design, Process, Packaging, and Test

MORNING AGENDA

7:30 am	**Registration Opens**
8:15 am – 8:30 am	**Welcome and Introduction**
SESSION ONE	**MEMS DESIGN INNOVATIONS**
8:30 am – 9:00 am	**Development of MEMS Micro-Relays** *Amit Kelkar, Ph.D., Maxim Integrated Products*
9:00 am – 9:30 am	**World's Smallest Chip Scale Packaged MEMS TCXO for Mobile Applications** *Niveditha Arumugam, SiTime Corporation*
9:30 am – 10:00 am	**High-Speed Testing of Pressure Sensors** *Gary Casey, Casey Engineering*
10:00 am – 10:30 am	**Morning Break and Exhibits**
SESSION TWO	**MEMS DEVICE TESTING CHALLENGES**
10:30 am – 11:00 am	**Design of MEMS Piezoelectric Vibrational Energy Harvesters for Industrial and Commercial Applications** *Kathleen M. Vaeth, Ph.D., MicroGen Systems Inc.*
11:00 am – 11:30 am	**Reducing Development Time for MEMS Devices** *Scott Smyser, SiWare Systems*
11:30 am – 12:00 pm	**MEMS Ultrasonic Rangefinding Solution for 3D Gesture Human Machine Interface (HMI)** *Michelle Meng-Hsiung Kiang , Ph.D., Chirp Microsystems, Inc.*
12:00 pm - 1:00 pm	**Lunch and Exhibits**

Twelfth Annual MEPTEC

MEMS TECHNOLOGY SYMPOSIUM

Advances in MEMS - Foundations of Design, Process, Packaging, and Test

AFTERNOON AGENDA

1:00 pm – 1:30 pm	**KEYNOTE** **The Current Entrepreneurial Environment for MEMS** *Kurt Petersen, Ph.D., Band of Angels*
SESSION THREE	**MEMS PACKAGING: IMPACT ON DEVICES AND VOLUMES**
1:30 pm – 2:00 pm	**Why Cognitive Silicon is a Crucial Companion to MEMS Sensor and Energy Harvesting Devices** *Guy Paillet, General Vision, Inc.*
2:00 pm – 2:30 pm	**Technology Diversity Rules the MEMS Packaging Landscape - An OSAT Perspective** *Charles W. Lee, ASE Singapore Pte Ltd.*
2:30 pm – 3:00 pm	**MEMS-based Autofocus in Cameras** *Vijay Chandrasekharan, Ph.D., Invensas Corporation*
3:00 pm – 3:30 pm	**Afternoon Break and Exhibits**
SESSION FOUR	**THE CHANGING LANDSCAPE OF MEMS MANUFACTURING AND PROCESS TECHNOLOGIES**
3:30 pm – 4:00 pm	**Through Wafer Dicing Without Saws or Lasers: High Productivity and Design Flexibility** *David Lishan, Ph.D., Plasma-Therm LLC*
4:00 pm – 4:30 pm	**Passive Micro Sensors: When Power isn't an Option** *Todd Christenson, Ph.D., HT Micro*
4:30 pm – 5:00 pm	**Critical Success Factors for the Commercialization of MEMS: The 2013 MEMS Industry Report Card** *Roger H. Grace, President, Roger Grace Associates*
5:00 pm – 6:30 pm	**Exhibitor and Sponsor Reception**

A SPECIAL THANKS TO OUR EVENT SPONSORS

GOLD SPONSOR

ASE Group

1255 E. Arques Avenue, Sunnyvale, CA 94085
Phone: 408-636-9752

www.aseglobal.com

ASE Group is the world's largest provider of independent semiconductor manufacturing services in assembly and test. As a global leader geared towards meeting the industry's ever growing needs for faster, smaller and higher performance chips, the Group develops and offers a wide portfolio of technology and solutions including IC test program design, front-end engineering test, wafer probe, wafer bump, substrate design and supply, wafer level package, flip chip, system-in-package, final test and electronic manufacturing services. The Group generated sales revenues of $2.6 billion in 2009 and employs over 26,000 people worldwide.

SILVER SPONSOR

Amkor Technology

1900 S. Price Road, Chandler, AZ 85286
Phone: 480-821-5000

www.amkor.com

Amkor Technology, Inc. is one of the world's largest providers of advanced semiconductor assembly and test services. Founded in 1968, Amkor has become a strategic manufacturing partner for many of the world's leading semiconductor companies and electronics OEMs, providing a broad array of advanced package design, assembly and test solutions. Amkor's operational base encompasses more than 5 million square feet of manufacturing facilities, product development centers, and sales & support offices in Asia, Europe and the United States. Amkor offers a suite of services, including electroplated wafer bumping, probe, assembly and final test. Amkor is a leader in advanced copper pillar bump and packaging technologies which enables next generation flip chip interconnect.

LANYARD SPONSOR

American Elements

1093 Broxton Ave. Suite 2000, Los Angeles, CA 90024
Phone: 310-208-0551

www.americanelements.com

American Elements is the world's manufacturer of engineered & advanced materials with a catalog of over 12,000 materials including rare earth metals, alloys, compounds and nanoparticles; high purity metals, chemicals, semiconductors and minerals; and crystal-grown materials for commercial & research applications including automotive, aerospace, military, medical, electronic, and green/clean technologies. American Elements maintains research and laboratory facilities in the U.S. and manufacturing/warehousing in the U.S., Mexico, Europe, & China. The complete catalog of advanced and engineered materials can be found at americanelements.com.

ASSOCIATION SPONSOR

MEMS Industry Group

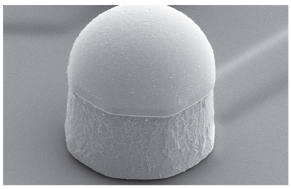
1620 Murray Avenue, 3rd Fl, Pittsburgh, PA 15217
Phone: 412-390-1644

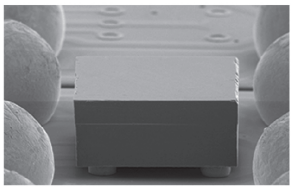
www.memsindustrygroup.com

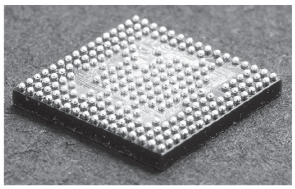
MEMS Industry Group® (MIG) is the trade association advancing MEMS across global marketing. MIG connects the MEMS supply chain, champions MEMS in established and emerging markets, and commercializes MEMS. For more information about joining MIG, please visit www.memsindustrygroup.org/join.

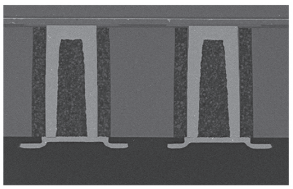
ASE GROUP

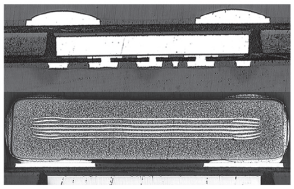
IC Packaging & Test for the next big thing in electronics.

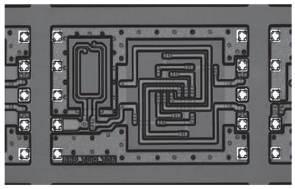

Copper Pillar

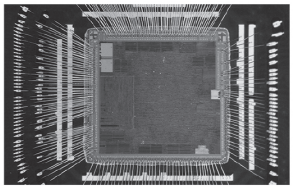

MEMS


WLP


2.5D/3D/TSV


Embedded


IPD


Copper Wire Bond

With a proven track record spanning three decades, ASE continues its tradition of dedication and commitment through close collaboration with customers, suppliers and partners, alike. Alongside a broad portfolio of established technologies, ASE is delivering advanced packaging and SiP solutions to meet growth momentum across a broad range of emerging applications and end markets.

For more: www.aseglobal.com

We would like to thank our sponsors and exhibitors for supporting this event!

MEPTEC
THE NEXT GENERATION

PO Box 222, Medicine Park, OK 73557
Tel: 650-714-1570 Fax: 866-424-0130
www.meptec.org

THANKS TO OUR MEDIA SPONSORS

3DInCites.com

Chip Scale REVIEW

CIRCUITS ASSEMBLY
The Journal for Surface Mount and Electronics Assembly

techfocusmedia
Electronic Engineering JOURNAL
www.eejournal.com

FELDMAN ENGINEERING

GLOBAL SMT & PACKAGING

MEMS and NanoTechnology Exchange
www.mems-exchange.org

MEMS JOURNAL

THE DISRUPTIVE SEMICONDUCTOR TECHNOLOGIES MAGAZINE
Micronews

ROGER GRACE ASSOCIATES
MARKETING COUNSEL

semiconductor packaging news
a circuitnet publication

TAP TIMES
Test, Assembly & Packaging TIMES

EXHIBITOR DIRECTORY

Advanced Packaging Center

Stenograaf 3, 6921EX, Duiven, The Netherlands
Phone: 480-488-9898

www.apcenter.nl

Advanced Package Center (APC), offers a one-stop shop for delivery of research, development, qualification, prototyping and small volume manufacturing services. APC focuses upon MEMS, Sensors, and advanced IC and wafer level packaging realized through Boschman Technologies' unique Film Assist Molding (FAM) technology. By working closely with customer R&D departments to explore new packaging concepts, APC provides value from Innovation to Industrialization.

AGC Electronics America

18694 Caminito Pasadero, San Diego, CA 92128
Phone: 714-745-3193

www.agcem.com

AGC, a Fortune Global 1000 company, is a leader in glass materials and related technologies. Our world class electronic packaging products include: AQ Fused silica; ideal for remarkable High Frequency Performance >20 GHz; EN-A1 Alkali Free Boro-Aluminosilicate; for IPD and interposer substrates and Specialty glass frits/paste provide solutions for MEMS bonding, high frequency, and PV and LED applications.

ASE Group

1255 E. Arques Avenue, Sunnyvale, CA 94085
Phone: 408-636-9500

www.aseglobal.com

ASE Group is the world's largest provider of independent semiconductor manufacturing services in assembly and test. As a global leader geared towards meeting the industry's ever growing needs for faster, smaller and higher performance chips, the Group develops and offers a wide portfolio of technology and solutions including IC test program design, front-end engineering test, wafer probe, wafer bump, substrate design and supply, wafer level package, flip chip, system-in-package, final test and electronic manufacturing services.

Boschman Technologies

Stenograaf 3, 6921EX, Duiven, The Netherlands
Phone: 480-488-9898

www.boschman.nl

Boschman Technologies is the world leading supplier of automatic molding systems that use film for the encapsulation of Sensor and MEMS devices. This process, called Film Assisted Molding is ideal for applications where sensing surfaces or bond pads or heat sinks must be exposed and free of mold compound bleed and flash. This technology is used for MEMS, Sensor, Solar, and Optical molding applications with the transfer molding of epoxy or silicone based mold compounds, including clear materials. Sintering systems are offered for power die attach applications.

Bullen Ultrasonics, Inc.

1301 Miller Williams Road, Eaton, OH 45320
Phone: 937-456-7133

www.bullentech.com

Bullen is a supplier of both structured and polished borosilicate glass, fused silica and silicon wafers for MEMS, Microfluidic, Life Sciences and packaging applications. Precision micro structuring of hard, brittle materials including glass, sapphire, quartz, silicon carbide and other advanced technical ceramics. Prototyping thru production volumes. 4", 6" and 8" wafer OD capability. Wafer level machining by means of abrasive jet machining and unique ultrasonic machining. High aspect ratio microstructures. High quality, low cost in support customer's application requirements. State of the art metrology capabilities. ISO9001-2008.

Ciposa S.A.

Rouges-Terres 61 - 2068, Hauterive, Switzerland
Phone: +41 32 566 6600

www.ciposa.com

Ciposa is a Swiss based equipment supplier with a business unit specializing in Reel to Reel UV exposure machines for high volume manufacturing of Flexible touch screen sensors used in tablets, pads, cell phones and computers along with reel to reel exposure of copper materials in the manufacturing of lead frames. Ciposa has another business unit specializing in equipment for Micro assembly, inspection and laser applications furnishing production machines to the Semiconductor, Medical Device and Watch industries. A standard product line with modular tooling makes engineering and producing custom solutions a process that helps get products to market on time.

cyberTECHNOLOGIES USA, LLC

962 Terra Bella Avenue, San Jose, CA 95125
Phone: 408-689-8144

www.cybertechnologies.com

cyberTECHNOLOGIES is the leading provider of standalone and fully integrated high resolution 3D Optical Metrology Systems for non-destructive process control of film thickness, surface topography, flatness, warpage, coplanarity and quality inspection of MEMS, Solar Cells, Fuel Cells, Lenses, Printed Products, Device Packages and many other Devices. Our systems reliably measure on absorbent, highly reflective, soft or transparent materials with high vertical and lateral resolution even over large areas of interest. Our customers take advantage of the systems' automation capabilities, high speed, accuracy and comprehensive parametric capabilities in R&D and production in industries as varied as MEMS, automotive, medical devices, semiconductors, solar, hybrid, pharmaceutical as well as optics manufacturing.

Disco Hi-Tec America

3270 Scott Blvd., Santa Clara, CA 95054
Phone: 408-987-3776

www.discousa.com

DISCO Corporation is the world leader in cutting, grinding, and polishing technology. With more than 40 years of experience processing a wide variety of materials, DISCO has amassed a vast knowledge base in these core competencies. Along with providing related equipment and tooling, DISCO offers a variety of services including process optimization, joint development initiatives, and consultative services. Additionally, next generation product prototyping and small run product output is available at the Development Center in Santa Clara, CA.

E-tec Interconnect Ltd.

P.O. Box 4078, Mountain View, CA 94040
Phone: 408-746-2800

www.e-tec.com

E-tec Interconnect is an established supplier of precision sockets and contactors for MEMS development and test applications. Custom requirements are welcome: they can accommodate virtually any footprint including "mixed pitch" and "non-Jedec" modules. Top and bottom openings can be modified to satisfy a variety test set-ups including open cavity probe and thermal emission microscopy. Standard features include: pin pitch from 0.3mm through 1.5 mm, pin counts up to 2000 and test speeds to 40 GHz. SMT, thru-hole and solderless mount options are available as well as various closure styles. Their socket products are engineered and manufactured by Swiss craftsmen, they are competitively priced and expedited delivery is available.

Expertech

200 Technology Circle
Scotts Valley, CA 95066
Phone: 831-439-9300

www.exper-tech.com

Expertech is a provider of full service custom solutions for Diffusion and LPCVD batch furnace systems. Expertech is located in the Silicon Valley area and has been doing business in the

EXHIBITOR DIRECTORY

Semiconductor, MEMS, and Solar industries for over 20 years. Expertech products are Compact Thermal Reactors which are small batch, horizontal table top reactors targeted at research and development; new, conventional large batch horizontal furnaces; OEM for the SVG/Aviza VTR (Vertical Thermal Reactor) large batch products; Femanufactured Semiconductor Fabrication Equipment and Equipment Engineering Services.

F&K Delvotec

28182 Burbank, Foothill Ranch, CA 92610
Phone: 949-595-2200

www.fkdelvotec.com

F&K Delvotec is an industry leader in wire bonding technology. Our broad portfolio of products deliver a solution for any wire bonding application. Over 30 patents in wire bonding technology testify to our continuing emphasis on innovative technology, and our dedicated development, applications and service team provides optimum customer support, worldwide. F&K Delvotec manufactures complete bonding systems including transducers and ultrasonic generators as well as test equipment that has become the industry standard for evaluation of ultrasonic bonding systems. Whatever wire bonding is required, F&K Delvotec offers a suitable tailored solution - from bond process development to complete automation systems.

Fab Owners Association (FOA)

19925 Stevens Creek, S-110, Cupertino, CA 95014
Phone: 408-725-7127

www.waferfabs.org

The Fab Owners Association (FOA) is an international, nonprofit, trade association of semiconductor & MEMS fab owners and industry suppliers who meet regularly to discuss and act on common manufacturing issues, combining strengths and resources to become more globally competitive.

The FOA-PT is the newly launched membership for semiconductor packaging, test owners and industry suppliers.

FRT of America

1101 S. Winchester, L-240, San Jose, CA 95128
Phone: Toll free 1-866-FRT PROF/408-261-2632

www.frtofamerica.com

FRT is recognized as a valued partner for non-contact, optical metrology systems. FRT of America serves you by providing high quality automated measuring tools which fulfill your research, inspection and process verification needs. Delivering increased manufacturing yield, enhanced productivity, improved quality and product performance, because that's what it's about at the end of the day. The MicroProf measures step height, shape, thickness, roughness and more; our MicroProf TTV measures wafer thickness, TTV, bow and warp for full thickness, thinned and bonded wafers and our MicroSpy Topo DT is a high resolution 3D profiler with confocal and interferometric measuring modes.

Gel-Pak

31398 Huntwood Ave., Hayward, California 94544
Phone: 888-621-4147 / 510-576-2220

www.gelpak.com

Gel-Pak manufactures Gel-Coated boxes, trays, slides and films that are designed to protect sensitive devices during transport and processing. The company's proprietary elastomer technology holds devices in place without the use of custom molded pockets. The systems are distributed worldwide.

Innovative Micro Technology

75 Robin Hill Road, Santa Barbara, CA 93117
Phone: 805-681-2800

www.imtmems.com

IMT was formed in 2000, specifically to produce MEMS (micro-electromechanical systems) devices. IMT is ISO 9001 certified, offering complete turnkey foundry services from design through high-volume production. IMT's 130,000 sq ft facility contains a 30,000 sq ft Class 100 clean room/fab, which is one of the largest independent MEMS fabs in the world. IMT has 40+ customers in diverse applications, including RF and DC switching, drug discovery/delivery, biomedical implants and cell purifiers, microfluidics, inertial navigation, WSS for optical telecommunications, night vision, IR emitters, and various sensors. In addition to comprehensive front-end wafer processing, key capabilities include sub-micron photolithography, hermetic wafer-level packaging, isolated metal-filled through-wafer vias, wafer thinning/CMP, and extensive non-CMOS materials flexibility, as well as unmatched metrology, FA, and testing. Speak with an IMT representative to see how we can make your MEMS work for you.

The Invenios Group

320 N. Nopal Street, Santa Barbara, CA 92020
Phone: 619-540-5578

www.invenios.com

Invenios is a world leader in the design and manufacture of gene-sequencing chips, microfluidic devices, and high volume precision micromanufacturing. Invenios maintains total process control of substrates from raw form to a finished product and is the only manufacturer in this field with multiple fabrication facilities on two continents (US/Eu).

memsstar Limited

Starlaw Park, Livingston EH54-8SG, UK
Phone: +44 1506 409160

www.memsstar.com

Founded in 2003, memsstar Limited is a leading provider of deposition and etch equipment and technology solutions to manufacturers of semiconductors and micro-electrical mechanical systems (MEMS). The company's remanufactured etch and deposition equipment and it's proprietary technology solutions support the European semiconductor market and the global MEMS market. memsstar delivers proprietary process technology and equipment to help the MEMS industry meet the challenges of developing and manufacturing increasingly complex and integrated MEMS devices. ISO 9001 certified, memsstar is recognized for its remanufacturing excellence, technology development, process guarantees, as well as extensive service capabilities to support its full range of OEM and remanufactured equipment.

Micrel, Inc.

2180 Fortune Drive, San Jose, CA 95131
Phone: 408-944-0800

www.micrel.com

Located in San Jose, California, Micrel has to date completed foundry work for several customers and has completed successful MEMS prototypes of accelerometer, microphone, pressure sensor, inkjet, microprobe, and BioMEMS devices. In two short years Micrel has been able to qualify two of the top 20 MEMS manufacturers and has begun full production. Micrel has invested significantly in MEMS capital to become a major US based MEMS Foundry Partner. In 2014, Micrel has and will install additional MEMS Foundry manufacturing capabilities, including DRIE, Gemini Wafer bonder, MA200C Suss projection aligner for thin wafers and thick photoresist, low-stress Nitride, etc. In addition to serving small-batch, flexible-production customers, Micrel has a proven track record in running high-volume, up to 300 wafers per day of MEMS. With the MEMS capital investments made every year since 2011 and planned investments for this year, Micrel now has open capacity of 200 MEMS wafers per day or in excess of 50,000 starts per year. Total wafer capacity in the San Jose fab is 30,000 per month.

EXHIBITOR DIRECTORY

Ozen Engineering, Inc.

1210 E. Arques Avenue #207
Sunnyvale, CA 94085
Phone: 408-732-4665

www.ozeninc.com

Ozen Engineering is the premier ANSYS Channel Partner and Distributor of advanced Computer Aided Engineering (CAE) Software in N. California. We also cater consulting services, technical support and training to a wide variety of industries such as Semiconductor, Biomed, Automotive, Aerospace and Manufacturing worldwide. Prestigious companies turn to Ozen Engineering as the single-source of reliable simulation solutions.

Pac Tech USA Inc.

328 Martin Avenue, Santa Clara, CA 95050
Phone: 408-588-1925

www.pactech-usa.com

Pac Tech USA Packaging Technologies Inc. facility in Santa Clara, California offers contract wafer bumping services using low cost electroless Ni/Au under-bump metallization, solder stencil printing and solder ball placement for quick-turn and mass-production. PacTech USA also provides product demonstrations, training and sales support. Pac Tech designs and builds state-of-the-art wafer bumping and assembly equipment for flip-chip and chip-scale packaging. Pac Tech is the worldwide leader in laser reflow and heating technology as implemented in systems for solder jetting (SB2) and flip-chip attach (LAPLACE) for advanced packaging applications like HGA assembly, MEMS and optoelectronic packaging, LCD driver assembly, etc.

PROMEX Industries, Inc.

3075 Oakmead Village, Santa Clara, CA 95051
Phone: 408-496-0222

www.promex-ind.com

PROMEX Industries offers complete microelectronics assembly, advanced packaging & semiconductor assembly services to the medical, commercial semiconductor and military markets. A world class technical staff applies process expertise and deep technical knowledge across our broad process capabilities. PROMEX is a recognized leader in custom process development and assembly of complex system-in-package and medical microelectronics, including implantable devices. Customers are provided with immediate onshore volume manufacturing, or the sequential steps of process development, prototyping, new product introductions and production scale up. Responsive IC assembly quick turns available, as well as full turnkey materials and supply chain management. ISO 13485:2003, ISO 9001:2008 certified and ITAR registered.

Qualicent Analytics Inc.

P. O. Box 6364, Santa Clara, CA 95056
Phone: 408-884-4033

www.qualicent.net

Qualicent Analytics Inc., based in San Jose, California is a provider of advanced analytics and big data infrastructure products and services. Our analytics techniques are a powerful combination of state-of-the-art machine learning methods and proprietary techniques proven in our decades in the semiconductors, electronics and automotive industries. In combination with our analytics software and big data Hadoop infrastructure services we bring organizations in manufacturing, healthcare, telecom, retail and finance a powerful arsenal of innovative tools and methods to lower business risks associated with high manufacturing defects, patient morbidity, cost of healthcare, telecom or retail customer churn and fraudulent financial transactions.

Quartet Mechanics

2343 Bering Drive, San Jose, CA 95131
Phone: 408-200-8345

www.quartetmechanics.com

BONDLESS PRECISION WAFER STACKING - San Jose-based Quartet Mechanics offers MEMS manufacturers' mid-end processing a wafer vehicle free from the traditional chemical bonding. This novel mechanical-based fragile wafer stacking solution features high precision alignment (± 5 µm); high yield is reached with its intelligent vision-guided robotic transferring and fixturing that prevents damage of delicate thin, warped or perforated wafers.

Quik-Pak

10987 Via Frontera, San Diego, CA 92127
Phone: 858-674-4676

www.icproto.com

Quik-Pak, a division of Delphon Industries, provides IC packaging and assembly services. The company's newest offering is its OmPP package. These pre-molded QFN packages provide a fast, inexpensive solution for your prototype or sample requirements. Quik-Pak also specializes in a variety of services that together provide a full turnkey solution including wafer preparation, die/wire bonding, remolding and marking/branding. Custom assembly services are also offered for Flip Chip, Ceramic Packages, Chip-on-Board, Stacked Die, MEMS, etc.

SemiProbe

276 East Allen Street, Winooski, VT 05404
Phone: 802-860-7000

www.semiprobe.com

SemiProbe manufactures a family of manual, semiautomatic and fully automatic probe systems used to test MEMS devices in environments ranging from Research to Production. Systems are configured to address numerous applications – DC, High Frequency, Optoelectronics, Motion, Microfluidic, High & Low Temperature, Vacuum and Double-Sided. A complete line of accessories and modules are available to compliment the probe system. The systems are built using SemiProbe's patented PS4L Adaptive Architecture. All foundation modules – bases, stages, chucks, microscope mounts, microscope movements, optics, manipulators and more – are interchangeable and configurable. The PS4L design enables users to implement test capabilities that precisely match their specific requirements – now and in the future.

Silex Microsystems

530 Lytton Avenue, 2nd Fl, Palo Alto, CA 94301
Phone: 781-690-1955

www.silexmicrosystems.com

Silex Microsystems is a world-leading MEMS foundry that brings advanced process technologies and manufacturing capacity to a wide range of high-tech companies. Silex operates two state-of-the-art MEMS fabs with 6" and 8" wafer size respectively. We serve customers in a broad range of markets, including automotive, communications, industrial, medical, and consumer electronics. Among the many types of products we manufacture are pressure sensors, inertial sensors, microfluidics and drug delivery chips. Silex is well recognized for its world leading through-wafer via processes (Sil-Via® and Met-Via®) that enable wafer level packaging of MEMS and CMOS using the extended process modules Sil-CAP™ and Met-CAP™.

SoftMEMS

2391 Nobili Avenue, Santa Clara, CA 95051
Phone: 408-426-4301

www.softmems.com

SoftMEMS is the creator of the popular, powerful, easy-to-use CAD tool suites MEMS Pro, MEMS Master and MEMS Xplorer. Software functionalities encompass mixed MEMS/IC schematic capture, simulation, optimization, statistical analysis, full custom mask layout, manufacturing rule verification, 3D model generation and visualization from manufacturing process descriptions, behavioral model creation and links to 3D analysis packages.

EXHIBITOR DIRECTORY

SPTS Technologies

1150 Ringwood Court, San Jose, CA 95131
Phone: 408-571-1400

www.spts.com

SPTS Technologies designs, manufactures, sells, and supports etch, PVD, CVD and thermal capital equipment and process technologies for the global semiconductor and micro-device industries, with focus on the MEMS, advanced packaging, high speed RF device, power management and LED markets. Solutions offered by SPTS include market-leading silicon etch, dielectric etch, dry-release etch, PVD, PECVD, APCVD and large batch vertical furnaces, applicable to R&D, pilot production, or volume production environments. Service and spare parts support are offered through a worldwide network of service centers.

SS RFID

2157 O'Toole Avenue, San Jose, CA 95131
Phone: 408-894-8160

www.ssrfid.com

SS RFID, Stars-Sinfonia RFID, is a joint venture company with Stars Microelectronics Inc. which began operations in July 2013. SS RFID is a Thailand-based company that manufactures and supplies RFID products at a high volume production, competitive cost, short production lead time, high quality, and flexibility in RFID tag design and customization. Stars Microelectronics has teamed up with world class electric and machinery manufacturer, Sinfonia, and the leading RFID chip and antenna design experts, Impinj to cover a broad range of applications offering three product categories: inlays, labels, and industrial tags.

Stars Microelectronics

2157 O'Toole Avenue, S-10, San Jose, CA 95131
Phone: 408-894-8160

www.starsmicroelectronics.com

Stars Microelectronics is a contract-manufacturing company founded in 1995, and houses a large, new state-of-the-art facility near Bangkok, Thailand. This facility, which has about 2500 employees, contains all the newest-generation equipment and tooling, featuring fully automated IC packaging, test, tape-and-reel, and drop-ship capabilities. Stars Microelectronics has numerous awards and recognition and is current on all certifications (ISO9001, ISO14001, ISO/TS16949, OHSAS18001). Stars Microelectronics manufactures TSOT, SOT, TSSOP, SOIC, MSOP, TQFN, TDFN, UDFN, XQFN, DFN, and QFN packages. Other capabilities include MEMS, Sensor-packaging, SiP, and PCBA. Stars Micro-electronics is also the parent company of the newly established SSRFID, specializing in manufacturing of RFID inlays, tags, and labels.

Tousimis

2211 Lewis Avenue, Rockville, CA 20851
Phone: 301-881-2450

www.tousimis.com

Tousimis is a globally recognized manufacturer of highly reliable CPD systems based in the Washington, DC area with global sales and service support. Four decades plus of CPD experience enables ground breaking design and patented firsts have crafting our technological edge for you. Our CPD process delicately preserves micro & Nano 3-D structure with reproducibility. Our technique enables successes for you in the following applications: MEMS/Bio-MEMS / AeroGEL / Nano Particle / Carbon Nanotubes / Graphene / MOF and WHATEVER others you can imagine. We are honored to be a member of the MEMS community.

Triton Microtechnologies

2726 Loker Avenue West, Carlsbad, CA 92010
Phone: 503-260-2002

www.tritonmicrotech.com

Triton Microtechnologies is the leader in the design and manufacture of high-performance 2.5D and 3D Through Glass Via (TGV) interposers. As we rapidly approach the barrier and performance limits of silicon, the need increases for a greater number of components in smaller package areas and the need for non-silicon based materials to better support this next generation assembly. Triton's proprietary technology offers faster cycle times, KGD testing at higher packaging integration levels, and the lowest cost/unit in the marketplace.

UBOTIC Company Limited

Unit 18, 15/F, International Trade Centre,
11 Sha Tsui Road, Tsuen Wan
New Territories, Hong Kong
Phone: 852-2691-8688

www.ubotic.com

UBOTIC Company Limited provides advanced MEMS and Specialty Semiconductor prototype to production assembly with a focus on low cost open-tool and custom package design and fabrication. They provide package, lead-frame and substrate design and fabrication of molded Air Cavity QFN Packages (AQFN), LGA Cavity, Over-molded QFN, SOIC cavity, stack-die, ceramic, and custom MEMS SIP. Additional services include both Thermal & Electrical Modeling along with package qualification and reliability testing.

ULVAC Technologies, Inc.

401 Griffin Brook Park, Methuen, MA 01844
Phone: 978-686-7550

www.ulvac.com

ULVAC is an international corporation that designs and manufactures systems, equipment, and materials for the industrial and research applications of vacuum technology. ULVAC systems products cover a broad spectrum of markets, with equipment for: MEMS device manufacturing, including DRIE and plasma ashing equipment; the automotive manufacturing industry, semiconductor fabrication, flat panel display manufacturing, roll-coating, precision metallurgy and industrial vacuum processes. A complete line of vacuum components is also offered which includes vacuum pumps of all types, helium leak detectors, UHV systems and gauges, RGA's and thermal analysis instrumentation.

Unisem Group

1284 Forgewood Avenue, Sunnyvale, CA 94089
Phone: 408-331-7329

www.unisemgroup.com

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. The company'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.

BIOGRAPHIES

SYMPOSIUM CO-CHAIRS

Gene Burk has been involved in the MEMS industry for over 40 years. He started his career at Honeywell SSEC in 1963 where he was one of the first members of the technical staff. In 1966 he discovered the use of hydroxides for anisotropically etching silicon. He used this technology to invent an Integral Constraint Pressure Sensor for in-vivo blood pressure applications believed to be the first MEMS device. He was a founder of IC Transducers, and as VP of Engineering he led the team that invented the Disposable Blood Pressure Sensor. Over many years Mr. Burk has held many different positions from engineering to sales and marketing to senior management. Mr. Burk is currently consulting with small and medium MEMS businesses in new business development, and currently serves as an Advisory Board member of MANCEF. He holds a BA in Physics and Mathematics and an MS in Clinical Psychology.

Sean Cahill is currently Director of MEMS Product Engineering at Maxim Integrated Products. Prior to that Sean was VP of R&D at BridgeWave Communications working on next generation millimeter-wave systems. Sean graduated with dual BS degrees in ECE/Signals and Systems and Biochemistry/Biophysics from UC Davis, and MSEE/Solid State Physics from UC Santa Barbara where he fabricated some of the first surface micromachined MOEMS. Over his many years in industry, Sean has worked for Exxon Research (flat panel displays), NovaSensor, Teknekron Sensor Development, and was a founder at three MEMS-based start-ups.

Ira Feldman is the principal consultant at Feldman Engineering Corp., where he manages and develops unique high technology solutions and business strategies. As a successful executive, he has proven his leadership ability to resolve product management and engineering challenges within organizations as well as with their supply chain and customers. Mr. Feldman's broad knowledge and management experience with high volume manufacturing of complex technology products is the result of his extensive expertise in the semiconductor test and computer test industries. He earned his BS in Engineering and Master of Engineering degrees from Harvey Mudd College. His "High Technology Business Development" blog at www.hightechbizdev.com often covers nanotechnology, MEMS, semiconductor, and test topics.

Dr. Mary Ann Maher is the CEO of SoftMEMS LLC. She received her Ph.D. degree in 1989 from Caltech in the area of semiconductor device modeling. She then moved to the Swiss Center for Electronics and Microtechnology (CSEM) in Neuchatel, Switzerland. She joined Tanner Research in 1992 becoming the software architect for their IC design tools. She moved to MEMSCAP in 1999 as an Executive Vice President and became the company's CTO in 2001. She founded SoftMEMS LLC in 2004 to address the need for co-design tools for systems incorporating MEMS sensors, electronics and packaging.

KEYNOTE SPEAKER

Dr. Kurt Petersen received his BS degree cum laude in EE from UC Berkeley in 1970. In 1975, he received a Ph.D. in EE from the Massachusetts Institute of Technology. Dr. Petersen established a micromachining research group at IBM from 1975 to 1982, during which he wrote the review paper "Silicon as a Mechanical Material," published in the IEEE Proceedings (May 1982). This paper is still the most frequently referenced work in the field of micromachining and micro-electro-mechanical systems (MEMS).

Since 1982, Dr. Petersen has co-founded six successful companies in MEMS technology, Transensory Devices Inc. in 1982, NovaSensor in 1985 (now owned by GE), Cepheid in 1996 (now a public company on NASDAQ: CPHD), SiTime in 2004 (still private), Profusa in 2008 (still private), and Verreon in 2009 (acquired

(continued)

by Qualcomm). All of these companies have become technical and commercial leaders in the field of MEMS devices and applications.

In 2011, Dr. Petersen joined the Band of Angels in Silicon Valley. The Band is an angel investment group which mentors and invests in early stage, high-tech, start-up companies. Today, he spends most of his time helping and mentoring such companies.

Dr. Petersen has published over 100 papers, and has been granted over 35 patents in the field of MEMS. In 2001 he was awarded the IEEE Simon Ramo Medal for his contributions to MEMS. Dr. Petersen is a member of the National Academy of Engineering and is a Fellow of the IEEE in recognition of his contributions to "the commercialization of MEMS technology".

PRESENTERS

Niveditha Arumugam has been with SiTime Corporation since 2007 and is now the Manager of the Systems Design and Packaging Engineering group. She is an expert in the characterization, testing and packaging of MEMS-based timing devices and has most recently focused on the design of the innovative 2-die chip-scale package and development of the calibration techniques and test methodology for SiTime's new 32 kHz TCXO product line. Prior to SiTime, she was a Research Assistant in the Stanford Microsystems Group, focusing on microfabricated devices for small-scale biomechanics. Niveditha received her Bachelors degree in Mechanical Engineering from College of Engineering Guindy, Chennai, India in 2006 and her M.S. degree in Mechanical Engineering from Stanford University in 2008, specializing in MEMS and mechatronics.

Gary Casey was Director of Engineering at Kavlico Corporation and was responsible for the creation, development and commercialization of all automotive products, primarily pressure and related sensors and during his tenure the sales volume increased from about $80 to almost $200 million. He was directly responsible for the engineering of all automotive products for Ford, Cummins, Chrysler, Volvo, Bosch and several other OEMs and Tier 1 suppliers. Previously, Mr. Casey was the Director of Engineering of advanced development at Bendix Corp. where he was responsible for the development of new products for all automotive divisions, which included electronic brake, suspension transmission and engine controls. Mr. Casey has been a technical contributor during his career, resulting in the acquisition of 37 US patents. His responsibilities included the management of patent activities, evaluation of outside submissions and patent licensing. Mr. Casey received his BS in Mechanical Engineering from Iowa State University and recently published a book, *Commonsense Engineering: Simple, Effective Practices for Engineering and Quality Control*.

Dr. Vijay Chandrasekharan is a Principal Engineer at Invensas Corporation. He was part of the core design team of the MEMS autofocus actuator team that took the world's first MEMS autofocus camera from concept to successful customer validation. Prior to this Dr. Chandrasekharan has consulted on MEMS microphones with companies like Analog Devices, Honeywell, and Freescale Semiconductor. In 2009 he was awarded one of the 13 postdoctoral entrepreneurial fellowships from the Ewing Marion Kauffman Foundation. He graduated in 2009 from University of Florida after successfully developing a MEMS shear stress sensor that was very well received by NASA and helped raise almost a $1 million in SBIR grants to further commercialize the sensor.

Dr. Todd Christenson is a co-founder, President and Chief Technology Officer of HT Micro in Albuquerque, New Mexico. Dr. Christenson earned his Ph.D. in Electrical Engineering from the University of Wisconsin under the late Henry Guckel. He then went on to Sandia National Laboratories where he started an effort to fabricate miniature metal components with unequaled tolerance levels using LIGA or "Deep X-ray Lithography". To better commercialize this technology, he took Entrepreneurial Leave from Sandia and founded HT Micro in 2003. Today, HT Micro is a leading manufacturer of batch fabricated ultra miniature switches, sensors, and precision components for both the commercial and military markets.

Roger Grace is president of Roger Grace Associates (Naples, Florida), a marketing consultancy which he founded in 1982. He has over 40 years in the electronics industry holding positions as a circuit designer, project engineer, applications engineer and most recently as a strategic marketing consultant. His focus has been on sensors and especially Microelectromechanical systems (MEMS). He was a co-founder and a past president of the Micro and Nanotechnology Commercialization Education Foundation (MANCEF). Mr. Grace's educational background includes a BSEE, MSEE from Northeastern University and the MBA program at the University of California Berkeley. He was selected as Northeastern University's Engineer of the Year in 2004.

Dr. Amit S. Kelkar is currently a Sr. PMTS (Sr. Scientist) at Maxim Integrated, working on MEMS inertial sensors. Earlier, Amit was part of the development team for MEMS micro-relays. Amit has spent the majority of his career in semiconductor fabrication in various capacities such as individual contributor, manager and director of process engineering. His specialties include MEMS processing, WLP, 3D IC integration, modeling & simulation, management & teaching. Amit holds a Ph.D. in Chemical Engineering from the University of Colorado at Boulder and a B.Tech. from the Indian Institute of Technology, Mumbai. He holds several patents in the areas of thermal processing of silicon wafers, MEMS fabrication and 3D integration.

Dr. Michelle Meng-Hsiung Kiang is an experienced entrepreneur with a focus on bringing technology innovation to commercialization. She is the CEO and Co-founder of Chirp Microsystems, Inc., a start-up company spun off from Berkeley Sensor and Actuator Center (BSAC). Previously, she has held executive positions in Corporate Business Development and Strategic Planning at NeoPhotonics and Micron Technology, Imaging Group. Her prior start-up experience included as a co-founder of two venture-backed companies providing RFID/sensor fusion-enabled SaaS solutions, and MEMS-based optical networking systems, respectively, raising a combined total of over $150M in venture financing. Dr. Kiang received the M.S. and Ph.D. degrees from University of California, Berkeley, and the B.S. degree from National Taiwan University, all in Electrical Engineering.

Charles W. Lee is currently a Technical Manager at ASE Singapore Pte Ltd. He received the M.App.Sc degree in Materials Science and Engineering from the University of New South Wales, Australia in 1993. He has over 18 years of experience in the semiconductor industry. Before joining ASE, he was Director of Strategic Marketing at the Institute of Microelectronics (IME) - a national research institute of the Agency for Science, Technology and Research (A*STAR) in Singapore, from 2007-2009. Charles began his career with Siemens Components Pte Ltd, Singapore (now Infineon Technologies Asia Pacific Pte Ltd) in 1993 as a Package Development Engineer. He held several functions spanning from spearheading research development to technology management over a period of 13 years with Siemens/Infineon. Charles is a Senior IEEE member and a recipient of the 2001 IEEE/CPMT Society Outstanding Young Engineer Award. He has more than 60 publications in international conferences and peer-reviewed journals ad more than 10 patents in electronic packaging technologies.

Dr. David Lishan, since receiving his undergraduate degree in Chemistry from UC Santa Cruz and Ph.D. from UC Santa Barbara in Solid State Electrical Engineering, he has worked and published on a wide range of material, semiconductor, and chemistry R&D projects in the areas of lithography, photochemistry, x-ray mask fabrication, PVD, and plasma processing. During his 15+ years at Plasma-Therm, he has had business unit management and worldwide marketing responsibilities as well as managing the development of plasma dicing product. Currently he is in the roles of Principal Scientist and Director in Technical Marketing, and recently organized and presented plasma processing workshops at leading institutions throughout the world. His primary focus is on the application of plasma processing for R&D, MEMS, photonics, data storage, power, and compound semiconductor applications. He holds two patents in the area of semiconductor processing and has over 60 publications and conference presentations.

(continued)

Guy Paillet is the chief executive officer of General Vision, Inc. He joined the company in 1999. Paillet is the inventor of the 1993 silicon neuron technology ZISC (zero instruction set computer), co-patented with IBM. While in France he developed high-speed target tracking and recognition embedded cameras using the ZISC made by IBM. Paillet brings a long experience in hard-wired artificial vision systems and parallel pattern recognition architecture to the company.

Scott Smyser is Executive Vice President, Worldwide Marketing and Business Development at SiWare Systems. Scott has 18 years of experience in the semiconductor industry as an executive and strategy consultant for companies focused on timing devices, MEMS sensors and wireless technologies. Prior to joining SWS, Scott was Vice President and General Manager for VTI Technologies, Inc. a leading supplier of MEMS sensors to the automotive, medical, and consumer markets. Before joining VTI, Scott co-founded a MEMS resonator startup, Beat Semiconductor, and served as CEO. He saw the company through inception and initial IP development to acquisition by VTI Technologies. Scott's prior roles include Director and Principal Analyst for iSuppli, a leading market research and consulting firm for the electronics industry, and product marketing and sales positions at Epson Toyocom, a top crystal and oscillator supplier, and Tektronix, a leading test and measurement equipment supplier. Scott earned a BS in Electrical Engineering and an MBA from the University of Southern California.

Dr. Kathleen Vaeth earned her B.S. degree in Chemical Engineering from Cornell University in 1994, where she was a Kodak Fellow, and her M.S. and Ph.D. degrees in Chemical Engineering from the Massachusetts Institute of Technology, where she was a Hertz Fellow. She is currently the Vice President of Engineering at MicroGen Systems Inc., developing microelectrical mechanical piezoelectric vibrational energy harvesters. Prior to joining MicroGen Systems, Dr. Vaeth spent 12 years at Eastman Kodak as a Senior Research Scientist in the Kodak Research Labs, where she worked in the areas of MEMS microfluidics, organic electronics and displays, controlled release chemistry in thin films, barrier coatings for flexible substrates, vapor deposited polymers, and piezoelectric materials and actuators, and as the Director of Future Technologies for the Functional Printing Business Unit. Her research interests spans the design, fabrication and characterization of devices, relating their performance to the materials used in their construction. Dr. Vaeth has 20 publications and 20 issued US patents.

Session One

MEMS DESIGN INNOVATIONS

MEMS product development often involves the co-design of MEMS devices, associated electronics, custom packaging and new fabrication processes requiring collaboration between domain experts – the "one product, one process, one package" dilemma. This session will focus on design for manufacturable MEMS based products and new trends in their design including design re-use and semi-custom design as well as new design techniques in fully custom designs. The increasing importance of system level design and software for MEMS-based products will also be highlighted.

Development of MEMS Micro-Relays

Amit Kelkar, Ph.D.
M Sr. PMTS (Sr. Scientist)
Maxim Integrated Products

RF MEMS micro-relays offer significant advantages over conventional electromechanical or reed relays – such as smaller size, better switching performance and lower cost. A novel process flow for fabricating MEMS micro-relays is presented here. First, a bottom wafer with contact metallization is bonded to a spring wafer with complementary contact metallization. Next, the spring wafer is micro-machined to the desired thickness and MEMS structures are formed using silicon reactive ion etch. Finally, a cap wafer is bonded to the bottom+spring wafer to form hermetically sealed cavities with MEMS micro-relays. Package sizes of 3 x 3 mm (WLCSP) and 5 x 5 mm (LGA) are successfully demonstrated. Two critical vectors for micro-relay performance are investigated – low stiction and stable on-resistance. Ruthenium is used as the contact metal for low stiction and Gold is used as the bonding metal for achieving a hermetic seal and enabling a stable on-resistance through 100 million switching cycles. With the device and process developed here, excellent cycling reliability consistent with benchmark conventional relays is shown.

World's Smallest Chip Scale Packaged MEMS TCXO for Mobile Applications

Niveditha Arumugam
Manager, Systems Design and Packaging Engineering
SiTime Corporation

Mobile applications require 32.768 kHz clock references with small form-factor, tight frequency stability, and ultra-low power at a competitive price. Legacy 32 kHz quartz-based technology has reached the limits of miniaturization, performance and cost.

SiTime's MEMS technology has enabled a 32 kHz temperature compensated MEMS based oscillator (TCXO) in a chip-scale package (1.5mm x 0.8mm CSP) with ±5 ppm frequency stability over -40°C to 85°C, making it the world's smallest and best-in-class 32 kHz TCXO. The SiTime solution enables increased functionality, smaller size and longer battery life in wearables, smartphones and other mobile devices.

This talk will provide an overview of the innovations that enabled this game-changing product for mobile applications. Topics will include innovations in MEMS/CMOS technology, chip scale packaging, and test and calibration techniques.

High-Speed Testing of Pressure Sensors

Gary Casey
President
Casey Engineering

This subject is perhaps unique in that there is no one answer that one can expect all experts to converge upon. In fact, small differences in sensor type, pressure range, and customer requirements may result in a considerably different answer to the question of how to test the sensor in production. As an example, a differential pressure sensor might be tested in essentially the same way as an absolute or gage sensor – but if there is a common mode requirement, the optimum method will likely be dramatically different.

There are essentially four aspects of testing; how to handle and transport the sensor, apply pressure, supply electrical power, and finally how to measure the result. Often the high-volume methodology grows from prototype and low-volume methodologies, usually leading to difficulties that could have been prevented. For example, the pressure application must be rapid, accurate and stable; and the traceability to NIST should be a short and robust path. Examples of solutions to these challenges will be discussed.

Session Two

MEMS DEVICE TESTING CHALLENGES

Testing of MEMS has been a traditional challenge as compared to CMOS devices. The need to measure a major physical input while eliminating minor inputs over temperature and with varying performance parameters has made this aspect of MEMS device production costly and difficult. The design of test systems follows closely the "one product, one test protocol, one test system" paradigm that is developed by the product company. Our speakers will address some of the issues and solutions that have been used in testing devices and which could be used in creating standardized testing of MEMS devices for high volume low cost applications in the future.

Design of MEMS Piezoelectric Vibrational Energy Harvesters for Industrial and Commercial Applications

Kathleen M. Vaeth, Ph.D.
Vice President of Engineering
MicroGen Systems Inc.

The increasing availability of small, lightweight, and affordable MEMS sensors and RF transmitters has opened up the possibilities of smart, integrated wireless sensor networks for monitoring and control of industrial equipment, building infrastructure, and transportation vehicles. Energy harvesting technology is key to enabling increased intelligence and proliferation of these networks, which are currently limited by available battery power. In this presentation, we report the design, fabrication, modeling, and characterization of MEMS-based piezoelectric vibrational energy harvesters with power output suitable for supporting wireless sensors and sensor networks. Finite element modeling of the harvester resonant frequency and peak AC power output as a function of deflection shows good agreement with experimental data over a range of frequencies, and mechanical analysis of the harvester movement provides guidance in design for robustness. Demonstrations of harvesting vibrational energy to power real world objects will be presented, including a wireless sensor network for monitoring building temperature. The data obtained and lessons learned from the installation will be discussed.

Reducing Development Time for MEMS Devices

Scott Smyser
Executive Vice President, Worldwide Marketing and Business Development
SiWare Systems

Increasing market demands and tough competition are driving MEMS companies to develop new products at an increasing rate. In this fast-paced environment, minimizing time-to-market is becoming critical. The need to quickly develop new sensor prototypes and quickly ramp into production calls for existing, proven, off-the shelf sensor signal conditioners.

Typically, MEMS product companies will develop their signal conditioner in conjunction with a MEMS sensor either by internal development or by an external ASIC design provider. The ASIC is specifically equipped with an analog front-end that converts the analog output of the MEMS to the digital domain. Consequently, the sensor and ASIC must be highly compatible to account for the analog output signal level with respect to offset, gain, sensitivity, linearity and other factors. Developing one side of this equation is challenging, but doing both in parallel is wrought with uncertainty as both the MEMS and ASIC can only be simulated and not fully tested until they both exist in silicon. The result is often a race to continuously revise the MEMS, ASIC or both until they "fit" sufficiently to be launched as a final product. This "fit" comes in addition to all other design considerations that must be given to an integrated sensor device with a physical sensor microstructure and a complex mixed-signal ASIC.

Repeated ASIC and MEMS tape-outs are costly, resource intensive and time-consuming. The risk is always that the final integrated product misses its design specification and market. Si-Ware Systems (SWS) has developed unique development platforms that combine high performance ASICs with configurability and programmability to interface with a variety of MEMS devices. With these platforms, time, risk, and cost are dramatically reduced for a MEMS product development.

MEMS Ultrasonic Rangefinding Solution for 3D Gesture Human Machine Interface (HMI)

Michelle Meng-Hsiung Kiang , Ph.D.
CEO and Co-founder
Chirp Microsystems, Inc.

Bulk piezoelectric ultrasonic transducers are widely used in industrial applications and medical imaging. The situation is somewhat analogous to the state of inertial sensors some ten to twenty years ago before the widespread commercialization of MEMS gyros and accelerometers. Micromachined ultrasonic transducers are poised to enter existing applications and introduce entirely new applications that take advantage of their small size, low cost, low power consumption, and compatibility with IC manufacturing methods.

This presentation will discuss some of the challenges faced in the design and manufacture of piezoelectric micromachined ultrasonic transducers (PMUTs) for human machine interface (HMI) in energy constraint applications such as consumer electronics.

KEYNOTE

Current Entrepreneurial Environment for MEMS

Kurt Petersen, Ph.D.
Band of Angels

Several converging trends are transforming the entrepreneurial process for starting MEMS companies and transitioning MEMS devices into production and into the market. First, it is well-known that recent market set-backs have caused traditional VC funds to view any hardware start-ups with renewed scrutiny and skepticism. Hardware start-ups typically require large amounts of capital ($50-$100M) and many years (7-10), before getting close to a reasonable exit. This large investment in money and time is on top of the already inherently risky prospects for such a start-up being commercially successful. Secondly, MEMS is recognized, by investors, by foundries, and by large consumer electronics companies, as a very successful new product area because of the huge up-take of MEMS components in mobile devices during recent years. Third, key strategic issues in huge upcoming new consumer markets, such as wearables and IoT, are sensors and contextual awareness; areas which are uniquely solved by MEMS devices. And fourth, the sheer number of successful, high volume MEMS devices currently on the market, has created a huge pool of skilled MEMS developers and manufacturers which can be drawn upon for new devices and new start-up companies. All these factors dramatically influence how such companies get funding and how they operate. We will discuss all these issues as they relate specifically to new MEMS companies.

Session Three

MEMS PACKAGING – IMPACT ON DEVICES AND VOLUMES

Electronics packages typically allow electrical connection while allowing the devices contained within to remain as isolated as possible from their environs. MEMS devices must interact with their surroundings, they are often subjected to direct contact with the environment, and usually must sense a particular variable without contamination from other potentially interfering inputs. Packages need to allow appropriate interaction with the measurand of interest, connect to power and signal I/Os, provide some isolation from undesired inputs, and create a test interface. The ideal package does all of the above and costs almost nothing. Low cost is achieved largely by exploiting existing high-volume technologies to the extent possible.

From another viewpoint, MEMS approaches have informed packaging efforts of traditional electronics. Stress isolation, deep trenching, wafer stacking, thermo-mechanical management techniques, and 2.5D and 3D package approaches have borrowed from the MEMS playbook.

This session will include speakers with insights into packaging of MEMS and the impact of MEMS on devices and their packaging at volume.

Why Cognitive Silicon is a Crucial Companion to MEMS Sensor and Energy Harvesting Devices

Guy Paillet
Chief Executive Officer
General Vision, Inc.

MEMS have revolutionized the sensor field by allowing miniaturization, lower power and lower cost. ICSD (Intelligent Connected Sensory Devices) in most cases are missing the intelligence. What developers call sensor intelligence is very often "naïve" signal processing leading to very simple, almost always, threshold bases decision. Nonlinear classification, which is the essence of the biological brain and is related to statistical data analysis (probabilistic or deterministic), is too "power hungry" to be miniaturized and powered by energy harvesting with standard methods (CPU, DSP, GPU). On the contrary, the biological brain is extremely frugal and low frequency. In order for a CPU to pull the same recognition (aka classification) and learning capability than the CM1K Neuromorphic Memory, such a hypothetical device would need to deliver more than 100,000 MIP at 500 mW with a frequency of 27 MHz. As an example, the very best Intel i7 processor delivers 180,000 MIPS but at 3.9 GHz and 47 W (not including the fan); therefore classification functions are poorly implemented by Von Neumann architecture.

Sensor and sensor fusion are very dependent of being able to filter unnecessary signals in order to convert signal to information and consolidate this information into actionable insights. This is the promise of merging neuromorphic silicon into MEMS technology for both the sensor and the energy harvester. A concept will be presented outlining fully autonomous wireless condition monitoring and anomaly detection (vibration). As IBM CEO Virginia Rometty stated, cognitive computing is the third wave of computing.

Technology Diversity Rules the MEMS Packaging Landscape - An OSAT Perspective

Charles W. Lee
Technical Manager
ASE Singapore Pte Ltd.

Abstract not available at time of printing.

MEMS-based Autofocus in Cameras

Vijay Chandrasekharan, Ph.D.
Principal Engineer
Invensas Corporation

Miniaturization of consumer electronics and inclusion of MEMS in these devices leads to a synergy of constant improvement and comes with its own challenges. This presentation discusses the development and challenges of the only MEMS autofocus actuator in the world. The actuation range is a 100 µm for the target focus range and can move a payload up to 4 mg to reach the desired focus range. The MEMS based design helps focus in at least half the time, with 1/100th the power with 1/5th the tilt of the current focus solution in the market that use voice coils. Large pay load with a 100 µm of motion poses a significant design challenge for a MEMS device for both modeling and mechanical reliability. The non-hermetically sealed injection molded plastic package is one of the key components in the reliability of the MEMS device and is pushes the limits of the injection molding process. The device has a shock survivability of > 10,000g and over 12 drops from heights > 1.0m in a smartphone.

Session Four

THE CHANGING LANDSCAPE OF MEMS MANUFACTURING AND PROCESS TECHNOLOGIES

MEMS product development has often involved creation of new fabrication processes, fabrication sequences, and the use of new materials. Equipment manufacturers are providing new MEMS-specific equipment with enhanced capabilities and new materials are being utilized to enhance MEMS performance. In addition, traditional MEMS fabrication processes are being combined with new technologies such as 3D printing, meso-scale fabrication techniques, and nanotechnologies creating both great opportunities and great challenges for getting products to market in a timely, cost effective manner. This session will provide a look at the changing landscape of MEMS manufacturing and process development in the context of the "manufacturing renaissance" happening worldwide.

Through Wafer Dicing Without Saws or Lasers: High Productivity and Design Flexibility

David Lishan, Ph.D.
Principal Scientist, Director-Technical Marketing
Plasma-Therm LLC

Wafer singulation technology is evolving. Although saws are widely accepted, the technology is running into performance boundaries regarding die strength (chipping), cutting speed for thin wafers, throughput for small die, large street widths, and are constrained to orthogonal streets. Laser dicing has been introduced to address some of these issues but limitations associated with induced damage and material incompatibilities have affected adoption.

This presentation will introduce a through wafer dicing using plasma etching that eliminates the constraints of saws and lasers, a new approach that utilizes standard dicing tapes and tape frames and enables non-orthogonal streets for layout flexibility, reduced street widths, chip/crack-free edges, and low stress corners. In addition, plasma etching dramatically increases singulation throughput as wafers become thinner to address the demands of smaller consumer form factors and volumes of smaller die (e.g. < 2mm2).

This new approach results in significantly higher yields, productivity increases, and encourages production of new die shapes. Examples highlighting this new technology will be presented along with various options for process flows.

Passive Micro Sensors: When Power isn't an Option

Todd Christenson, Ph.D.
Chairman, CTO and Founder
HT Micro

Microsensors requiring no electrical power to provide their monitoring function along with the MEMS approaches enabling them are discussed. Several aspects are contributing to the high volume exploitation of these zero-power devices. This family of electromechanical sensors in effect operates as their own energy harvesters and extracts energy from their physical surroundings to monitor the measurand. Their output is provided through ultra-reliable switch contacts which in turn require specific feature sizes and materials that are unique relative to semiconductor devices. Long lifetime requires that the micro-electromechanical structures reside within integrated hermetic packages. By their nature these sensors also must be able to be easily positioned and integrated into strategic or remote positions within a system. Tremendous volume demand and growth is apparent for such devices in situations such as awareness and intermittent monitoring. Examples including inertial and magnetic switches are described.

Critical Success Factors for the Commercialization of MEMS: the 2013 MEMS Industry Report Card

Roger H. Grace
President
Roger Grace Associates

Barriers to the commercialization of every industry and technology exist… Microelectromechanical Systems (MEMS) are no exception. As we have passed more than a half-century of MEMS research, design, and development, many people ask… "Why has it taken so long for the MEMS technology to realize its potential or reach true commercialization?" This presentation addresses 14 critical success factors that I have developed and consider to be the major barriers to the commercialization of MEMS and the progress made to date to overcome these barriers through the introduction of a "MEMS Industry Report Card" for the year 2013. Some of the topics addressed are: R&D, Marketing, Infrastructure Development, Management Expertise, Creation of Wealth and Profitability. The report card has been updated and presented yearly since 1998 (where it was first given at the seminal Hilton Head Conference) and continues to be given yearly to many enthusiastic audiences worldwide.

About MEPTEC

MEPTEC is a trade association of semiconductor companies and professionals involved in the manufacturing, packaging, assembling and testing of integrated circuits. Since its inception over 30 years ago, MEPTEC has provided a forum for the semiconductor industry to learn and exchange ideas through our monthly luncheons, conferences, and our quarterly publication, the MEPTEC Report. With the support of an Advisory Board consisting of individuals from all segments of the industry, MEPTEC has, over the years, kept current not just with semiconductor industry developments, but has expanded its scope to cover relevant industry segments such as MEMS and medical electronics. For more information about MEPTEC events and membership please visit www.meptec.org.

P.O. Box 222, Medicine Park, OK 73557
Tel: 650-714-1570 Fax: 1-866-424-0130
Email: bcooper@meptec.org

Visit the MEPTEC web site at www.meptec.org for more information.