# 2020 IEEE 70th Electronic Components and Technology Conference (ECTC)

# ECTC 2020

## Table of Contents


**Foreword** ........ **lvi**
**Welcome from ECTC Sponsoring Organization** ........ **lviii**
**Executive Committee** ........ **lix**
**Program Committee** ........ **lxi**
**ECTC 2020 Special Sessions** ........ **lxxxvi**
**ECTC 2019 Best of Conference Paper Awards** ........ **xc**
**ECTC & EPS 2020 Awards** ........ **xci**
**ECTC 2020 Major Non-IEEE Sponsors** ........ **xciii**


## Session 1: Fan-Out Technologies for System Integration


InFO_SoW (System-on-Wafer) for High Performance Computing ........ 1
*Shu-Rong Chun (Taiwan Semiconductor Manufacturing Company), Tin-Hao Kuo (Taiwan Semiconductor Manufacturing Company), Hao-Yi Tsai (Taiwan Semiconductor Manufacturing Company), Chung-Shi Liu (Taiwan Semiconductor Manufacturing Company), Chuei-Tang Wang (Taiwan Semiconductor Manufacturing Company), Jeng-Shien Hsieh (Taiwan Semiconductor Manufacturing Company), Tsung-Shu Lin (Taiwan Semiconductor Manufacturing Company), Terry Ku (Taiwan Semiconductor Manufacturing Company), and Douglas Yu (Taiwan Semiconductor Manufacturing Company)*

Fan-Out Wafer Level Packaging of GaN Components for RF Applications ........ 7
*Tanja Braun (Fraunhofer Institute for Reliability and Microintegration), Thanh Duy Nguyen (Fraunhofer Institute for Reliability and Microintegration), Steve Voges (Fraunhofer Institute for Reliability and Microintegration), Markus Wöhrmann (Fraunhofer Institute for Reliability and Microintegration), Robert Gernhardt (Fraunhofer Institute for Reliability and Microintegration), Karl-Friedrich Becker (Fraunhofer Institute for Reliability and Microintegration), Ivan Ndip (Fraunhofer Institute for Reliability and Microintegration), Damian Freimund (Technical University Berlin), Martin Schneider-Ramelow (Technical University Berlin), Klaus-Dieter Lang (Technical University Berlin), Dirk Schwantuschke (Fraunhofer Institute for Applied), Erdin Ture (Fraunhofer Institute for Applied), Michael Pretl (Rohde & Schwarz GmbH & Co.), and Sven Engels (Rohde & Schwarz GmbH & Co.)*

Scalable Chiplet Package using Fan-Out Embedded Bridge ........ 14
*Joe Lin (Siliconware Precision Industries Co., Ltd), C. Key Chung (Siliconware Precision Industries Co., Ltd), C. F. Lin (Siliconware Precision Industries Co., Ltd), Ally Liao (Siliconware Precision Industries Co., Ltd), Ying Ju Lu (Siliconware Precision Industries Co., Ltd), Jia Shuang Chen (Siliconware Precision Industries Co., Ltd), and Daniel Ng (Siliconware Precision Industries Co., Ltd)*

Design, Process and Reliability of Face-Up 2-Layer Molded FOWLP Antenna-in-Package ........ 19
*Chai Tai Chong (A*STAR, Singapore), Lim Teck Guan (A*STAR, Singapore), Han Yong (A*STAR, Singapore), F. X. Che (A*STAR, Singapore), David Ho Soon Wee (A*STAR, Singapore), and Ser Choong Chong (A*STAR, Singapore)*

Functional RDL of FOPLP by Using LTPS-TFT Technology for ESD Protection Application ........ 25
*Terry Wang (Industrial Technology Research Institute (ITRI)), Hsin-Cheng Lai (Industrial Technology Research Institute (ITRI)), Yu-Hua Chung (Industrial Technology Research Institute (ITRI)), Chieh-Wei Feng (Industrial Technology Research Institute (ITRI)), Liang-Cyuan Chang (Industrial Technology Research Institute (ITRI)), Jui-Wen Yang (Industrial Technology Research Institute (ITRI)), Tzu-Hao Yu (Industrial Technology Research Institute (ITRI)), Shao-An Yan (Industrial Technology Research Institute (ITRI)), Yuh-Zheng Lee (Industrial Technology Research Institute (ITRI)), and Steve Chiu (Industrial Technology Research Institute (ITRI))*

Development of Embedded Glass Wafer Fan-Out Package with 2D Antenna Arrays for 77GHz Millimeter-Wave Chip ........ 31
*Tian Yu (Xiamen Uninversity, China), Xiaodong Zhang (Xiamen Sky Semiconductor, China), Li Chen (Xiamen University, China), Xiaoli Ren (Xiamen Sky Semiconductor, China), Zongming Duan (East China Research Institute of Electronic Engineering, China), and Daquan Yu (Xiamen University)*

Flexible Fan-Out Wafer Level Packaging of Ultra-Thin Dies ........ 37
*Jean-Charles Souriau (Univ. Grenoble Alpes, CEA, LETI), Laëtitia Castagné (Univ. Grenoble Alpes, CEA, LETI), Carine Ladner (Univ. Grenoble Alpes, CEA, LETI), Rémi Franiatte (Univ. Grenoble Alpes, CEA, LETI), and Jennifer Guillaume (Univ. Grenoble Alpes, CEA, LETI)*

## Session 2: Innovation on WLCSP and 3D Packaging

Extreme Wafer Thinning and Nano-TSV Processing for 3D Heterogeneous Integration ........ 42
*Anne Jourdain (IMEC), Filip Schleicher (IMEC), Joeri De Vos (IMEC), Michele Stucchi (IMEC), Emmanuel Chery (IMEC), Andy Miller (IMEC), Gerald Beyer (IMEC), Geert Van der Plas (IMEC), Edward Walsby (SPTS), Kerry Roberts (SPTS), Huma Ashraf (SPTS), Dave Thomas (SPTS), and Eric Beyne (IMEC)*

Chemical Thinning Approach for High-Topography Glass Wafers ........ 49
*Messaoud Bedjaoui (Univ. Grenoble Alpes, CEA, LETI, DCOS Minatec Campus), Jean Brun (Univ. Grenoble Alpes, CEA, LETI, DCOS Minatec Campus), Steve Martin (Univ. Grenoble Alpes, CEA, LETI, DCOS Minatec Campus), and Raphael Salot (Univ. Grenoble Alpes, CEA, LETI, DCOS Minatec Campus)*

Material Optimization of Permanent and Temporary Adhesives for Wafer-Level Three-Dimensional Integration ........ 56
*Naoko Araki (DAICEL Corp.), Shinji Maetani (DAICEL Corp.), YoungSuk Kim (DISCO Corp.), Toshiaki Hirota (TAZMO Co. Ltd.), Tomoji Nakamura (Tokyo Institute of Technology), and Takayuki Ohba (Tokyo Institute of Technology)*

Fabrication and Reliability Demonstration of 5µm Redistribution Layer Using Low-Stress Dielectric Dry Film ........ 62
*Pratik Nimbalkar (Georgia Institute of Technology), Fuhan Liu (Georgia Institute of Technology), Atom Watanabe (Georgia Institute of Technology), David Weyers (Georgia Institute of Technology), Mohanalingam Kathaperumal (Georgia Institute of Technology), Cheng Ping Lin (Panasonic Corporation, Japan), Fukuya Naohito (Panasonic Corporation, Japan), Toshiyuki Makita (Panasonic Corporation, Japan), Naoki Watanabe (Panasonic Industrial Devices Sales Company of America, USA), Atsushi Kubo (Tokyo Ohka Kogyo Co. Ltd., Japan), Madhavan Swaminathan (Georgia Institute of Technology), and Rao Tummala (Georgia Institute of Technology)*

A Novel Design of Temporary Bond Debond Adhesive Technology for Wafer-Level Assembly .... 68
*Dingying Xu (Intel Corporation), Hsin-Wei Wang (Intel Corporation), Jigneshkumar Patel (Intel Corporation), Xavier F. Brun (Intel Corporation), Kosuke Hirota (Intel Corporation), Elliott Capsuto (Shin-Etsu MicroSi Corporation), Hideto Kato (Shin-Etsu Chemical), and Michihiro Sugo (Shin-Etsu Chemical)*

Development of Self-Releasing Adhesive Tape as a Temporary Bonding Material for 3D Integration ........ 75
*Taro Shiojima (SEKISUI CHEMICAL CO., LTD., Japan), Ryoichi Watanabe (SEKISUI CHEMICAL CO., LTD., Japan), Munehiro Hatai (SEKISUI CHEMICAL CO., LTD., Japan), and Daihei Sugita (SEKISUI CHEMICAL CO., LTD., Japan)*

Novel Low Temperature Curable Photo-Patternable Low Dk/Df for Wafer Level Packaging (WLP) ... 83
*Katherine Han (Kayaku Advanced Materials), Yasumasa Akatsuka (Nippon Kayaku), Jenna Cordero (Kayaku Advanced Materials), Daniel Nawrocki (Kayaku Advanced Materials), and Shinya Inagaki (Nippon Kayaku)*

## Session 3: Antenna-in-Package for 5G and Radar Systems

Glass-Based IC-Embedded Antenna-Integrated Packages for 28-GHz High-Speed Data Communications ........ 89
*Atom Watanabe (Georgia Institute of Technology), Muhammad Ali (Georgia Institute of Technology), Rui Zhang (Georgia Institute of Technology), Siddharth Ravichandran (Georgia Institute of Technology), Takenori Kakutani (Taiyo Ink Mfg. Co., Ltd.), Raj Pulugurtha (Florida International University), Rao Tummala (Georgia Institute of Technology), and Madhavan Swaminathan (Georgia Institute of Technology)*

3D Integrated Through Fused Silica Via (TFV) Based Array Antenna for mm Wave Communications ..... 95
*Renuka Bowrothu (University of Florida), Haein Kim (University of Florida), Yong Kyu Yoon (University of Florida), and Stephan Schmidt (LPKF Laser & Electronics North America)*

A Novel Packaging and System-Integration Platform with Integrated Antennas for Scalable, Low-Cost and High-Performance 5G mmWave Systems ..... 101
*Ivan Ndip (Fraunhofer IZM), Kristoffer Andersson (Ericsson), Stefan Kosmider (Fraunhofer IZM), Thi Huyen Le (Fraunhofer IZM), Abhijeet Kanitkar (Fraunhofer IZM), Marius van Dijk (Fraunhofer IZM), Kavin Senthil Murugesan (Fraunhofer IZM), Uwe Maaß (Fraunhofer IZM), Thomas Löher (Fraunhofer IZM), Marco Rossi (Fraunhofer IZM), Johannes Jaeschke (Fraunhofer IZM), Andreas Ostmann (Fraunhofer IZM), Rolf Aschenbrenner (Fraunhofer IZM), Martin Schneider-Ramelow (Fraunhofer IZM), and Klaus-Dieter Lang (Fraunhofer IZM)*

High Performance mm-Wave MIMO Radar with Integrated Antenna-on-Package ..... 108
*Meysam Moallem (Texas Instruments), Zachary Crawford (Texas Instruments), Ross Kulak (Texas Instruments), Marc Dewilde (Texas Instruments), Cathy Chi (Texas Instruments), Athena Lin (Texas Instruments), and Brian Ginsburg (Texas Instruments)*

mmWave AiP Measurement Turnkey Solution in Millimeter-Wave Wireless Communication Applications ..... 114
*Sheng Chi Hsieh (ASE Group), Fu-Cheng Chu (ASE Group), Cheng-Yu Ho (ASE Group), Wei-Yang Chen (ASE Group), and Chen-Chao Wang (ASE Group)*

Imprint-Through Mold Via (i-TMV) with High Aspect Ratio and Narrow Pitch for Antenna in Package ..... 120
*Xinrong Li (Hitachi Chemical Co., Ltd., Japan), Tsuyoshi Ogawa (Hitachi Chemical Co., Ltd., Japan), Tomoaki Shibata (Hitachi Chemical Co., Ltd., Japan), Satoshi Yoneda (Hitachi Chemical Co., Ltd., Japan), Naoya Suzuki (Hitachi Chemical Co., Ltd., Japan), and Toshihisa Nonaka (Hitachi Chemical Co., Ltd., Japan)*

One-Dimensional Steerable End-Fire Orthogonal Beams for 5G Millimeter Wave Applications by L-Shape Antenna Element Arrangement in Antenna-in-Packaging Design ..... 126
*Kuan-Hsun Wu (National Taiwan University), Zhao-He Lin (National Taiwan University), Hsi-Tseng Chou (National Taiwan University), Pin-Zhong Shen (National Taiwan University of Science and Technology), Ding-Bing Lin (National Taiwan University of Science and Technology), Li-Chih Fang (Powertech Technology Inc.), Ji-Cheng Lin (Powertech Technology Inc.), Chao-Shun Yang (Powertech Technology Inc.), Chieh-Wei Chou (Powertech Technology Inc.), Chi-Liang Pan (Powertech Technology Inc.), and Chun-Te Lin (Powertech Technology Inc.)*

## Session 4: Advanced Photonic Integration Packaging

Automated Assembly of High Port Count Silicon Photonic Switches .......................................132
*Nicolas Boyer (IBM Corporation), Fuad Doany (IBM T. J. Watson Research Center, USA), Elaine Cyr (IBM Corporation), Christian W Baks (IBM T. J. Watson Research Center, USA), Nicolas Dupuis (IBM T. J. Watson Research Center, USA), Jonathan E. Proesel (IBM T. J. Watson Research Center, USA), Herschel A. Ainspan (IBM T. J. Watson Research Center, USA), Isabel De Sousa (IBM Corporation), and Benjamin G. Lee (IBM T. J. Watson Research Center, USA)*

Electro-Optical Co-Integration of Chip-Components in Optical Transceivers for Optical Inter-Chip Communication ......................................................................................... 139
*Krzysztof Nieweglowski (Technische Universität Dresden), Lukas Lorenz (Technische Universität Dresden), Karlheinz Bock (Technische Universität Dresden), Mircea Catuneanu (Technische Universität Dresden), and Kambiz Jamshidi (Technische Universität Dresden)*

Integrated Optical Single-Mode Waveguide Structures in Thin Glass for Flip-Chip PIC Assembly ........................................................................................................... 148
*Julian Schwietering (Technical University of Berlin), Christian Herbst (Fraunhofer Institute for Reliability and Microintegration IZM), Oliver Kirsch (Fraunhofer Institute for Reliability and Microintegration IZM), Norbert Arndt-Staufenbiel (Fraunhofer Institute for Reliability and Microintegration IZM), Philipp Wachholz (Fraunhofer Institute for Reliability and Microintegration IZM), Henning Schroder (Fraunhofer Institute for Reliability and Microintegration IZM), and Martin Schneider-Ramelow (Technical University of Berlin)*

Multi-channel Single-Mode Polymer Waveguide Fabricated by the Mosquito Method Realizing Low Connection Loss with Single-Mode Optical Fiber Arrays .................................................. 156
*Sho Yakabe (Keio University / Sumitomo Electric Industries, Ltd.), Hitomi Matsui (Keio University), Yui Kobayashi (Keio University), and Takaaki Ishigure (Keio University)*

Integrated Silicon Photonic True-Time Delay Beam-Former for Wide-Band Phased-Array Antenna.. 162
*Stephen Anderson (Rensselaer Polytechnic Institute), Amir Begović (Rensselaer Polytechnic Institute), Alexander Chen (Rensselaer Polytechnic Institute), Zhaoran Huang (Rensselaer Polytechnic Institute), Guifu Sun (Army Research Laboratory), and Weimin Zhou (Army Research Laboratory)*

Hybrid Vanadate Silicon Nanophotonic Platform for Extreme Light Management at Telecom Bands ........................................................................................................... 168
*Yusheng Bian (Globalfoundries), Ajey Jacob (Globalfoundries), Won Suk Lee (Globalfoundries), Bo Peng (Globalfoundries.com), Michal Rakowski (Globalfoundries), Abdelsalam Aboketaf (Globalfoundries), and Rod Augur (Globalfoundries)*

High-Brightness Displays Made with Micro-Transfer Printed Flip-Chip microLEDs .................. 175
*C. A. Bower (X Display Company), S. Bonafede (X Display Company), B. Raymond (X Display Company), A. Pearson (X Display Company), C. Prevatte (X Display Company), T. Weeks (X Display Company), E. Radauscher (X Display Company), E. Vick (X Display Company), C. Verreen (X Display Company), B. Krongard (X Display Company), and M. A. Meitl (X Display Company)*

## Session 5: Advanced Bonding Methods and Processing

Low Temperature Direct Bonding of SiN and SiO Interfaces for Packaging Applications .......... 182
*Xavier F. Brun (Intel Corporation), Jürgen Burggraf (EV Group), Barb Ruxandra-Aida (EV Group), and Christian Mühlstätter (EV Group)*

Development of Multi-die Stacking with Cu-Cu Interconnects Using Gang Bonding Approach .. 188
*Ser Choong Chong (Institute of Microelecronics), Ling Xie (Institute of Microelectronics), Hongyu Li (Institute of Microelectronics), and Seow Huang Lim (Institute of Microelectronics)*

Bond at the End: A Comprehensive Study of a New High-Throughput Bonding Process ......... 194
*Salwa Ben Jemaa (Université de Sherbrooke), Pascale Gagnon (IBM Canada), Assane Dione (Université de Sherbrooke), Mamadou Kabirou Touré (Université de Sherbrooke), Jean-Francois Morissette (Université de Sherbrooke), Papa Momar Souare (Université de Sherbrooke), and Julien Sylvestre (Université de Sherbrooke)*

A Reliable Copper-Free Wafer Level Hybrid Bonding Technology for High-Performance Medical Imaging Sensors ........................................................................................................ 201
*Amandine Jouve (CEA, LETI), E. Lagoutte (CEA, LETI), R. Crochemore (CEA, LETI), G. Mauguen (CEA, LETI), T. Flahaut (CEA, LETI), C. Dubarry (CEA, LETI), V. Balan (CEA, LETI), F. Fournel (CEA, LETI), E. Bourjot (CEA, LETI), F. Servant (CEA, LETI), M. Scannell (CEA, LETI), K. Rohracher (ams AG, Austria), T. Bodner (ams AG, Austria), A. Faes (ams AG, Austria), and J. Hofrichter (ams AG, Switzerland)*

Nanotwinned Copper Hybrid Bonding and Wafer-on-Wafer Integration ................................ 210
*Wei-Lan Chiu (Industrial Technology Research Institute (ITRI)), Kai-Wei Chou (Industrial Technology Research Institute (ITRI)), and Hsiang-Hung Chang (Industrial Technology Research Institute (ITRI))*

Novel Cu/SiCN Surface Topography Control for 1 μm Pitch Hybrid Wafer-to-Wafer Bonding .... 216
*Soon-Wook Kim (IMEC), Ferenc Fodor (IMEC), Nancy Heylen (IMEC), Serena Iacovo (IMEC), Joeri De Vos (IMEC), Andy Miller (IMEC), Gerald Beyer (IMEC), and Eric Beyne (IMEC)*

Formation of Smooth Au Surfaces Produced by Multiple Thin-Film Transfer Process Based on Template Stripping for Low-Temperature Bonding .......... 223
*Eiji Higurashi (National Institute of Advanced Industrial Science and Technology), Michitaka Yamamoto (National Institute of Advanced Industrial Science and Technology), Ryutaro Nishimura (The University of Tokyo), Takashi Matsumae (National Institute of Advanced Industrial Science and Technology), Yuichi Kurashima (National Institute of Advanced Industrial Science and Technology), Hideki Takagi (National Institute of Advanced Industrial Science and Technology), Tadatomo Suga (Meisei University), and Toshihiro Itoh (The University of Tokyo)*

## Session 6: Interconnect Modeling

Numerical Model for Understanding Failure Mechanism of Back End of Line (BEOL) in Bump Shear .......... 229
*Wei Wang (Qualcomm Technologies, Inc.), Wei Zhao (Qualcomm Technologies, Inc.), Mark Nakamoto (Qualcomm Technologies, Inc.), Mark Schwarz (Qualcomm Technologies, Inc.), Dongming He (Qualcomm Technologies, Inc.), Xuefeng Zhang (Qualcomm Technologies, Inc.), Lily Zhao (Qualcomm Technologies, Inc.), and Ahmer Syed (Qualcomm Technologies, Inc.)*

Combined Peridynamic Theory and Kinetic Theory of Fracture for Solder Joint Fatigue Life Prediction .......... 236
*E. Madenci (University of Arizona), Cagan Diyaroglu (University of Arizona), Yanan Zhang (University of Arizona), Forest Baber (Virginia Commonwealth University), and Ibrahim Guven (Virginia Commonwealth University)*

Board Level Reliability Enhancement with Considerations of Solder Ball, Substrate and PCB ... 249
*Yangming Liu (Western Digital), Bo Yang (Western Digital), Shenghua Huang (Western Digital), Ning Ye (Western Digital), Shrikar Bhagath (Western Digital), and Rama Shukla (Western Digital)*

Property-Performance Relationships for Sustained High Temperature Operation of Electronics..... 257
*Pradeep Lall (Auburn University), Yunli Zhang (Auburn University), Madhu Kasturi (Auburn University), Haotian Wu (Auburn University), Edward Davis (Auburn University), and Jeff Suhling (Auburn University)*

Investigation of Thermo-Mechanical and Phase-Change Behavior in the Sn/Cu Interconnects During Self-Propagating Exothermic Reaction Bonding .......... 269
*Shuibao Liang (Loughborough University, UK), Yi Zhong (Loughborough University, UK), Stuart Robertson (Loughborough University, UK), Allan Liu (Loughborough University, UK), Zhaoxia Zhou (Loughborough University, UK), and Changqing Liu (Loughborough University, UK)*

Novel Piezoelectric Force Sensor Array for Investigation of Ultrasonic Wire Bonding .......... 276
*Matthias Arndt (Leibniz University Hannover), Yangyang Long (Leibniz University Hannover), Folke Dencker (Leibniz University Hannover), Jannik Reimann (Leibniz University Hannover), Jens Twiefel (Leibniz University Hannover), and Marc Christopher Wurz (Leibniz University Hannover)*

A Comprehensive Study of Electromigration in Lead-Free Solder Joint .................................... 284
*Jiefeng Xu (Binghamton University), Chongyang Cai (Binghamton University), Vanlai Pham (Binghamton University), Ke Pan (Binghamton University), Huayan Wang (Binghamton University), and Seungbae Park (Binghamton University)*

## Session 7: Advances in Packaging at the Wafer/Panel Level

A Production-Worthy Fan-Out Solution – ASE FOCoS Chip Last ............................................... 290
*Jan-Kuang Fang (Advanced Semiconductor Engineering Inc.), Min-Lung Huang (Advanced Semiconductor Engineering Inc.), Hung-Jung Tu (Advanced Semiconductor Engineering Inc.), Wen-Long Lu (Advanced Semiconductor Engineering Inc.), and Peng Yang (Advanced Semiconductor Engineering Inc.)*

Introduction of a New Carrier System for Collective Die-to-Wafer Hybrid Bonding and Laser-Assisted Die Transfer. ........................................................................................ 296
*Koen Kennes (IMEC), Alain Phommahaxay (IMEC), Alice Guerrero (Brewer Science, Inc.), Olga Bauder (SUSS MicroTec Lithography GmbH), Samuel Suhard (IMEC), Pieter Bex (IMEC), Serena Iacovo (IMEC), Xiao Liu (Brewer Science, Inc.), Thomas Schmidt (SUSS MicroTec Lithography GmbH), Gerald Beyer (IMEC), and Eric Beyne (IMEC)*

A Study on the Mechanical Debonding Process through Static-Elastic Stress Analysis for 3-D Wafer Level Packages (WLPs) ........................................................................................ 303
*Hyeong-Gi Lee (Samsung Electronics Co., Ltd, Republic of Korea), Dae-Sung Kim (Samsung Electronics Co., Ltd, Republic of Korea), Jung-Hyun Cho (Samsung Electronics Co., Ltd, Republic of Korea), Jung-Hyuk Lee (Samsung Electronics Co., Ltd, Republic of Korea), Jae-Yong Park (Samsung Electronics Co., Ltd, Republic of Korea), Min-Ho Kim (Samsung Electronics Co., Ltd, Republic of Korea), and Jae-Wook Lee (Samsung Electronics Co., Ltd, Republic of Korea)*

Study of Submicron Patterning Exposure Tool for Fine 500 mm Panel Size FOPLP .................. 309
*Ken-ichiro Mori (Canon Inc.), Douglas Shelton (Canon Inc.), Yoshio Goto (Canon Inc.), Hiromi Suda (Canon Inc.), Hiroyuki Wada (Canon Inc.), Hideo Tanaka (Canon Inc.), and Seiya Miura (Canon Inc.)*

Photolithography Solution that Overcomes Significant Die Placement Error for Advanced Packaging ........................................................................................................................315
*Tong Yang (Onto Innovation) and Zhiyang Li (Onto Innovation)*

Better Thermal, Mechanical and Dielectric Properties of Cured Polyimides Using Low Pressure Vacuum Cure Processing ........................................................................... 321
*Zia Karim (Yield Engineering Systems), Melvin Zussman (Hitachi Chemical Dupont MicroSystems, USA), Kenneth Sautter (Yield Engineering Systems), Kay Song (Yield Engineering Systems), Ron Legario (Hitachi Chemical Dupont MicroSystems, USA), Charudatta Galande (Yield Engineering Systems), Sung Yeon Lee (Yield Engineering Systems), and Kaushal Singh (Yield Engineering Systems)*

Advanced Packaging Cost Reduction by Selective Copper Metallization ................................. 327
*Rashid Mavliev (Ipgrip Inc.), Knut Gottfried (Fraunhofer ENAS), and Robert Rhoades (Revasum Inc.)*

## Session 8: High-Density RDL for Advanced Interconnects

Hybrid Fan-out Package for Vertical Heterogeneous Integration ............................................ 333
*Po-Yao Chuang (Taiwan Semiconductor Manufacturing Company Ltd.), M.-L. Lin (Taiwan Semiconductor Manufacturing Company Ltd.), S.-T. Hung (Taiwan Semiconductor Manufacturing Company Ltd.), Y.-W. Wu (Taiwan Semiconductor Manufacturing Company Ltd.), D.-C. Wong (Taiwan Semiconductor Manufacturing Company Ltd.), M.-C. Yew (Taiwan Semiconductor Manufacturing Company Ltd.), C.-K. Hsu (Taiwan Semiconductor Manufacturing Company Ltd.), L.-L Liao (Taiwan Semiconductor Manufacturing Company Ltd.), P.-Y. Lai (Taiwan Semiconductor Manufacturing Company Ltd.), P.-H. Tsai (Taiwan Semiconductor Manufacturing Company Ltd.), S.-M. Chen (Taiwan Semiconductor Manufacturing Company Ltd.), S.-K. Cheng (Taiwan Semiconductor Manufacturing Company Ltd.), and Shin-Puu Jeng (Taiwan Semiconductor Manufacturing Company Ltd.)*

Fan-Out RDL-First Panel-Level Packaging for Heterogeneous Integration ............................... 339
*John H. Lau (Unimicron Technology Corporation), Cheng-Ta Ko (Unimicron Technology Corporation), Kai-Ming Yang (Unimicron Technology Corporation), Chia-Yu Peng (Unimicron Technology Corporation), Tim Xia (Unimicron Technology Corporation), Puru Bruce Lin (Unimicron Technology Corporation), JJ Chen (Unimicron Technology Corporation), Po-Chun Huang (Unimicron Technology Corporation), Hsing Ning Liu (Unimicron Technology Corporation), and Tzvy-Jang Tseng (Unimicron Technology Corporation)*

Effect of Dielectric Process on the Interfacial Adhesion of RDL for FOWLP ............................. 348
*Kirak Son (Andong National University), Gahui Kim (Andong National University), Hyun-Kyu Ryu (SK Hynix Inc.), and Young-Bae Park (Andong National University)*

A Comparative Study of 2.5D and Fan-Out Chip on Substrate: Chip First and Chip Last .......... 354
*Wei-Hong Lai (Advanced Semiconductor Engineering, Inc.), Penny Yang (Advanced Semiconductor Engineering, Inc.), Ian Hu (Advanced Semiconductor Engineering, Inc.), Tse-Wei Liao (Advanced Semiconductor Engineering, Inc.), Karen Yu Chen (Advanced Semiconductor Engineering, Inc.), David Tarng (Advanced Semiconductor Engineering, Inc.), and CP Hung (Advanced Semiconductor Engineering, Inc.)*

Electromigration Failure Study of a Fine-Pitch 2μm/2μm L/S Cu Redistribution Line Embedded in Polyimide for Advanced High-Density Fan-Out Packaging .................................................. 361
*Chien-Lung Liang (National Cheng Kung University, Taiwan), Yung-Sheng Lin (Advanced Semiconductor Engineering, Inc.), Chin-Li Kao (Advanced Semiconductor Engineering, Inc.), David Tarng (Advanced Semiconductor Engineering, Inc.), Shan-Bo Wang (Advanced Semiconductor Engineering, Inc.), Yun-Ching Hung (Advanced Semiconductor Engineering, Inc.), and Kwang-Lung Lin (National Cheng Kung University, Taiwan)*

Versatile Electrochemical Plating Process Development for Heterogeneous WLP Structure ..... 367
*Jianwen Han (MacDermid Alpha Electronic Solutions), Stephan Braye (MacDermid Alpha Electronic Solutions), Pingping Ye (MacDermid Alpha Electronic Solutions), David Shaffer (MacDermid Alpha Electronic Solutions), Kyle Whitten (MacDermid Alpha Electronic Solutions), Thomas Richardson (MacDermid Alpha Electronic Solutions), and Elie Najjar (MacDermid Alpha Electronic Solutions)*

Molded Interconnect Substrate (MIS) Technology for Semiconductor Packages ..................... 374
*Michael M. Liu (JCET Group)*

## Session 9: Power Delivery and Conversion

Design and Analysis of Logic-HBM2E Power Delivery System on CoWoS® Platform with Deep Trench Capacitor ........................................................................................................ 380
*Wei-Ting Chen (Taiwan Semiconductor Manufacturing Company, Ltd.), Chia-Chia Lin (Taiwan Semiconductor Manufacturing Company, Ltd.), Chung-Hao Tsai (Taiwan Semiconductor Manufacturing Company, Ltd.), Harry Hsia (Taiwan Semiconductor Manufacturing Company, Ltd.), Kuo-Chiang Ting (Taiwan Semiconductor Manufacturing Company, Ltd.), Shang-Yun Hou (Taiwan Semiconductor Manufacturing Company, Ltd.), Chuei-Tang Wang (Taiwan Semiconductor Manufacturing Company, Ltd.), and Douglas Yu (Taiwan Semiconductor Manufacturing Company, Ltd.)*

Performance Improvement for FPGA due to Interposer Metal Insulator Metal Decoupling Capacitors (MIMCAP) ........................................................................................................ 386
*Myongseob Kim (Xilinx, Inc.), Henley Liu (Xilinx, Inc.), Dima Klokotov (Xilinx, Inc.), Anna Wong (Xilinx, Inc.), Thomas To (Xilinx, Inc.), and Jonathan Chang (Xilinx, Inc.)*

Three-Dimensional Capacitor Embedded in Fully Cu-Filled Through-Silicon Via and Its Thermo-Mechanical Reliability for Power Delivery Applications ............................................ 393
*Ye Lin (Nanyang Technological University), Anak Agung Alit Apriyana (Nanyang Technological University), Hong Yu Li (Agency for Science, Technology and Research (A*STAR)), and Chuan Seng Tan (Nanyang Technological University)*

Magnetic Inductor Arrays for Intel® Fully Integrated Voltage Regulator (FIVR) on 10th Generation Intel® Core™ SoCs ........................................................................................ 399
*Malavarayan Sankarasubramanian (Intel Corporation), Kaladhar Radhakrishnan (Intel Corporation), Yongki Min (Intel Corporation), William J. Lambert (Intel Corporation), Michael J. Hill (Intel Corporation), Ashay Dani (Intel Corporation), Ryan Mesch (Intel Corporation), Leigh Wojewoda (Intel Corporation), Jose Chavarria (Intel Corporation), and Anne Augustine (Intel Corporation)*

Design and Demonstration of Single and Coupled Embedded Toroidal Inductors for 48V to 1V Integrated Voltage Regulators ........ 405
*Claudio Alvarez Barros (Georgia Institute of Technology), Suresh Srinidhi (Georgia Institute of Technologi), Madhavan Swaminathan (Georgia Institute of Technology), Rao Tummala (Georgia Institute of Technology), Daisuke Sasak (Panasonic Corporation), Kazuki Watanabe (Panasonic Corporation), Ryo Nagatsuka (Panasonic Corporation), Cheng Ping Lin (Panasonic Corporation), Tatsuyoshi Wada (Panasonic Corporation), and Naoki Watanabe (Panasonic Industrial Devices Sales Company of America)*

Ultra Low Profile Thin Film Capacitor for High Performance Electronic Packages ........ 414
*Kenichi Yoshida (TDK Corporation, Japan), Hitoshi Saita (TDK Corporation, Japan), and Takashi Kariya (TDK Corporation, Japan)*

Co-Optimization of PDN Design for Tri-Cluster Multiple CPU Cores of SOC with Various Decoupling Capacitors Integrated in Small Form-Factor Package ........ 419
*Jisoo Hwang (Samsung Electronics Co. Ltd.), Heejung Choi (Samsung Electronics Co. Ltd.), Heeseok Lee (Samsung Electronics Co. Ltd.), James Jeong (Samsung Electronics Co. Ltd.), Yohan Kwon (Samsung Electronics Co. Ltd.), Jegil Moon (Samsung Electronics Co. Ltd.), Kyoungsoo Kim (Samsung Electronics Co. Ltd.), Junghwa Kim (Samsung Electronics Co. Ltd.), Hoi-Jin Lee (Samsung Electronics Co. Ltd.), and Youngmin Shin (Samsung Electronics Co. Ltd.)*

## Session 10: MEMS and Sensors

Hybrid Package for high Performance Inertial Measurement Units ........ 425
*Marco Del Sarto (STMicroelectronics), Alex Gritti (STMicroelectronics), Douglas Lodgson (STMicroelectronics), David Cheng (STMicroelectronics), Nicolo' Manca (STMicroelectronics), Roseanne Duca (STMicroelectronics), Tom Quoc Lao (STMicroelectronics), and YiYi Ma (STMicroelectronics)*

Cap Fabrication and Transfer Bonding Technology for Hermetic and Quasi Hermetic Wafer Level MEMS Packaging ........ 432
*Kai Zoschke (Fraunhofer IZM), Piotr Mackowiak (Fraunhofer Institute for Reliability and Microintegration (IZM)), Kevin Kröhnert (Fraunhofer Institute for Reliability and Microintegration (IZM)), Hermann Oppermann (Fraunhofer Institute for Reliability and Microintegration (IZM)), Nils Jürgensen (Fraunhofer Institute for Reliability and Microintegration (IZM)), Matthias Wietstruck (IHP – Leibniz Institut für Innovative Mikroelektronik), Alexander Göritz (IHP – Leibniz Institut für Innovative Mikroelektronik), Selin Tolunay Wipf (IHP – Leibniz Institut für Innovative Mikroelektronik), Mehmet Kaynak (IHP – Leibniz Institut für Innovative Mikroelektronik), and Klaus-Dieter Lang (Technical University of Berlin)*

Giant Magneto-Resistive Effect Based Sensor on Laser Direct Structured MID Substrates ........ 439
*Eike Christian Fischer (Leibniz University Hannover), Sebastian Bengsch (Leibniz University Hannover), Sascha de Wall (Leibniz University Hannover), and Marc Christopher Wurz (Leibniz University Hannover)*

Low-Temperature Metallic Joints for Strain-Sensing Sensor Dies ........ 445
*Markus Feisst (University of Freiburg - IMTEK), Joscha Hoffmann (University of Freiburg - IMTEK), and Juergen Wilde (University of Freiburg - IMTEK)*

Fan-Out Ultrasound Transducer Array in Substrate ........ 451
*Yao Lu (Institute of Microelectronics of Chinese Academy of Sciences, China; National Center for Advanced Packaging, China; University of Chinese Academy of Sciences, China) and Lixi Wan (Institute of Microelectronics of Chinese Academy of Sciences, China; University of Chinese Academy of Sciences, China)*

Development and Reliability Study of 3D WLCSP for Automotive CMOS Image Sensor using TSV Technology ........ 461
*Shuying Ma (HuaTian Technology (Kunshan) Electronics Co., Ltd.), Yi Liu (HuaTian Technology (Kunshan) Electronics Co., Ltd.), Fengxia Zheng (HuaTian Technology (Kunshan) Electronics Co., Ltd.), Feng Li (HuaTian Technology (Kunshan) Electronics Co., Ltd.), Daquan Yu (Xiamen University), Aimo Xiao (HuaTian Technology (Kunshan) Electronics Co., Ltd.), and Xiaobing Yang (HuaTian Technology (Kunshan) Electronics Co., Ltd.)*

Long-Term Encapsulation of Platinum Metallization Using a HfO2 ALD - PDMS Bilayer for Non-Hermetic Active Implants ........ 467
*Kambiz Nanbakhsh (Delft University of Technology), Riina Ritasalo (Picosun Oy), Wouter A. Serdijn (Delft University of Technology), and Vasiliki Giagka (Fraunhofer Institute for Reliability and Microintragration IZM and Delft University of Technology)*

## Session 11: Reliability of Next-Generation Interconnects

Electromigration Induced Interfacial Microstructure Evolution of Solder Joints in Electronic Packaging ........ 473
*Pilin Liu (Intel Corporation), Alan Overson (Intel Corporation), and Deepak Goyal (Intel Corporation)*

Electromigration in 2 μm Redistribution Lines and Cu-Cu Bonds with Highly <111>-Oriented Nanotwinned Cu ........ 479
*I-Hsin Tseng (National Chiao Tung University), Kai-Cheng Shie (National Chiao Tung University), Benson Tzu-Hung Lin (MediaTek Inc), Chia-Cheng Chang (MediaTek Inc), and Chih Chen (National Chiao Tung University)*

Effect of Intermetallic Morphology Evolution on Void Formation in Ni/Sn/Ni Micro Joints ........ 485
*Sanoop Thekkut (Binghamton University), Ronit Das (Binghamton University), Michael Njuki (Binghamton University), Jiaxin Li (Binghamton University), Rajesh Sharma Sivasubramony (Binghamton University), Firas W Alshatnawi (Binghamton University), Marleen M Moise (Binghamton University), Christopher M Greene (Binghamton University), Nikolay G Dimitrov (Binghamton University), Peter Borgesen (Binghamton University), Ninad Shahane (Texas Instruments Inc.), Patrick Thompson (Texas Instruments Inc.), and Kabir Mirpuri (NXP Semiconductors N.V.)*

Investigation and Comparison of Aging Effects in SAC+X Solders Exposed to High Temperatures ........ 492
*Jing Wu (Auburn University), Mohammad S. Alam (Auburn University), KM Rafidh Hassan (Auburn University), Jeffrey C. Suhling (Auburn University), and Pradeep Lall (Auburn University)*

Corrosion of Copper Wire Bonded Packages by Chlorine Containing Foreign Particles ........ 504
*Varughese Mathew (NXP Semiconductors), Enakshi Wikramanayake (The University of Texas at Austin), and Sheila Chopin (NXP Semiconductors)*

Thermal Aging Reliability of Socketable, Surface-Modified Solder BGAs with and without Polymer Collars ........ 512
*Omkar Gupte (Georgia Institute of Technology), Gregorio Murtagian (Intel Corporation), Rao Tummala (Georgia Institute of Technology), and Vanessa Smet (Georgia Institute of Technology)*

Key Takeaways and Relevance of Extrinsic Corrosion Mechanisms During Extended Biased HAST . 518
*Amar Mavinkurve (NXP Semiconductors), K. Kasuriya (NXP Semiconductors), R.T.H. Rongen (NXP Semiconductors), P. Jirachutiroj (NXP Semiconductors), N. Tappetch (NXP Semiconductors), J. Gülpen (NXP Semiconductors), and M. van Soestbergen (NXP Semiconductors)*

## Session 12: Modeling for Heterogeneous Integration: From Wafer to Board Level

A Novel Warpage Reinforcement Architecture with RDL Interposer for Heterogeneous Integrated Packages ........ 526
*Chia-Yu Peng (Unimicron Technology Corporation), Puru Bruce Lin (Unimicron Technology Corporation), Cheng-Ta Ko (Unimicron Technology Corporation), Chi-Wei Wang (National Tsing Hua University), Oscar Chuang (National Tsing Hua University), and Chang-Chun Lee (National Tsing Hua University)*

Mechanical Deformation Study of Flexible Leadset Components for Electromechanical Reliability of Wearable Electrocardiogram Sensors ........ 532
*Benjamin G. Stewart (Georgia Institute of Technology), Gabriel Cahn (Georgia Institute of Technology), David Samet (Georgia Institute of Technology), Matthew J. Misner (GE Healthcare), Andrew Burns (GE Healthcare), Darshana L. Weerawarne (Binghamton University), Carol Lapinski (Dupont Electronic Materials), Shannon Dugan (Dupon Electronic Materials), Mark D. Poliks (Binghamton University), Azar Alizadeh (GE Healthcare), Olivier Pierron (Georgia Institute of Technology), Antonia Antoniou (Georgia Institute of Technology), Samuel Graham (Georgia Institute of Technology), and Suresh K. Sitaraman (Georgia Institute of Technology)*

Thermal Analysis of a 3D Stacked High-Performance Commercial Microprocessor using Face-to-Face Wafer Bonding Technology ........ 541
*Rahul Mathur (Arm Inc, The University of Texas at Austin), Chien-Ju Chao (Arm Inc), Rossana Liu (Arm Inc), Nikhil Tadepalli (Arm Inc), Pranavi Chandupatla (Arm Inc), Shawn Hung (Arm Inc), Xiaoqing Xu (Arm Inc), Saurabh Sinha (Arm Inc), and Jaydeep Kulkarni (The University of Texas at Austin)*

Thermal, Mechanical and Reliability Assessment of Hybrid Bonded Wafers, Bonded at 2.5µm Pitch ..... 548
*Vladimir Cherman (IMEC), S. Van Huylenbroeck (IMEC), M. Lofrano (IMEC), X. Chang (IMEC), H. Oprins (IMEC), M. Gonzalez (IMEC), G. Van der Plas (IMEC), G. Beyer (IMEC), K.J. Rebibis (IMEC), and E. Beyne (IMEC)*

A Numerical Technique to Evaluate Warpage Behavior of Double Sided Rigid-Flex Board Assemblies During Reflow Soldering Process ..... 554
*Chun-Sean Lau (Western Digital Corporation), Ning Ye (Western Digital Corporation), Yi Chun Tan (Western Digital Corporation), and Choon Kuai Lee (Western Digital Corporation)*

Thermomechanical Deformations of Power Modules with Sintered Metal Buffer Layers Under Consideration of the Operating Time and Conditions ..... 561
*Alexander Schiffmacher (IMTEK - University of Freiburg), Carsten Kempiak (IESY - Otto-von Guericke-University), Andreas Lindemann (IESY - Otto-von Guericke-University), Jacek Rudzki (Danfoss Silicon Power GmbH), Frank Osterwald (Danfoss Silicon Power GmbH), and Juergen Wilde (IMTEK - University of Freiburg)*

Bonding Integrity Enhancement in Wafer to Wafer Fine Pitch Hybrid Bonding by Advanced Numerical Modelling ..... 568
*Lin Ji (Institute of Microelectronics A*STAR), Fa Xing Che (Institute of Microelectronics A*STAR), Hong Miao Ji (Institute of Microelectronics A*STAR), Hong Yu Li (Institute of Microelectronics A*STAR), and Masaya Kawano (Institute of Microelectronics A*STAR)*

## Session 13: 2.5D and 3D Technology Enabling High Performance Computing

Ultra High Density SoIC with Sub-Micron Bond Pitch ..... 576
*Yi-Hsiu Chen (Taiwan Semiconductor Manufacturing Company, Ltd.), Chun-An Yang (Taiwan Semiconductor Manufacturing Company, Ltd.), Chun-Chiang Kuo (Taiwan Semiconductor Manufacturing Company, Ltd.), Ming-Fa Chen (Taiwan Semiconductor Manufacturing Company, Ltd.), Chih-Hang Tung (Taiwan Semiconductor Manufacturing Company, Ltd.), Wen-Chih Chiou (Taiwan Semiconductor Manufacturing Company, Ltd.), and Douglas Yu (Taiwan Semiconductor Manufacturing Company, Ltd.)*

Waferscale S-MCM for High Performance Computing ..... 582
*Rabindra N. Das (MIT Lincoln Laboratory), Vladimir Bolkhovsky (MIT Lincoln Laboratory), Alex Wynn (MIT Lincoln Laboratory), Ravi Rastogi (MIT Lincoln Laboratory), Scott Zarr (MIT Lincoln Laboratory), Dmitri Shapiro (MIT Lincoln Laboratory), Manuel Docanto (MIT Lincoln Laboratory), Leonard M. Johnson (MIT Lincoln Laboratory), and Eric A. Dauller (MIT Lincoln Laboratory)*

Die to Wafer Stacking with Low Temperature Hybrid Bonding ..... 589
*Guilian Gao (Invensas Xperi Corporation), Laura Mirkarimi (Xperi Corporation), Gill Fountain (Xperi Corporation), Thomas Workman (Xperi Corporation), Jeremy Theil (Xperi Corporation), Gabe Guevara (Xperi Corporation), Cyprian Uzoh (Xperi Corporation), Dominik Suwito (Xperi Corporation), Bongsub Lee (Xperi Corporation), KM Bang (Xperi Corporation), and Rajesh Katkar (Xperi Corporation)*

Face to Face Hybrid Wafer Bonding for Fine Pitch Applications ............ 595
*Daniel Fisher (GLOBALFOUNDRIES, Inc.), Sarah Knickerbocker (GLOBALFOUNDRIES, Inc.), Daniel Smith (GLOBALFOUNDRIES, Inc.), Robert Katz (GLOBALFOUNDRIES, Inc.), John Garant (GLOBALFOUNDRIES, Inc.), Jorge Lubguban (GLOBALFOUNDRIES, Inc.), Vilmarie Soler (GLOBALFOUNDRIES, Inc.), and Norman Robson (GLOBALFOUNDRIES, Inc.)*

High Frequency Characteristics of Glass Interposer ............ 601
*Masaya Tanaka (Dai Nippon Printing), Satoru Kuramochi (Dai Nippon Printing), Takahiro Tai (Dai Nippon Printing), Yoichiro Sato (AGC), and Nobutaka Kidera (AGC)*

A 2-Tier Embedded 3D Capacitor with High Aspect Ratio TSV ............ 611
*King-Jien Chui (Institute of Microelectronics A*STAR), I-Ting Wang (Institute of Microelectronics A*STAR), Faxing Che (Institute of Microelectronics A*STAR), Zhixian Chen (Institute of Microelectronics A*STAR), Xiang Yu Wang (Institute of Microelectronics A*STAR), Woon Leng Loh (Institute of Microelectronics A*STAR), Qin Ren (Institute of Microelectronics A*STAR), Lin Ji (Institute of Microelectronics A*STAR), and Yao Zhu (Institute of Microelectronics A*STAR)*

10 and 7 µm Pitch Thermo-Compression Solder Joint, Using a Novel Solder Pillar and Metal Spacer Process ............ 617
*Jaber Derakhshandeh (IMEC), Giovanni Capuz (IMEC), Vladimir Cherman (IMEC), Fumihiro Inoue (IMEC), Inge De Preter (IMEC), Lin Hou (IMEC), Pieter Bex (IMEC), Carine Gerets (IMEC), Tomas Webers (IMEC), Julien Bertheau (IMEC), Stefaan Van Huylenbroeck (IMEC), Fabrice Duval (IMEC), Alain Phommahaxay (IMEC), Ehsan Shafahian (IMEC), Geert Van der Plas (IMEC), Eric Beyne (IMEC), Andy Miller (IMEC), and Gerald Beyer (IMEC)*

## Session 14: Materials for High-Speed/Frequency and 5G

High Aspect Ratio, High Resolution, and Broad Process Window Description of a Low Loss Photodielectric for 5G HS/HF Applications Using High and Low Numerical Aperture Photolithography Tools ............ 623
*Colin Hayes (DuPont), Kevin Wang (DuPont), Rosemary Bell (DuPont), Colin Calabrese (DuPont), Michael Gallagher (DuPont), Kirk Thompson (DuPont), Robert Barr (DuPont), Keith Best (OntoInnovation), Corey Shay (OntoInnovation), and Christian Ayala (OntoInnovation)*

Active Antenna Subsystem Integration of Steerable Boresight Radiation Beams for 5G Millimeter Wave Applications by System-in-Packaging Process ............ 629
*Pin-Zhong Shen (National Taiwan University of Science and Technology, Taiwan), Zhao-He Lin (National Taiwan University, Taiwan), Hsi-Tseng Chou (National Taiwan University, Taiwan), Kuan-Hsun Wu (National Taiwan University, Taiwan), Ding-Bing Lin (National Taiwan University of Science and Technology, Taiwan), Li-Chih Fang (Powertech Technology Inc.), Chao-Shun Yang (Powertech Technology Inc.), Chieh-Wei Chou (Powertech Technology Inc.), Chi-Liang Pan (Powertech Technology Inc.), Chun-Te Lin (Powertech Technology Inc.), and Ji-Cheng Lin (Powertech Technology Inc.)*

Low Permittivity and Dielectric Loss Polyimide with Patternability for High Frequency Applications ........ 635
*Hitoshi Araki (Toray Industries, Inc.), Yohei Kiuchi (Toray Industries, Inc.), Akira Shimada (Toray Industries, Inc.), Hisashi Ogasawara (Toray Industries, Inc.), Masaya Jukei (Toray Industries, Inc.), and Masao Tomikawa (Toray Industries, Inc.)*

Development of New Dielectric Material to Reduce Transmission Loss ........ 641
*Isao Nishimura (JSR Corporation), Shintarou Fujitomi (JSR Corporation), Yuutoku Yamashita (JSR Corporation), Naoyuki Kawashima (JSR Corporation), and Nobuyuki Miyaki (JSR Corporation)*

Evaluation of Package-Level EMI Shielding using Conformally Coated Conductive and Magnetic Materials in Low and High Frequency Ranges ........ 647
*Kisu Joo (Ntrium Inc), Kyu Jae Lee (Ntrium Inc), Hyun Jun Sung (Ntrium Inc), Seung Jae Lee (Ntrium Inc), Se Young Jeong (Ntrium Inc), Hyun Ho Park (The University of Suwon), and Yoon-Hyun Kim (Ntrium Inc)*

Advanced Low Loss Dielectric Material Reliability and Filter Characteristics at High Frequency for mmWave Applications ........ 653
*Takenori Kakutani (Taiyo Ink Mfg. Co., Ltd.), Daichi Okamoto (Taiyo Ink Mfg. Co., Ltd.), Zhong Guan (Taiyo Ink Mfg. Co., Ltd.), Yuya Suzuki (Taiyo Ink Mfg. Co., Ltd.), Muhammad Ali (Georgia Institute of Technology), Atom Watanabe (Georgia Institute of Technology), Mohanalingam Kathaperumal (Georgia Institute of Technology), and Madhavan Swaminathan (Georgia Institute of Technology)*

W-Band and D-Band Transmission Lines on Glass Based Substrates for Sub-THz Modules ...... 660
*Mutee ur Rehman (Georgia Institute of Technology), Siddharth Ravichandran (Georgia Institute of Technology), Serhat Erdogan (Georgia Institute of Technology), and Madhavan Swaminathan (Georgia Institute of Technology)*

## Session 15: Flexible and Printed Electronics

Direct Printing of Antennas on Large 3D Printed Plastic Structures ........ 666
*Vincens Gjokaj (Michigan State University), Cameron Crump (Michigan State University), Brian Wright (Michigan State University), and Premjeet Chahal (Michigan State University)*

Remateable and Deformable Area-Array Interconnects in 3D Smart Wireless Sensor Packages ..... 671
*Jose F Solis Camara (Florida International University), Sepehr Soroushiani (Florida International University), Daniel Wilding (Florida International University), Sk Yeahia Been Sayeed (Florida International University), Md Monirojjaman Monshi (Florida International University), John L Volakis (Florida International University), Shubhendu Bhardwa (Florida International University), and Markondeyaraj Pulugurtha (Florida International University)*

A Heterogeneously Integrated, High Resolution and Flexible Inorganic muLED Display using Fan-Out Wafer-Level Packaging ........ 677
*Goutham Ezhilarasu (University of California, Los Angeles), Ajit Paranjpe (Veeco Instruments Inc.), Jay Lee (DISCO Corporation), Frank Wei (DISCO Hi-Tec America, Inc.), and Subramanian S. Iyer (University of California, Los Angeles)*

Graphene-Based Sensing Skins Manufactured by Scalable and Controllable Assembly ........ 685
*Long Wang (University of California, San Diego), Rui Kou (University of California, San Diego), and Ying Zhong (University of South Florida)*

Effect of Ni(P) Thickness of Ultrathin ENEPIG on the Interfacial Reaction and Board Level Reliability of Solder Joints ........ 690
*Yibo Wang (Shanghai Jiao Tong University), Hongfa Pan (Shanghai Jiao Tong University), Charles Nan-Cheng Chen (Shanghai Jiao Tong University), Ming Li (Shanghai Jiao Tong University), and Liming Gao (Shanghai Jiao Tong University)*

Interposing of Microelectronics by Micro Transfer Printing to Create 3-D Structures ........ 696
*Kevin Oswalt (X-Celeprint Inc.), James Thostenson (X-Celeprint Inc.), Tanya Moore (X-Celeprint Inc.), David Gomez (X-Celeprint Inc.), Carl Prevatte (X-Display Co.), Matthew Meitl (X-Display Co.), Salvatore Bonafede (X-Display Co.), Julia Roe (X-Celeprint Inc.), Ron Cok (X-Celeprint Inc.), and Christopher Bower (X-Display Co.)*

Heterogenous Bump Metallurgy Through a Sequential Plating Based Process ........ 702
*Abderrahim Amrani (Université de Sherbrooke), Etienne Paradis (Université de Sherbrooke), David Danovitch (Université de Sherbrooke), and Dominique Drouin (Université de Sherbrooke)*

## Session 16: Sintering and Interconnect Reliability

Microstructure Evolution and Acceleration Factor (AF) of Micro-Bumps in through-Silicon-Via (TSV) in High Temperature Storage (HTS) Conditions ........ 710
*Yoosun Kim (SK Hynix), Joowan Hong (SK Hynix), Yeonji Park (SK Hynix), Sungho Hyun (SK Hynix), Minsoo Park (SK Hynix), Jaehyun Son (SK Hynix), Gyujei Lee (SK Hynix), Hoyoung Son (SK Hynix), Namseok Kim (SK Hynix), and Jin-Wook Jang (SK Hynix)*

Electro-Migration Evaluation between Organic Interposer and Build-Up Substrate on 2.3D Organic Package ........ 716
*Kei Murayama (Shinko Electric Industries Co., Ltd.), Shota Miki (Shinko Electric Industries Co., Ltd.), Hiromi Sugahara (Shinko Electric Industries Co., Ltd.), and Kiyoshi Oi (Shinko Electric Industries Co., Ltd.)*

Study of Electromigration Failure in Solder Interconnects Under Low Frequency Pulsed Direct Current Condition ........ 723
*Yi Ram Kim (University of Texas at Arlington), Allison T. Osmanson (University of Texas at Arlington), Hossein Madanipour (University of Texas at Arlington), Choong-Un Kim (University of Texas at Arlington), Patrick F. Thompson (Texas Instruments, Inc.), and Qiao Chen (Texas Instruments, Inc.)*

Low Temperature Au-Au Bonding Using Ag Nanoparticles as Intermediate ............................ 729
*Jun-Peng Fang (Tsinghua University), Jian Cai (Tsinghua University), Qian Wang (Tsinghua University), and Zhi-Ting Geng (Tsinghua University)*

Nickel Dependence of Hydrogen co-Deposition and Nanoporosity in Electrolessly Deposited Cu-Films ........................................................................................................ 735
*Tobias Bernhard (Atotech Deutschland GmbH), Edith Steinhäuser (Atotech Deutschland GmbH), Stefan Kempa (Atotech Deutschland GmbH), Gerson Krilles (Atotech Deutschland GmbH), Roger Massey (Atotech Deutschland GmbH), and Frank Brüning (Atotech Deutschland GmbH)*

Plating-Free Bumping by Cu Nanopaste and Injection Molded Solder (IMS) for Fine Pitch Flip Chip Joining ........................................................................................................ 742
*Toyohiro Aoki (IBM Research), Eiji Nakamura (IBM Research), Sayuri Kohara (IBM Research), Chinami Marushima (IBM Research), Kuniaki Sueoka (IBM Research), Takashi Hisada (IBM Research), Ryota Yamaguchi (DIC Corporation, Japan), Nobuhiro Sekine (DIC Corporation, Japan), Kenichi Yatsugi (DIC Corporation, Japan), and Makoto Yada (DIC Corporation, Japan)*

The Bonding Properties of Various Surface Finishes with Cu Paste for Pressure Sintering ...... 749
*Jung-Lae Jo (Mitsui Mining & Smelting Co., Ltd.), Kei Anai (Mitsui Mining & Smelting Co., Ltd.), Sinichi Yamauchi (Mitsui Mining & Smelting Co., Ltd.), Takashi Hattori (Mitsui Mining & Smelting Co., Ltd.), and Takahiko Sakaue (Mitsui Mining & Smelting Co., Ltd.)*

Facile Preparation of Cu-Ag Micro-Nano Composite Paste for High Power Device Packaging ... 755
*Jiaxin Liu (Huazhong University of Science & Technology), Yun Mou (Huazhong University of Science & Technology), Yang Peng (Huazhong University of Science & Technology), and Mingxiang Chen (Huazhong University of Science & Technology)*

## Session 17: Automotive and Harsh Environment Reliability

Reliability Assessment of mmWave Modules ........................................................................ 762
*Laura Wambera (Technische Universität Dresden), Karsten Meier (Technische Universität Dresden), Christian Götze (GLOBALFOUNDRIES), Marcel Wieland (GLOBALFOUNDRIES), and Karlheinz Bock (Technische Universität Dresden)*

Module Used in Robotaxi and Autonomous Truck Applications ............................................ 769
*Dongji Xie (Nvidia Corp.), Joe Hai (Nvidia Corp.), Jack Huang (Nvidia Corp.), Zhongming Wu (Nvidia Corp.), Vivienne Zou (Nvidia Corp.), and Manthos Economou (Nvidia Corp.)*

Influence of Copper Wire Material Additive Elements to the Reliability of Wire Bonded Contacts ........................................................................................................ 774
*Robert Klengel (Fraunhofer IMWS), Sandy Klengel (Fraunhofer IMWS), Jan Schischka (Fraunhofer IMWS), Tino Stephan (Fraunhofer IMWS), Motoki Eto (Nippon Micrometal Corporation), Noritoshi Araki (Nippon Micrometal Corporation), Takashi Yamada (Nippon Micrometal Corporation), and Matthias Petzold (Fraunhofer IMWS)*

Extreme Cold-Temperature High-Strain Rate Properties of SAC Solder Alloys ........................ 782
*Pradeep Lall (Auburn University), Vikas Yadav (Auburn University), Vishal Mehta (Auburn University), Jeff Suhling (Auburn University), and Ken Blecker (US Army Combat Capabilities Development Command - Armament Center)*

Considerations on a Smart Strategy for Simultaneously Testing Multiple PCB Assemblies in Board Level Vibration ........................................................................................ 793
*Varun Thukral (NXP Semiconductors), R. Roucou (NXP Semiconductors), S. Sauze (NXP Semiconductors), J.J.M. Zaal (NXP Semiconductors), J. Jalink (NXP Semiconductors), and R.T.H. Rongen (NXP Semiconductors)*

Low Temperature Vibration Reliability of Lead-Free Solder Joints .......................................... 801
*Karsten Meier (Technische Universität Dresden), Maximilian Ochmann (Technische Universität Dresden), David Leslie (University of Maryland), Abhijit Dasgupta (University of Maryland), and Karlheinz Bock (Technische Universität Dresden)*

Board Level Reliability Study of WLCSP with 5-Sided and 6-Sided Protection .......................... 807
*Yen Yao Chi (MediaTek Inc.), Chieh Lung Lai (Siliconware Precision Industries Co., Ltd.), Jun Yi Huang (Siliconware Precision Industries Co., Ltd.), C. Key Chung (Siliconware Precision Industries Co., Ltd.), Chia Yu Kuo (Siliconware Precision Industries Co., Ltd.), Yih Jenn Jiang (Siliconware Precision Industries Co., Ltd.), Hong da Chang (Siliconware Precision Industries Co., Ltd.), NW Liu (MediaTek Inc.), and Benson Lin (MediaTek Inc.)*

## Session 18: Emerging Flexible Hybrid Electronics

RDL-First Flexible FOWLP Technology with Dielets Embedded in Hydrogel ............................. 811
*Noriyuki Takahashi (Tohoku University), Yuki Susumago (Tohoku University), Sungho Lee (Tohoku University), Yuki Miwa (Tohoku University), Hisashi Kino (Tohoku University), Tetsu Tanaka (Tohoku University), and Takafumi Fukushima (Tohoku University)*

Wafer Scale Flexible Interconnect Transfer for Hetrogeneous Integration .............................. 817
*Pan Liu (Fudan University), Jian Li (Delft University of Technology), Henk van Zeijl (Delft University of Technology), and Guoqi Zhang (Delft University of Technology)*

Heterogenous Integration of MEMS Gas Sensor Using FOWLP: Personal Environment Monitors .... 824
*Samatha Benedict (University of California, Los Angeles), Ashvin Nagarajan (University of California, Los Angeles), Thejas Kumar (Indian Institute of Science), Arsalan Alam (University of California, Los Angeles), Murugaiya Sridar Illango (Indian Institute of Science), Goutham Ezhilarasu (University of California, Los Angeles), Chandra Shekhar Prajapati (Indian Institute of Science), Navakanta Bhat (Indian Institute of Science), and Subramanian Iyer (University of California, Los Angeles)*

Development of Next Generation Stretchable Materials for Flexible Hybrid Electronics (FHE)... 829
*S. Manian Ramkumar (Sun Ray Scientific LLC), Andrew Stemmermann (Sun Ray Scientific LLC), Benny Mathew Rajan (Sun Ray Scientific LLC), Isabelle Quelhas (Sun Ray Scientific LLC), Mohammed Alhendi (Binghamton University), Mark Poliks (Binghamton University), El Mehdi Abbara (Binghamton University), Benson Chan (Binghamton University), Toshiaki Ogiwara (NAMICS Corporation), Nori Saki (NAMICS Corporation), Masayoshi Otomo (NAMICS Corporation), and Ken Araujo (NAMICS Corporation)*

High-Density Embedded Electronics in Textiles with 3D Flex Package Transfer ........................ 835
*Md Monirojjaman Monshi (Florida International University), Jose-Solis Camara (Florida International University), Shubhendu Bhardwaj (Florida International University), John Volakis (Florida International University), and Pulugurtha Markondeya Raj (Florida International University)*

Development of Dry EEG Electrodes and Dry EEG Cap for Neuromonitoring .......................... 841
*Maria Ramona Ninfa Bautista Damalerio (Institute of Microelectronics, A-STAR) and Ming-Yuan Cheng (Institute of Microelectronics, A-STAR)*

Computational Modeling of Flexible Biodegradable Films with Engineered Defects ................. 847
*R. Waxman (Virginia Commonwealth University), Ibrahim Guven (Virginia Commonwealth University), and Vamsi Yadavalli (Virginia Commonwealth University)*

## Session 19: Embedded and Heterogeneous Integration

SoIC for Low-Temperature, Multi-layer 3D Memory Integration ............................................. 855
*Ming-Fa Chen (Taiwan Semiconductor Manufacturing Company, Ltd.), Chen-Sheng Lin (Taiwan Semiconductor Manufacturing Company, Ltd.), Ebin Liao (Taiwan Semiconductor Manufacturing Company, Ltd.), Wen-Chih Chiou (Taiwan Semiconductor Manufacturing Company, Ltd.), Chun-Chiang Kuo (Taiwan Semiconductor Manufacturing Company, Ltd.), Chih-Chia Hu (Taiwan Semiconductor Manufacturing Company, Ltd.), Chung-Hao Tsai (Taiwan Semiconductor Manufacturing Company, Ltd.), Chuei-Tang Wang (Taiwan Semiconductor Manufacturing Company, Ltd.), and Douglas Yu (Taiwan Semiconductor Manufacturing Company, Ltd.)*

Ultra-Low ESL Capacitor Based on Silicon Technology with Substrate Embedded Platform ...... 861
*JungHwa Kim (Samsung Electronics, Korea), Heeseok Lee (Samsung Electronics, Korea), Jisoo Hwang (Samsung Electronics, Korea), and Jongkyu Yoo (Samsung Electronics, Korea)*

Fine-Pitch Interconnection and Highly Integrated Assembly Packaging with FOMIP (Fan-Out Mediatek Innovation Package) Technology ........................................................................ 867
*Ming-Che Hsieh (JCET Group Co. Ltd.), Ian Hsu (MediaTek, Inc.), Chi-Yuan Chen (MediaTek, Inc.), Stanley Lin (MediaTek, Inc.), Ta-Jen Yu (MediaTek, Inc.), KeonTaek Kang (JCET Group Co. Ltd.), and Seung Wook Yoon (JCET Group Co. Ltd.)*

Demonstration of Vertically Integrated POP Using FOWLP Approach ..................................... 873
*Ser Choong Chong (Institute of Microelectronics), Leong Ching Eva (Institute of Microelectronics), Pei Siang Lim (Institute of Microelectronics), Siak Boon Lim (Institute of Microelectronics), and Tai Chong Chai (Institute of Microelectronics)*

Large-Body-Sized Glass-Based Active Interposer for High-Performance Computing ................ 879
*Siddharth Ravichandran (Georgia Institute of Technology), Mohanalingam Kathaperumal (Georgia Institute of Technology), Madhavan Swaminathan (Georgia Institute of Technology), and Rao Tummala (Georgia Institute of Technology)*

Heterogeneous Integration Using Organic Interposer Technology ........................................ 885
*George Scott (Amkor Technology, Inc.), JaeHun Bae (Amkor Technology, Inc.), KiYeul Yang (Amkor Technology, Inc.), WonMyoung Ki (Amkor Technology, Inc.), Nathan Whitchurch (Amkor Technology, Inc.), Mike Kelly (Amkor Technology, Inc.), Curtis Zwenger (Amkor Technology, Inc.), JongHyun Jeon (Amkor Technology, Inc,), and TaeKyeong Hwang (Amkor Technology, Inc.)*

## Session 20: Materials and Processes for FOWLP and PLP

Reliability Investigation of Ultra Fine Line, Multi-layer Copper Routing for Fan-Out Packaging Using a Newly Designed Micro Tensile Test Method ............................................ 893
*Markus Woehrmann (Fraunhofer IZM), Aleksander Keller (Fraunhofer IZM), Thomas Fritzsch (Fraunhofer IZM), Michael Schiffer (Fraunhofer IZM), Martin Schneider-Ramelow (Technical University Berlin), Klaus-Dieter Lang (Technical University Berlin), Hans Walter (Fraunhofer IZM), and Astrid Gollhardt (Fraunhofer IZM)*

Polyimide Fine-Via Etching and Low-Damage Surface-Modification Process for High-Density Fan-Out Wafer Level Package ................................................................................ 900
*Yasuhiro Morikawa (ULVAC, Inc), Daisuke Hironiwa (ULVAC, Inc), and Takahide Murayama (ULVAC, Inc)*

Effect of Annealing on the Toughness of 40-μm-Wide Nanotwinned Cu Lines ......................... 906
*Wei-You Hsu (National Chiao Tung University), Yu-Jin Li (National Chiao Tung University), I-Hsin Tseng (National Chiao Tung University), Benson Tzu-Hung Lin (MediaTek Inc.), Chia-Cheng Chang (MediaTek Inc.), and Chih Chen (National Chiao Tung University)*

Novel Photosensitive Dielectric Material with Superior Electric Insulation and Warpage Suppression for Organic Interposers in Reliable 2.1D Package .............................................. 912
*Shunsuke Katagiri (Mitsubishi Gas Chemical Company, Inc.), Seiji Shika (Mitsubishi Gas Chemical Company, Inc.), Yune Kumazawa (Mitsubishi Gas Chemical Company, Inc.), Katsuhiko Shimura (Mitsubishi Gas Chemical Company, Inc.), Takuya Suzuki (Mitsubishi Gas Chemical Company, Inc.), Tsuyoshi Kida (Mitsubishi Gas Chemical Company, Inc.), and Shu Yoshida (Mitsubishi Gas Chemical Company, Inc.)*

Adaptive Shot Technology to Address Severe Lithography Challenges for Advanced FOPLP ..... 918
*John Chang (Onto Innovation), Keith Best (Onto Innovation), Jian Lu (Onto Innovation), Burhan Ali (Onto Innovation), and Mike Marshall (Onto Innovation)*

Low Warpage Liquid Compression Molding (LCM) Material for High Density Fan-out and Wafer Level Packaging Applications ................................................................................ 924
*Jay Chao (Henkel Corporation), Rong Zhang (Henkel Corporation), Tu Do (Henkel Corporation), AnhBinh Tong (Henkel Corporation), Yijia Ma (Henkel Corporation), David Grimes (Henkel Corporation), Ramachandran K. Trichur (Henkel Corporation), and Lirong Bao (Henkel Corporation)*

## Session 21: High Speed in Signal Integrity

EMI Shielding Technology in 5G RF System in Package Module ............ 931
*Jay Li (Siliconware Precision Industries Co. Ltd.), Mike Tsai (Siliconware Precision Industries Co. Ltd.), Ryan Chiu (Siliconware Precision Industries Co. Ltd.), Eric He (Siliconware Precision Industries Co. Ltd.), Alex Hsieh (Siliconware Precision Industries Co. Ltd.), Ming-fan Tsai (Siliconware Precision Industries Co. Ltd.), Frank Chu (Siliconware Precision Industries Co. Ltd.), J. Y. Chen (Siliconware Precision Industries Co. Ltd.), Shunyu Jian (Siliconware Precision Industries Co. Ltd.), Simon Chen (Siliconware Precision Industries Co. Ltd.), and Yu-Po Wang (Siliconware Precision Industries Co. Ltd.)*

Complex Permittivity Measurements in a Wide Temperature Range for Printed Circuit Board Material Used in Millimeter Wave Band ............ 938
*Kazuki Takahashi (Fujitsu Advanced Technologies Limited), Shunichi Kikuchi (Fujitsu Advanced Technologies Limited), Akiko Matsui (Fujitsu Advanced Technologies Limited), Mitsunori Abe (Fujitsu Advanced Technologies Limited), and Kouhei Chouraku (Fujitsu Advanced Technologies Limited)*

Minimally Invasive 3D Printed Fixtures for Multi Gb/s Channel Characterization with a Logic Analyzer ............ 946
*Matteo Cocchini (IBM Corporation), Khaalid McMillan (IBM Corporation), Wiren D. Becker (IBM Corporation), Michael Cracraft (IBM Corporation), Matt Doyle (IBM Corporation), and Jason Bjorgaard (IBM Corporation)*

CTLE Adaptation Using Deep Learning in High-Speed SerDes Link ............ 952
*Bowen Li (North Carolina State University), Brandon Jiao (Xilinx Inc.), Chih-Hsun Chou (Xilinx Inc.), Romi Mayder (Xilinx Inc.), and Paul Franzon (North Carolina State University)*

An Efficient and Fast 112Gbps/PAM4 Signal Line Design with Conventional FCBGA Substrate Based on a 3-D Component Library ............ 956
*Ryuichi Oikawa (Renesas Electronics Corporation)*

Optimization of High-Speed Package Design on Statistical Domain ............ 964
*Il-Joon Kim (Samsung Electronics Company, Ltd.), Manho Lee (Samsung Electronics Company, Ltd.), Ki Jin Han (Dongguk University), Gyoungbum Kim (Samsung Electronics Company, Ltd.), Dae-Woo Kim (Samsung Electronics Company, Ltd.), and Dan Oh (Samsung Electronics Company, Ltd.)*

OpenCAPI Memory Interface Simulation and Test for Differential DIMM Channel with SNIA SFF-TA-1002 Connector ........ 970
*Biao Cai (IBM Corporation), Jose Hejase (IBM Corporation), Kevin Mcilvain (IBM Corporation), Kyle Giesen (IBM Corporation), Zhaoqin Chen (IBM Corporation), Hongqing Zhang (IBM Corporation), Junyan Tang (IBM Corporation), Megan Nguyen (IBM Corporation), Devon Baughen (IBM Corporation), Daniel Dreps (IBM Corporation), Brian Connolly (IBM Corporation), Glen Wiedemeier (IBM Corporation), Dale Becker (IBM Corporation), Sungjun Chun (IBM Corporation), Brian Beaman (IBM Corporation), Zhineng Fan (Amphenol ICC), Yifan Huang (Amphenol ICC), Abhijit Wander (Amphenol ICC), and Victor Mahran (Smart Modular Technologies)*

## Session 22: Advanced Biosensors and Bioelectronics

Smart and Connected Physiological Monitoring Enabled by Stretchable Bioelectronics and Deep-Learning Algorithm ........ 979
*Musa Mahmood (Georgia Institute of Technology), Young-Tae Kwon (Georgia Institute of Technology), Yun-Soung Kim (Georgia Institute of Technology), Jongsu Kim (Georgia Institute of Technology), and Woon-Hong Yeo (Georgia Institute of Technology)*

A High Spatial Resolution Surface Electromyography (sEMG) System Using Fan-Out Wafer-Level Packaging on FlexTrateTM ........ 985
*Arsalan Alam (University of California, Los Angeles), Michael Molter (University of California, Los Angeles), Bilwaj Gaonkar (University of California, Los Angeles), Amir Hanna (University of California, Los Angeles), Randall Irwin (University of California, Los Angeles), Samatha Benedict (University of California, Los Angeles), Goutham Ezhilarasu (University of California, Los Angeles), Luke Macyszyn (University of California, Los Angeles), Michael Selvan Joseph (Calfornia State University, Los Angeles), and Subramanian S. Iyer (University of California, Los Angeles)*

Microfabricated SERF Atomic Magnetometers for Measurement of Weak Magnetic Field ........ 991
*Kangni Liu (Southeast University), Jintang Shang (Southeast University), Jin Zhang (Southeast University), Xiang Yue (Southeast University), Chen Ye (Southeast University), Jianfeng Zhang (Southeast University), and Ching-Ping Wong (Georgia Institute of Technology)*

Development of Long Term Stable Multiple-Ion-Selective Sensors for Agriculture and Aquaculture Applications ........ 997
*Yu Chen (Institute of Microelectronics (IME)), Shermin S. Goh (Institute of Materials Research and Engineering (IMRE)), Ramona Damalerio (Institute of Microelectronics (IME)), Weiguo Chen (Institute of Microelectronics (IME)), David Choong (Institute of Microelectronics (IME)), Jason Y.C. Lim (Institute of Materials Research and Engineering (IMRE)), Lionel C.H. Lim (Institute of Materials Research and Engineering (IMRE)), Georgina E.K.K. Seah (Institute of Materials Research and Engineering (IMRE)), and Angeline Y.X. Tan (Institute of Materials Research and Engineering (IMRE))*

3D Heterogeneous and Flexible Package Integration for Zero-Power Wireless Neural Recording.... 1003
*Sk Yeahia Been Sayeed (Florida International University), Satheesh Bojja Venkatakrishnan (Florida International University), Md Monirojjaman Monshi (Florida International University), Abdal Abdulhameed (Florida International University), John L. Volakis (Florida International University), and P. M Raj (Florida International University)*

A Compact Wireless Passive Breath Analyzer for Health Monitoring .................................... 1010
*Saranraj Karuppuswami (Michigan State University), Saikat Mondal (Michigan State University), Deepak Kumar (Michigan State University), and Premjeet Chahal (Michigan State University)*

## Session 23: Advanced Dicing and Laser-Assisted Bonding

Laser-Assisted Bonding (LAB) and de-Bonding (LAdB) as an Advanced Process Solution for Selective Repair of 3D and Multi-die Chip Packages .......................................................... 1016
*Matthias Fettke (PacTech GmbH), Timo Kubsch (PacTech GmbH), Andrej Kolbasow (PacTech GmbH), Vinith Bejugam (PacTech GmbH), Alexander Frick (PacTech GmbH), and Thorsten Teutsch (PacTech GmbH)*

High-Performance Flip Chip Bonding Mechanism Study with Laser Assisted Bonding ............ 1025
*MinHo Gim (Amkor Technology), ChoongHoe Kim (Amkor Technology), SeokHo Na (Amkor Technology), DongSu Ryu (Amkor Technology), KyungRok Park (Amkor Technology), and JinYoung Kim (Amkor Technology)*

Development of Digital Signage Modules Composed of Mini-LEDs Using Laser-Assisted Bonding (LAB) Technology ........................................................................................................ 1031
*Choi Kwang-Seong (ETRI), Joo Jiho (ETRI), Jang Ki-seok (ETRI), Eom Yong-Sung (ETRI), Choi Gwang-Mun (ETRI), Yun Ho-Gyeong (ETRI), Moon Seok Hwan (ETRI), Kim Jong-Sun (SiliconInside Co., Ltd), Oh Mingyun (SiliconInside Co., Ltd), Choi Ji-Hoon (AQLASER Co., Ltd), Choi Ji-Woong (AQLASER Co., Ltd), Choi Shin (LB Lusem Co., Ltd), Park Sang-Hong (LB Lusem Co., Ltd), Kim Sang-Ki (HS Semicon), Kim Jin Sung (JIST Co. Ltd), and Yoo Sehoon (KITECH)*

Step Coverage Improvement for Electromagnetic Interference (EMI) Shield Film by Forming Bevel-Shaped Packages ........................................................................................... 1037
*Byeongdeck Jang (DISCO Corporation), Fumio Uchida (DISCO Corporation), Shigenori Harada (DISCO Corporation), Naotaka Oshima (DISCO Corporation), Satoshi Sawaki (DISCO Corporation), Shigeru Ishii (DISCO Corporation), Takuya Kaminaga (DISCO Corporation), Hayato Kiuchi (DISCO Corporation), Tomoharu Takita (DISCO Corporation), and Young Suk Kim (DISCO Corporation)*

Damage-Less Singulation of Ultra-Thin Wafers Using Stealth Dicing .................................... 1043
*Natsuki Suzuki (Tokyo Institute of Technology), Tomoji Nakamura (Tokyo Institute of Technology), Yuta Kondo (Hamamatusu Photonics K. K., Japan), Shimpei Tominaga (Hamamatusu Photonics K. K.), Kazuhiro Atsumi (Hamamatusu Photonics K. K.), and Takayuki Ohba (Tokyo Institute of Technology)*

In-Process Measurement of the Grinding Force in Silicon Wafer Self-Rotating Grinding Process ........ 1050
*Lixiang Zhang (Beijing University of Technology), Fei Qin (Beijing University of Technology), Pei Chen (Beijing University of Technology), Tong An (Beijing University of Technology), Yanwei Dai (Beijing University of Technology), Zhongbo Yi (The 45th Research Institute of China Electronic Technology Corporation), and Haiming Wang (The 45th Research Institute of China Electronic Technology Corporation)*

High Expansion Tape for Fan-Out WLP Applying a Novel Stress-Strain Curve Measuring Method ... 1057
*Ken Takano (LINTEC Corporation), Tadatomo Yamada (LINTEC Corporation), Toshiaki Menjo (LINTEC Corporation), and Shinya Takyu (LINTEC Corporation)*

## Session 24: Material and Interface Modeling

A Direct Multi-Field Coupling Methodology for Modeling Moisture-Induced Stresses and Delamination in Electronic Packages ........ 1064
*Liangbiao Chen (ON Semi), Xuejun Fan (Lamar University), and Yong Liu (ON Semi)*

Accuracy, Hysteresis and Extended Time Stability of Additively Printed Temperature and Humidity Sensors ........ 1070
*Pradeep Lall (Auburn University), Kartik Goyal (Auburn University), and Jinesh Narangaparambil (Auburn University)*

Viscoelastic Modeling for Heterogeneous Fan-out Wafer Molding Process ........ 1081
*Shu-Shen Yeh (Taiwan Semiconductor Manufacturing Company), P. Y. Lin (Taiwan Semiconductor Manufacturing Company), K. C. Lee (Taiwan Semiconductor Manufacturing Company), M. C. Yew (Taiwan Semiconductor Manufacturing Company), C. C. Yang (Taiwan Semiconductor Manufacturing Company), J. H. Wang (Taiwan Semiconductor Manufacturing Company), C. K. Hsu (Taiwan Semiconductor Manufacturing Company), P. C. Lai (Taiwan Semiconductor Manufacturing Company), Dion Tseng (Taiwan Semiconductor Manufacturing Company), S. K. Cheng (Taiwan Semiconductor Manufacturing Company), and Shin-Puu Jeng (Taiwan Semiconductor Manufacturing Company)*

A Mechanistic Study of Underfill Cracks by the Confocal-DIC Method ........ 1087
*Ying Yang (3IT, University of Sherbrooke, Canada), Fakhreddine Habib (3IT, University of Sherbrooke, Canada), Papa Momar Souare (3IT, University of Sherbrooke, Canada), Eric Duchesne (IBM Bromont, Canada), and Julien Sylvestre (3IT, University of Sherbrooke, Canada)*

Mechanical Characterization of Dual Curable Adhesives ........ 1094
*Sukrut Prashant Phansalkar (University of Maryland, College Park), Changsu Kim (University of Maryland, College Park), and Bongtae Han (University of Maryland, College Park)*

Chip Package Interaction (CPI) Risk Assessment of 22FDX® Wafer Level Chip Scale Package (WLCSP) Using 2D Finite Element Analysis Modeling ........ 1100
*Kashi Vishwanath Machani (GLOBALFOUNDRIES Dresden Module One LLC & Co. KG), Frank Kuechenmeister (GLOBALFOUNDRIES Dresden Module One LLC & Co. KG), Dirk Breuer (GLOBALFOUNDRIES Dresden Module One LLC & Co. KG), Christian Klewer (GLOBALFOUNDRIES Dresden Module One LLC & Co. KG), Jae Kyu Cho (GLOBALFOUNDRIES Inc.), and Kristina Young-Fisher (GLOBALFOUNDRIES Inc.)*

Biaxial Inflation Stretch Test for Printed Electronics ........ 1106
*Benjamin G. Stewart (Georgia Institute of Technology), Nicholas J. Ginga (Georgia Institute of Technology), and Suresh K. Sitaraman (Georgia Institute of Technology)*

## Session 25: High Density Fan-Out Technology

Process Window Enhancement of Via Holes for Fine Pitch RDL by Design Optimization ........ 1114
*Cliff McCold (Veeco Instruments, Inc., USA), Robert Hsieh (Veeco Instruments, Inc., USA), Ha-Ai Nguyen (Veeco Instruments, Inc., USA), Warren W. Flack (Veeco Instruments, Inc., USA), John Slabbekoorn (IMEC, Belgium), and Andy Miller (IMEC, Belgium)*

Applications and Reliability Study of InFO_UHD (Ultra-High-Density) Technology ........ 1120
*Ting-Chu Ko (Taiwan Semiconductor Manufacturing Company, Ltd.), Han-Ping Pu (Taiwan Semiconductor Manufacturing Company, Ltd.), Yung-Ping Chiang (Taiwan Semiconductor Manufacturing Company, Ltd.), Huang-Jui Kuo (Taiwan Semiconductor Manufacturing Company, Ltd.), Chuei-Tang Wang (Taiwan Semiconductor Manufacturing Company, Ltd.), Chung-Shi Liu (Taiwan Semiconductor Manufacturing Company, Ltd.), and Douglas C. H. Yu (Taiwan Semiconductor Manufacturing Company, Ltd.)*

Fine-Pitch RDL Integration for Fan-Out Wafer-Level Packaging ........ 1126
*Ser Choong Chong (Institute of Microelectronics), Soon Wee David Ho (Institute of Microelectronics), Siew Boon Serine Soh (Institute of Microelectronics), Seow Huang Sharon Lim (Institute of Microelectronics), Hung Ming Calvin Chua (Institute of Microelectronics), Ahmad Abdillah Haron (Institute of Microelectronics), Huan Ching Kenneth Lee (Institute of Microelectronics), Mingsheng Zhang (Institute of Materials Research and Engineering), Zhi Hao Ko (WinTech Nano-Technology Services Pte. Ltd.), Ye Ko San (WinTech Nano-Technology Services Pte. Ltd.), Henry Leong (WinTech Nano-Technology Services Pte. Ltd.), Chin Wei Tan (Applied Materials), Qi Jie Peng (Applied Materials), Abdul Hakim Jumat (Applied Materials), Xundong Dai (Applied Materials), Khai Mum Peter Fung (Applied Materials), Guan Huei See (Applied Materials), and Prayudi Lianto (Applied Materials)*

Advances in High Performance RDL Technologies for Enabling IO Density of 500 IOs/mm/layer and 8-μm IO Pitch Using Low-k Dielectrics ........ 1132
*Fuhan Liu (Georgia Institute of Technology), Rui Zhang (Georgia Institute of Technology), Bartlet DeProspo (Georgia Institute of Technology), Shreya Dwarakanath (Georgia Institute of Technology), Pratik Nimbalkar (Georgia Institute of Technology), Siddharth Ravichandran (Georgia Institute of Technology), David Weyers (Georgia Institute of Technology), Mohanalingam Kathaperumal (Georgia Institute of Technology), Rao Tummala (Georgia Institute of Technology), and Madhavan Swaminathan (Georgia Institute of Technology)*

Challenges of Large Fan out Multi-chip Module and Fine Cu Line Space ........ 1140
*Yu Lung Huang (Siliconware Precision Industries Co., Ltd), C. Key Chung (Siliconware Precision Industries Co., Ltd), C. F. Lin (Siliconware Precision Industries Co., Ltd), Guan Hua Lu (Siliconware Precision Industries Co., Ltd), Ching Hung Tseng (Siliconware Precision Industries Co., Ltd), Hong Da Chang (Siliconware Precision Industries Co., Ltd), Chih Hsun Hsu (Siliconware Precision Industries Co., Ltd), and Bruce Xu (Siliconware Precision Industries Co., Ltd)*

Fan-In Panel-Level with Multiple Diced Wafers Packaging ........ 1146
*John H. Lau (Unimicron Technology Corporation), Cheng-Ta Ko (Unimicron Technology Corporation), Tzvy-Jang Tseng (Unimicron Technology Corporation), Kai-Ming Yang (Unimicron Technology Corporation), Chia-Yu Peng (Unimicron Technology Corporation), Tim Xia (Unimicron Technology Corporation), Puru Bruce Lin (Unimicron Technology Corporation), Eagle Lin (Unimicron Technology Corporation), Leo Chang (Unimicron Technology Corporation), Hsing Ning Liu (Unimicron Technology Corporation), and David Cheng (Unimicron Technology Corporation)*

Development of Mold-First Fan-Out Panel-Level Packaging (FO-PLP) on 600mm x 600mm Size Panel ........ 1154
*Srinivasa Rao Vempati (Institute of Microelectronics), Ser Choong Chong (Institute of Microelectronics), and Yamamoto Kazunori (Institute of Microelectronics)*

## Session 26: Breakthroughs in TSV and TGV Technologies

Trench Isolation Technology for Cost-Effective Wafer-Level 3D Integration with One-Step TSV ........ 1161
*Masaya Kawano (Institute of Microelectronics, A*STAR), Xiang-Yu Wang (Institute of Microelectronics, A*STAR), and Qin Ren (Institute of Microelectronics, A*STAR)*

Coaxial Through-Silicon-Vias Using Low-k SiO2 Insulator ........ 1167
*Pengbo Yu1 (Tsinghua University), Hongxiao Lin (China Agricultural University), Zhiwei He (China Agricultural University), Changming Song (Tsinghua University), Jian Cai (Tsinghua University), Qian Wang (Tsinghua University), and Zheyao Wang (Tsinghua University)*

Study of the Impact of Pitch Distance on the Statistical Variation of TSV Protrusion and the Underlying Mechanisms ........ 1173
*Golareh Jalilvand (University of Central Florida), Omar Ahmed (University of Central Florida), Nicolas Dube (University of Central Florida), and Tengfei Jiang (University of Central Florida)*

Defect Localization in Through-Si-Interposer Based 2.5DICs ........ 1180
*Sajay Bhuvanendran Nair Gourikutty (Institute of Microelectronics, A*STAR), Yew Meng Chow (Xilinx Asia Pacific Pte Ltd.), Jesse Alton (TeraView Limited), Ratan Bhimrao Umralkar (Institute of Microelectronics, A*STAR), Haonan Bai (Xilinx Asia Pacific Pte Ltd.), Kok Keng Chua (Xilinx Asia Pacific Pte Ltd.), and Surya Bhattacharya (Institute of Microelectronics, A*STAR)*

Interfacial Crack Initiation and Delamination Propagation in Cu-Filled TSV Structure by Incorporating Cohesive Zone Model and Finite Element Method ........ 1186
*Jiu-Bin Fei (South China University of Technology), Tao Xu (South China University of Technology), Jie-Ying Zhou (South China University of Technology), Chang-Bo Ke (South China University of Technology), and Xin-Ping Zhang (South China University of Technology)*

Fabrication and Characterization of Through-Glass Vias (TGV) Based 3D Spiral and Toroidal Inductors by Cost-Effective ECDM Process ........ 1192
*Harindra Kumar Kannojia (Indian Institute of Technology Bombay), Julfekar Arab (Indian Institute of Technology Bombay), Aboobackkar Sidhique (Indian Institute of Technology Bombay), Dileep Kumar Mishra (Indian Institute of Technology Bombay), Ritesh Kumar (Research & Development Establishment (Engineers)), Jaising Pednekar (Research & Development Establishment (Engineers)), and Pradeep Dixit (Indian Institute of Technology Bombay)*

Low-Temperature Multichip-to-Wafer 3D Integration Based on Via-Last TSV with OER-TEOS-CVD and Microbump Bonding without Solder Extrusion ........ 1199
*Kousei Kumahara (Tohoku University), Rui Liang (Tohoku University), Sungho Lee (Tohoku University), Yuki Miwa (Tohoku University), Mariappan Murugesan (Tohoku University), Hisashi Kino (Tohoku University), Takafumi Fukushima (Tohoku University), and Tetsu Tanaka (Tohoku University)*

## Session 27: WLP and Advanced Technology Reliability

A Mechanics Model for the Moisture Induced Delamination in Fan-Out Wafer-Level Package 1205
*Tz-Cheng Chiu (National Cheng Kung University), Ji-Yen Wu (National Cheng Kung University), Wei-Te Liu (National Cheng Kung University), Chang-Wei Liu (National Cheng Kung University), Dao-Long Chen (Advanced Semiconductor Engineering, Inc.), MengKai Shih (Advanced Semiconductor Engineering, Inc.), and David Tarng (Advanced Semiconductor Engineering, Inc.)*

WLCSP Solder Ball Interconnection Enhancement for High Temperature Stress Reliability ..... 1212
*C.C. Chen (Taiwan Semiconductor Manufacturing Company, Ltd.), K.H Chen (Taiwan Semiconductor Manufacturing Company, Ltd.), Y.S Wu (Taiwan Semiconductor Manufacturing Company, Ltd.), P.H Tsao (Taiwan Semiconductor Manufacturing Company, Ltd.), and S.T Leu (Taiwan Semiconductor Manufacturing Company, Ltd.)*

Investigation into the Failure Mechanism of Silver Nanowire Network Film Under Electrical Stress ..... 1218
*Kaiqing Wang (Fudan University), Yunxia Jin (Fudan University), Xiaocun Wang (Fudan University), Baifan Qian (Fudan University), Jianzhong Wang (Fudan University), and Fei Xiao (Fudan University)*

Damage Accumulation in Printed Interconnects on Flex Under Combinations of Bending and Tension with Different Amplitudes ..... 1225
*Rajesh Sharma Sivasubramony (Binghamton University), Mohammed Alhendi (Binghamton University), Maan Kokash (Binghamton University), Manu Yadav (Binghamton University), Arun Raj (Binghamton University), Sanoop Thekkut (Binghamton University), Emuobosan Enakerakpo (Binghamton University), Nardeeka Adams (Binghamton University), Peter Borgesen (Binghamton University), and Mark Poliks (Binghamton University)*

Photosensitive Polymer Reliability for Fine Pitch RDL Applications ..... 1234
*Emmanuel Chery (IMEC), Fabrice Duval (IMEC), Michele Stucchi (IMEC), John Slabbekoorn (IMEC), Kristof Croes (IMEC), and Eric Beyne (IMEC)*

Atomic Layer Deposited Al_2O_3 Encapsulation for the Silicon Interconnect Fabric ..... 1241
*Niloofar Shakoorzadeh Chase (University of California, Los Angeles), Krutikesh Sahoo (University of California, Los Angeles), Yu Tao Yang (University of California, Los Angeles), and Subramanian S. Iyer (University of California, Los Angeles)*

Process-Consistency-Performance Relationships for Additively Printed Z-Axis Interconnects in Multilayer Circuits ..... 1247
*Pradeep Lall (Auburn University), Kartik Goyal (Auburn University), Nakul Kothari (Auburn University), and Scott Miller (NextFlex National Manufacturing Institute)*

## Session 28: Enhanced Manufacturing and Process Integration

Varied Ball BGA Technology to Eliminate Solder Ball Bridging Defects in SMT ..... 1259
*Xiao Lu (Intel Corporation) and Heuijong Ju (SSP Company)*

Full Low Temperature Solder BGA Development for Large Size BGA Package ..... 1265
*Masateru Koide (Fujitsu Advanced Technologies Limited), Kenji Fukuzono (Fujitsu Advanced Technologies Limited), Manabu Watanabe (Fujitsu Advanced Technologies Limited), Tsuyoshi Yamamoto (Fujitsu Advanced Technologies Limited), and Seiki Sakuyama (Service Platform Business Group Fujitsu Limited)*

Thermal Compression Bonding with Pre-Applied Underfill for Very Large Die ..... 1270
*Divya Taneja (University of Sherbrooke), David Danovitch (University of Sherbrooke), Ahmed Chakroun (Kulicke and Soffa Industries Inc.), Catherine Dufort (IBM-Canada), Pascale Gagnon (IBM-Canada), and Robert Martel (IBM-Canada)*

Thermo Compression Bonding for Large Dies Under Protective Atmosphere ........................ 1277
*Jonathan Abdilla (BESI Austria GmbH), Uwe Bayer (Besi Austria GmbH), Ruurd Boomsma (Besi Austria GmbH), Stephan Bulacher (Besi Austria GmbH), Alexander Kalss (Besi Austria GmbH), Stephan Martin (Besi Austria GmbH), Harald Meixner (Besi Austria GmbH), Thiago Moura (Besi Austria GmbH), Hubert Selhofer (Besi Austria GmbH), Wolfgang Voegele (Besi Austria GmbH), and Martin Widauer (Besi Austria GmbH)*

The Effect of Solder Paste Volume on Solder Joint Shape and Self-Alignment of Passive Components ........................ 1289
*Ke Pan (Binghamton University), Jong Hwan Ha (Binghamton University), Van Lai Pham (Binghamton University), Huayan Wang (Binghamton University), Jiefeng Xu (Binghamton University), and Seungbae Park (Binghamton University)*

Achieving Selective Cleaning on Semiconductors Packaging Using Atmospheric Pressure Plasma... 1298
*Sagung Dewi Kencana (National Taiwan University of Science and Technology), Wallace Chuang (Robert Bosch Taiwan Co., Ltd.), Clarissa Changraini (National Taiwan University of Science and Technology), Eckart Schellkes (Robert Bosch Taiwan Co., Ltd.), Yu-Lin Kuo (National Taiwan University of Science and Technology), and Ken Chang (Robert Bosch Taiwan Co., Ltd.)*

An Additive Production Approach for Microvias and Multilayered Polymer Substrate Patterning of 2.5 µm Feature Sizes ........................ 1304
*Sarthak Acharya (Luleå Technical University), Shailesh Singh Chouhan (Luleå Technical University), and Jerker Delsing (Luleå Technical University)*

## Session 29: Advances in Bonding Materials and Processes

Development of Bonding Process for Flexible Devices with Fine-Pitch Interconnection Using Anisotropic Solder Paste and Laser-Assisted Bonding Technology ........................ 1309
*Jiho Joo (Electronics and Telecommunications Research Institute), Yong-Sung Eom (Electronics and Telecommunications Research Institute), Ki-seok Jang (Electronics and Telecommunications Research Institute), Gwang-Mun Choi (Electronics and Telecommunications Research Institute), and Kwang-Seong Choi (Electronics and Telecommunications Research Institute)*

Demonstration of a Collective Hybrid Die-to-Wafer Integration ........................ 1315
*Samuel Suhard (IMEC), Alain Phommahaxay (IMEC), Koen Kennes (IMEC), Pieter Bex (IMEC), Ferenc Fodor (IMEC), Maarten Liebens (IMEC), John Slabbekoorn (IMEC), Andy Miller (IMEC), Gerald Beyer (IMEC), and Eric Beyne (IMEC)*

A Novel Low-Temperature Cu-Cu Direct Bonding with Cr Wetting Layer and Au Passivation Layer ........................ 1322
*Demin Liu (National Chiao Tung University), Po-Chih Chen (National Chiao Tung University), and Kuan-Neng Chen (National Chiao Tung University)*

Direct Bonding of GaN to Diamond Substrate at Room Temperature ........................ 1328
*Tadatomo Suga (Meisei University) and Fengwen Mu (Meisei University)*

Development of an Extremely High Thermal Conductivity TIM for Large Electronics Packages in the 4th Industrial Revolution Era ........ 1332
*Mikyeong Choi (Amkor Technology), HyunHye Jung (Amkor Technology), KwangSeok Oh (Amkor Technology), DongSu Ryu (Amkor Technology), SangHyoun Lee (Amkor Technology), WonChul Do (Amkor Technology), YoungDo Kweon (Amkor Technology), Mike Kelly (Amkor Technology), KyungRok Park (Amkor Technology), JinYoung Khim (Amkor Technology), and Ron Huemoeller (Amkor Technology)*

Pressureless Sintering Process of Ag Sinter Paste Bonding Ag Si Die on Bare Cu DBC Using Convection Reflow Oven in Nitrogen for Die Attach ........ 1338
*Guangyu Fan (Indium Corporation of America), Christine LaBarbera (Indium Corporation of America), Ning-Cheng Lee (Indium Corporation of America), Zachary Boushie (Rochester Institute of Technology), and Nicole Lockwood (Rochester Institute of Technology)*

Characterization and Application of a Novel Permanent Bonding Material ........ 1344
*Xiao Liu (Brewer Science, Inc), Trevor Stanley (Brewer Science, Inc.), and Reihaneh Sejoubsari (Brewer Science, Inc.)*

## Session 30: RF and Power Components and Modules

Metamaterial-Inspired Dual-Function Loop Antenna for Wireless Power Transfer and Wireless Communications ........ 1351
*Woosol Lee (University of Florida), Haein Kim (University of Florida), and Yong-Kyu Yoon (University of Florida)*

Power Integrity Performance Gain of a Novel Integrated Stack Capacitor (ISC) Solution for High-End Computing Applications ........ 1358
*Eunseok Song (Samsung Electronics Company, Ltd.), Dan (Kyung Suk) Oh (Samsung Electronics Company, Ltd.), Seung-Yong Cha (Samsung Electronics Company, Ltd.), Jaejune Jang (Samsung Electronics Company, Ltd.), Taejoo Hwang (Samsung Electronics Company, Ltd.), Gyoungbum Kim (Samsung Electronics Company, Ltd.), Jongkook Kim (Samsung Electronics Company, Ltd.), Sunghwan Min (Samsung Electronics Company, Ltd.), Kilsoo Kim (Samsung Electronics Company, Ltd.), Dae-Woo Kim (Samsung Electronics Company, Ltd.), and Seungwook Yoon (Samsung Electronics Company, Ltd.)*

Integrated Magnetic Cores in FOWLP and Their Applications ........ 1363
*Xiao Sun (IMEC), John Slabbekoorn (IMEC), Dimitrios Velenis (IMEC), Pieter Bex (IMEC), Fabrice Duval (IMEC), Tom Sterken (IMEC), Giacomo Talmelli (IMEC), Inge de Preter (IMEC), Tomas Webers (IMEC), Christoph Adelmann (IMEC), Andy Miller (IMEC), Geert Van der Plas (IMEC), and Eric Beyne (IMEC)*

Multi-physical Simulations and Modelling of an Integrated GaN-on-Si Module Concept for Millimetre-Wave Communications ........ 1369
*Kimmo Rasilainen (Chalmers University of Technology), Koen Buisman (Chalmers University of Technology), Kristoffer Andersson (Ericsson AB), and Christian Fager (Chalmers University of Technology)*

Heterogeneous Integration of 5G and Millimeter-Wave Diplexers with 3D Glass Substrates .. 1376
*Muhammad Ali (Georgia Institute of Technology), Atom Watanabe (Georgia Institute of Technology), Takenori Kakutani (Taiyo Ink Mfg. Co., Ltd.), Pulugurtha M. Raj (Florida International University), Rao R. Tummala (Georgia Institute of Technology), and Madhavan Swaminathan (Georgia Institute of Technology)*

Modeling and Characterization of Through-Silicon-Vias (TSVs) in Radio Frequency Regime in an Active Interposer Technology ........ 1383
*Arian Rahimi (Intel Corporation), Pratheesh Somarajan (Intel Corporation), and Qiang Yu (Intel Corporation)*

Co-Design of a Highly Integrated, High Peformance, 16-Channel Pulsers and Tx/Rx Switches for Ultrasound Imaging Systems ........ 1390
*Prashuk Jain (Texas Instruments, Inc.), Jie Chen (Texas Instruments, Inc.), Rajen Murugan (Texas Instruments, Inc.), Vajeed Nimran (Texas Instruments, Inc.), Aravind Miriyala (Texas Instruments, Inc.), and Tony Tang (Texas Instruments, Inc.)*

## Session 31: Automotive and Power Electronics Packaging

Imaging Sub-Surface Defects in Power Electronic Modules using Shear-Force Microscopy ..... 1396
*Vijay Venkatesh (The Ohio State University), Shailesh N Joshi (Toyota Research Institute of North America), and Vishnu Baba Sundaresan (The Ohio State University)*

Very low Parasitic Inductance Double Side Cooling Power Modules Based on Ceramic Substrates and GaN Devices ........ 1402
*Christine Laurant (CEA, France), Johan Delaine (CEA, France), Pierre Périchon (CEA, France), Charley Lanneluc (CEA, France), Benoit Thollin (CEA, France), Antoine Izoulet (CEA, France), Manon Porlan (CEA, France), René Escoffier (CEA, France), Jean Brun (CEA, France), and Jacques Favre (aPSI3D)*

Advanced SiC Power Module Packaging Technology Direct on DBA Substrate for High Temperature Applications: Ag Sinter Joining and Encapsulation Resin Adhesion ........ 1408
*Chuantong Chen (Osaka University), Zheng Zhang (Osaka University), and Katsuaki Suganuma (Osaka University)*

High Thermal Die-Attach Paste Development for Analog Devices ........ 1414
*Kiichiro Higaki (Amkor Technology, Inc.), Toru Takahashi (Amkor Technology, Inc.), Akinori Ono (Amkor Technology, Inc.), Daisuke Koike (Toshiba Electronic Devices & Storage Corporation), Masahiko Hori (Toshiba Electronic Devices & Storage Corporation), Keiichi Kusaka (Sumitomo Bakelite Company, Limited), Takayuki Nishi (Sumitomo Bakelite Company, Limited), and Takeshi Mori (Sumitomo Bakelite Company, Limited)*

Demonstration of Package Level 3D-Printed Direct Jet Impingement Cooling Applied to High Power, Large Die Applications ........ 1422
*Tiwei Wei (IMEC), Herman Oprins (IMEC), Vladimir Cherman (IMEC), Zhi Yang (GLOBALFOUNDRIES), Katie Rivera (GLOBALFOUNDRIES), Geert Van der Plas (IMEC), Bartek Pawlak (GLOBALFOUNDRIES), Luke England (GLOBALFOUNDRIES), Eric Beyne (IMEC), and Martine Baelmans (KU Leuven)*

Sintered Micro-Silver Paste Doped with Indium for Die Attachment Applications of Power ICs........ 1430
*Chin-Hao Tsai (National Taiwan University), Wei-Chen Huang (National Taiwan University), Ly May Chew (Heraeus Deutschland GmbH & Co. KG), Wolfgang Schmitt (Heraeus Deutschland GmbH & Co. KG), Hiroshi Nishikawa (Osaka University), and C. Robert Kao (National Taiwan University)*

Direct Bonding of Diamond and Si Substrates at Low Temperatures Under Atmospheric Conditions ........ 1436
*Takashi Matsumae (National Institute of Advanced Industrial Science and Technology), Yuichi Kurashima (National Institute of Advanced Industrial Science and Technology), Hitoshi Umezawa (National Institute of Advanced Industrial Science and Technology), and Hideki Takagi (National Institute of Advanced Industrial Science and Technology)*

## Session 32: Stacking and Bonding Technologies

A Novel iso-Thermal Intermetallic Compound Insertion Bonding Approach to Improve Throughput for 3D die to Wafer Stacking ........ 1442
*Lin Hou (IMEC), Jaber Derakhshandeh (IMEC), Giovanni Capuz (IMEC), Ingrid De Wolf (IMEC), Eric Beyne (IMEC), Andy Miller (IMEC), Gerald Beyer (IMEC), and Melina Lofrano (IMEC)*

Tight-Pitch Au-Sn Interconnections for 3D-ICs Integration and Packaging Applications ........ 1448
*Murugesan Mariappan (Tohoku University), Mitsumasa Koyanagi (Tohoku University), and Takafumi Fukushima (Tohoku University)*

7-µm-Thick NCF Technology with Low-Height Solder Microbump Bonding for 3D Integration 1453
*Yuki Miwa (Tohoku University), Kousei Kumahara (Tohoku University), Sungho Lee (Tohoku University), Rui Liang (Tohoku University), Hisashi Kino (Tohoku University), Takafumi Fukushima (Tohoku University), and Tetsu Tanaka (Tohoku University)*

BEOL-Embedded 3D Polylithic Integration: Thermal and Interconnection Considerations ...... 1459
*Ankit Kaul (Georgia Institute of Technology), Sreejith Kochupurackal Rajan (Georgia Institute of Technology), Md Obaidul Hossen (Georgia Institute of Technology), Gary S. May (Georgia Institute of Technology; University of California, Davis), and Muhannad S. Bakir (Georgia Institute of Technology)*

Quasi-Ambient Bonding Semiconductor Components for Power Electronics Integration ....... 1468
*Yi Zhong (Loughborough University Leicestershire), Allan Yu Liu (Loughborough University Leicestershire), Stuart Robertson (Loughborough University Leicestershire), Shuibao Liang (Loughborough University Leicestershire), Canyu Liu (Loughborough University Leicestershire), Zhaoxia Zhou (Loughborough University Leicestershire), and Changqing Liu (Loughborough University Leicestershire)*

Development of CMOS-Compatible Low Temperature Cu Bonding Optimized by the Response Surface Methodology ........ 1474
*Haesung Park (Seoul National University of Science and Technology), Han Kyeol Seo (Seoul National University of Science and Technology), Manseok Park (Seoul Technopark), and Sarah Eunkyung Kim (Seoul National University of Science and Technology)*

Design and Simulation of Symmetric Wafer-to-Wafer Bonding Compesating a Gravity Effect . 1480
*Kyeongbin Lim (Samsung Electronics Company, Ltd.), Minsoo Han (Samsung Electronics Company, Ltd.), Gwanghee Jo (Samsung Electronics Company, Ltd.), Hyeonjun Yun (Samsung Electronics Company, Ltd.), Jewon Lee (Samsung Electronics Company, Ltd.), Jun Hyung Kim (Samsung Electronics Company, Ltd.), SeungDae Seok (Samsung Electronics Company, Ltd.), and Minwoo Daniel Rhee (Samsung Electronics Company, Ltd.)*

## Session 33: Advances in Reliability Assessment

Investigation on the Mechanical Behavior Evolution Occurring in Lead Free Solder Joints Exposed to Thermal Cycling ........ 1486
*Abdullah Fahim (Auburn University), S M Kamrul Hasan (Auburn University), Jeffrey C. Suhling (Auburn University), and Pradeep Lall (Auburn University)*

Reliability of Homogeneous Sn-Bi and Hybrid Sn-Bi/SAC BGAs ........ 1496
*Chongyang Cai (Binghamton University), Jiefeng Xu (Binghamton University), Huayan Wang (Binghamton University), and Seungbae Park (Binghamton University)*

Empirical Model for the Degradation of IMC in SACQ Solder Bumps During High Temperature Storage ........ 1502
*R. Roucou (NXP Semiconductors), C. Bestory (Nexperia), A. Mavinkurve (NXP Semiconductors), and R.T.H. Rongen (NXP Semiconductors)*

Package on System Level Solder Joint Stress Analysis Under Shock Test ........ 1509
*Hsin-Chih Shih (Advanced Semiconductor Engineering), Howard TW Liao (Advanced Semiconductor Engineering), Ryan Chen (Advanced Semiconductor Engineering), York Liao (Universal Scientific Industrial (USI) Co. Ltd.), David Tarng (Advanced Semiconductor Engineering (ASE), Inc.), and CP Hung (Advanced Semiconductor Engineering (ASE), Inc.)*

An Effective and Application-Specific Evaluation of Low-k Dielectric Integration Integrity Using Copper Pillar Shear Testing ........ 1517
*Arman Ahari (Portland State University), Omar Ahmed (University of Central Florida), Peng Su (Juniper Networks), Bernard Glasauer (Juniper Networks), Tengfei Jiang (University of Central Florida), and Tae-Kyu Lee (Portland State University)*

Thermal Aging Induced Underfill Degradation and Its Effect on Reliability of Advanced Packaging ........ 1525
*Faxing X. Che (Institute of Microelectronics A*STAR), X. R. Zhang (Xilinx Asia Pacific Pte. Ltd.), and L. Ji (Institute of Microelectronics A*STAR)*

Stretchability of Serpentine Interconnect on Polymer Substrate for Flexible Electronics: A Geometry and Material Sensitivity Analysis ........ 1533
*Chong Ye (Georgia Institute of Technology), Benjamin G Stewart (Georgia Institute of Technology), and Suresh K. Sitaraman (Georgia Institute of Technology)*

## Session 34: Emerging Materials and Processing

Effect of a Backing Material on the Bendability of Flexible Substrates with Passive SMD Components ........ 1542
*Kartik Sondhi (University of Florida), Sai Guruva Reddy Avuthu (Jabil Inc.), Nathaniel Richards (Jabil Inc.), Z. Hugh Fan (University of Florida), and Toshikazu Nishida (University of Florida)*

Nanowire Impregnated Poly-Dimethyl Siloxane for Flexible, Thermally Conductive Fan-Out Wafer-Level Packaging ........ 1548
*Randall Irwin (University of California, Los Angeles Center for Heterogeneous Integration and Performance Scaling (UCLA CHIPS)), Yuan Hu (University of California, Los Angeles Center for Heterogeneous Integration and Performance Scaling (UCLA CHIPS)), Arsalan Alam (University of California, Los Angeles Center for Heterogeneous Integration and Performance Scaling (UCLA CHIPS)), Samatha Benedict (University of California, Los Angeles Center for Heterogeneous Integration and Performance Scaling (UCLA CHIPS)), Timothy Fisher (University of California, Los Angeles Center for Heterogeneous Integration and Performance Scaling (UCLA CHIPS)), and Subramanian Iyer (University of California, Los Angeles Center for Heterogeneous Integration and Performance Scaling (UCLA CHIPS))*

A Flexible Resistive Pressure Sensor Based on Thermally Expandable Microspheres ........ 1554
*Jianing Wu (Fudan University, China), Miao Tang (Fudan University, China), Haoyue Zhuo (Fudan University, China), Hongkun Lv (State Grid Zhejiang Electric Research Institute, China), Jiecong Cai (State Grid Zhejiang Electric Research Institute, China), and Zhuo Li (Fudan University, China)*

Panel Packaging Approach to Micro Thin-Film Battery Sealing for Healthcare and Internet of Things (IoT) Applications ........ 1560
*Qianwen Chen (IBM Corporation), Bing Dang (IBM Corporation), Leanna Pancoast (IBM Corporation), Jae-woong Nah (IBM Corporation), John Knickerbocker (IBM Corporation), Andy Shih (Front Edge Technologies Inc.), Bo Wen Cheng (Front Edge Technologies Inc.), Kai Liu (Front Edge Technologies Inc.), Mengnian Niu (Front Edge Technologies Inc.), and Simon Nieh (Front Edge Technologies Inc.)*

Embedded Power Inductor in Organic Substrate with Novel Magnetic Epoxy ........ 1566
*Chi-Hao Chiang (Advanced Semiconductor Engineering, Inc), Thomas Wang (Advanced Semiconductor Engineering, Inc), Shu-Ting Yang (Advanced Semiconductor Engineering, Inc), Pao-Nan Lee (Advanced Semiconductor Engineering, Inc), Wei-Yu Nien (Advanced Semiconductor Engineering, Inc), CT Lee (Advanced Semiconductor Engineering, Inc), Sidney Huang (Advanced Semiconductor Engineering, Inc), and Harrison Chang (Advanced Semiconductor Engineering, Inc)*

The Real Demonstration of High-Quality Carbon Nano-Tubes (CNTs) as the Electrical Connection for the Potential Application in a Vertical 3D Integrated Technology .................. 1573
*P.-Y. Lu (National Taiwan University), Y.-R. Li (National Taiwan University), C.-M. Yen (National Taiwan University), H.-T. Hung (National Taiwan University), C.-R. Kao (National Taiwan University), W.-C. Pu (National Taiwan University of Science and Technology), C.-C. A. Chen (National Taiwan University of Science and Technology), M.-H. Lee (National Taiwan Normal University), and Ming-Han Liao (National Taiwan University)*

## Session 35: Additive Manufacturing and Innovative Materials for Packaging

A Comparative Study of Aerosol Jet Printing on Polyimide and Liquid Crystal Polymer Substrates for RF Applications .......... 1579
*Mohammed Alhendi (Binghamton University), Ashraf Umar (Binghamton University), El Mehdi Abbara (Binghamton University), Ryan Cadwell (Binghamton University), Nancy Huang (Binghamton University), Darshana L. Weerawarne (University of Colombo), Peter Borgesen (Binghamton University), Joseph Iannotti (GE Global Research), Nancy Stoffel (GE Global Research), and Mark D. Poliks (Binghamton University)*

Development of Integrated Pressure and Temperature Sensing Strips for Monitoring Venous Leg Ulcer Application .......... 1586
*Ruiqi Lim (Institute of Microelectronics), David Sze Wai Choong (Institute of Microelectronics), and Ming-Yuan Cheng (Institute of Microelectronics)*

Investigation of Pressureless Sintered Interconnections on Plasma Based Additive Copper Metallization for 3-Dimentional Ceramic Substrates for Surface Acoustic Wave Sensors in High Temperature Applications .......... 1592
*Christian Schwarzer (Aschaffenburg University of Applied Sciences), Alexander Hensel (Friedrich-Alexander-University Erlangen-Nuremberg), Frederik Roth (Aschaffenburg University of Applied Sciences), Joerg Franke (Friedrich-Alexander-University Erlangen-Nuremberg), and Michael Kaloudis (Aschaffenburg University of Applied Sciences)*

Electrical Isolation Performance of Microgasket Technology for Implant Packaging .............. 1601
*Paritosh Rustogi (University of Florida) and Jack W. Judy (University of Florida)*

Thermomechanical Reliability Enhancement of High-Power MEMS with Movable Structure Based on Implanted Skin Hairs .......... 1608
*Yunna Sun (Shanghai Jiao Tong University), Yongpeng Wu (Shanghai Jiao Tong University), Hongfang Li (Shanghai Jiao Tong University), Yan Wang (Shanghai Jiao Tong University), Zhuoqing Yang (Shanghai Jiao Tong University), Yuzhuo Fu (Shanghai Jiao Tong University), and Guifu Ding (Shanghai Jiao Tong University)*

Integrated and Discrete Ultra-Thin Capacitors Based on Carbon Nanofibers with High Capacitance Density .......... 1614
*Rickard Andersson (Smoltek AB), Maria Bylund (Smoltek AB), Sascha Krause (Smoltek AB), Victor Marknäs (Smoltek AB), Amin M Saleem (Smoltek AB), Elisa Passalacqua (Smoltek AB), Mohammad S Kabir (Smoltek AB), and Vincent Desmaris (Smoltek AB)*

Role of Grain Size on the Effective Resistivity of Cu-Graphene Hybrid Interconnects ............. 1620
*Rahul Kumar (IIT Ropar), Sunil Pathania (IIT Ropar), Surila Guglani (IIT Roorkee), Amit Kumar (IIT Roorkee), Somesh Kumar (ABV-IIITM Gwalior), Sourajeet Roy (IIT Roorkee), Brajesh Kumar Kaushik (IIT Roorkee), and Rohit Sharma (Indian Institute of Technology Ropar)*

## Session 36: Multiphysics and AI-Enhanced Modeling Approaches

Prediction of Fan-out Panel Level Warpage using Neural Network Model with Edge Detection Enhancement ........ 1626
*S. W. Liu (National Tsing Hua University), S. K. Panigrahy (National Tsing Hua University), and K. N. Chiang (National Tsing Hua University)*

Implementation of General Coupling Model of Electromigration in ANSYS ........ 1632
*Zhen Cui (Delft University of Technology), Xuejun Fan (Lamar University), and Guoqi Zhang (Delft University of Technology)*

Learning the Stress-Strain Relationships of Ultra-Thin Package Materials using a Bayesian Approach ........ 1638
*Cheryl Selvanayagam (Singapore University of Technology and Design; Advanced Micro Devices (AMD)), Pham Luu Trung Duong (Singapore University of Technology and Design), and Nagarajan Raghavan (Singapore University of Technology and Design)*

Numerical Study of Edge Condensation in Wafer to Wafer Bonding Process with Lattice Boltzmann Approach ........ 1646
*Jung Shin Lee (Samsung Electronics Company, Ltd.), Jun Hyung Kim (Samsung Electronics Company, Ltd.), and Daniel Min Woo Rhee (Samsung Electronics Company, Ltd.)*

Coupled Thermal-Mechanical Simulation Methodology to Estimate BGA Reliability of 2.5D Packages ........ 1653
*Manish Nayini (Marvell Semiconductor), Timothy Horn (GLOBALFOUNDRIES), Janak Patel (Marvell Semiconductor), and Lloyd Burrell (GLOBALFOUNDRIES)*

Three-Dimensional Simulation of Effects of Electro-Thermo-Mechanical Multi-physical Fields on Cu Protrusion and Performance of Micro-Bump Joints in TSVs Based High Bandwidth Memory (HBM) Structures ........ 1659
*Jie-Ying Zhou (South China University of Technology), Zheng Wang (South China University of Technology), Cheng Wei (South China University of Technology), Jiu-Bin Fei (South China University of Technology), Chang-Bo Ke (South China University of Technology), and Xin-Ping Zhang (South China University of Technology)*

## Session 37: New Methods, Techniques and Devices in Packaging

Bending Effects on a Fabric-Based Antenna for Wearable Applications ........ 1665
*Hsuan-ling Kao (Chang Gung University) and Chun-Hsiang Chuang (Chang Gung University)*

Progress and Applications of Embedded System in Chip (eSinC®) Technology ..................... 1671
*Shuying Ma (HuaTian Technology (Kunshan) Electronics Co., Ltd.), Jianwei Chang (HuaTian Technology (Kunshan) Electronics Co., Ltd.), Jiao Wang (HuaTian Technology (Kunshan) Electronics Co., Ltd.), Daquan Yu (Xiamen University), Xiaobing Yang (HuaTian Technology (Kunshan) Electronics Co., Ltd.), Tony Curtis (HuaTian Technology (Kunshan) Electronics Co., Ltd.), and Aimo Xiao (HuaTian Technology (Kunshan) Electronics Co., Ltd.)*

Effects of Two-Step Plasma Treatment on Cu and SiO2 Surfaces for 3D Bonding Applications ........ 1677
*Han Kyeol Seo (Seoul National University of Science and Technology), Hae Sung Park (Seoul National University of Science and Technology), Gahui Kim (Andong National University), Young-Bae Park (Andong National University), and Sarah Eunkyung Kim (Seoul National University of Science and Technology)*

A Study of the Board Level Reliability of Large 16FF Wafer Level Package for RF Transceivers ........ 1684
*Andreas Wolter (Intel Deutschland GmbH), Horst Baumeister (Intel Deutschland GmbH), Ceren Yeni (Intel Deutschland GmbH), Bernd Waidhas (Intel Deutschland GmbH), Jan Proschwitz (Intel Deutschland GmbH), Thomas Wagner (Intel Deutschland GmbH), and Beth Keser (Intel Deutschland GmbH)*

Application of Package-Level High-Performance EMI Shield Material with a Novel Nozzleless Spray Coating Technology ........ 1691
*Stuart Erickson (Ultrasonic Systems, Inc.) and Mike Sakaguchi (Tatsuta Wire & Chemical Co., Ltd.)*

A Highly Reliable Die Bonding Approach for high Power Devices by Low Temperature Pressureless Sintering using a Novel Cu Nanoparticle Paste ........ 1697
*Hai-Jun Huang (South China University of Technology), Xue Wu (South China University of Technology), Min-Bo Zhou (South China University of Technology), and Xin-Ping Zhang (South China University of Technology)*

Integration of GaN-LEDs with Heterogeneous Device Components by Epitaxil Film Bonding .. 1703
*Mitsuhiko Ogihara (Filnex Corporation Hachioji, Japan), Yoshiteru Amemiya (Hiroshima University), and Shin Yokoyama (Hiroshima University)*

Evaluation of ICP Sputter Etch with Reducing Atmosphere for the Improvement of Rc in UBM/RDL Applications ........ 1711
*Patrik Carazzetti (Evatec AG), Juergen Weichart (Evatec AG), Andreas Erhart (Evatec AG), Mohamed Elghazzali (Evatec AG), and Ewald Strolz (Evatec AG)*

Chip/Package/Board Co-Design Methodology Applied to Full-Custom Heterogeneous Integration . 1718
*Thomas Brandtner (Infineon Technologies Austria AG, Austria), Klaus Pressel (Infineon Technologies AG, Germany), Natalia Floman (Infineon Technologies Austria AG, Austria), Michael Schultz (Infineon Technologies AG, Germany), and Michael Vogl (Infineon Technologies AG, Germany)*

3D FOWLP Integration ........ 1728
*Teck Guan Lim (Institute of Microelectronic), David Soon Wee Ho (Institute of Microelectronic), Chai Tai Chong (Institute of Microelectronic), and Surya Bhattacharya (Institute of Microelectronic)*

Impact of Electroless-Ni Seed Layer on Cu-Bottom-up Electroplating in High Aspect Ratio (>10) TSVs for 3D-IC Packaging Applications ........ 1736
*Murugesan Mariappan (Tohoku University), Mitsumasa Koyanagi (Tohoku University), and Takafumi Fukushima (Tohoku University)*

## Session 38: 5G, mm-Wave and RF Packaging

Stripline-Slotline Rectangular Resonators for Measurement of Uniaxial Anisotropic Permittivity of Composite PCB Dielectric Material ........ 1742
*Zhaoqing Chen (IBM Corporation)*

High Bandwidth and Multi-channel Power over Coaxial Filters for Automotive Low-Voltage Differential Signaling Interconnect ........ 1749
*Yutaka Uematsu (The Center for Technology Innovation, Hitachi, Ltd., Japan) and Hideyuki Sakamoto (Smart Digital Solution Business Development Division, Hitachi Ltd., Japan)*

"Molded-Package-Last" Process for Fan-out System in Package (FO-SiP) ........ 1757
*Tomoaki Shibata (Hitachi Chemical Co., Ltd.), Tsuyoshi Ogawa (Hitachi Chemical Co., Ltd.), Xinrong Li (Hitachi Chemical Co., Ltd.), Satoshi Yoneda (Hitachi Chemical Co., Ltd.), Naoya Suzuki (Hitachi Chemical Co., Ltd.), and Toshihisa Nonaka (Hitachi Chemical Co., Ltd.)*

A Pen-Writable Electroless Plating Method for Large-Area RF Circuit Applications ........ 1763
*Yihang Chu (Michigan State University) and Premjeet Chahal (Michigan State University)*

Extracting Power Supply Current Profile by using Interposer-Based Low-Noise Probing Technique for PDN Design of High-Density POP ........ 1769
*Heeseok Lee (Samsung Electronics, Co. Ltd.), Hoi-Jin Lee (Samsung Electronics, Co. Ltd.), Jisoo Hwang (Samsung Electronics, Co. Ltd.), Taekeun An (Samsung Electronics, Co. Ltd.), Seokjoon Hong (Samsung Electronics, Co. Ltd.), and Youngmin Shin (Samsung Electronics, Co. Ltd.)*

Design and Fabrication of Band-Pass Filter on Glass IPD for 5G New Radio ........ 1775
*Pan-Nan Lee (Advanced Semiconductor Engineering (ASE), Inc.), Yu-Chang Hsieh (Advanced Semiconductor Engineering (ASE), Inc.), Sheng-Chi Hsieh (Advanced Semiconductor Engineering (ASE), Inc.), Cheng-Yuan Kung (Advanced Semiconductor Engineering (ASE), Inc.), and Chen-Chao Wang (Advanced Semiconductor Engineering (ASE), Inc.)*

A new C-FDFD Method Capturing Per-Unit Length Parameter of Quasi-TEM Mode Transmission Line with Reduced Computational Resource ........ 1781
*Heeseok Lee (Samsung Electronics, Co. Ltd.), Jisoo Hwang (Samsung Electronics, Co. Ltd.), and Taekeun An (Samsung Electronics, Co. Ltd.)*

Antenna on Silicon Interconnect Fabric ........ 1788
*Arpan Dasgupta (University of California, Los Angeles), Arsalan Alam (University of California, Los Angeles), Guangqi Ouyang (University of California, Los Angeles), SivaChandra Jangam (University of California, Los Angeles), and Subramanian S. Iyer (University of California, Los Angeles)*

Low Loss BT Resin for Substrates in 5G Communication Module ........ 1795
*Katsuya Yamamoto (Mitsubishi Gas Chemical Company, Inc.), Shouta Koga (Mitsubishi Gas Chemical Company, Inc.), Saori Seino (Mitsubishi Gas Chemical Company, Inc.), Kazuyuki Higashita (Mitsubishi Gas Chemical Company, Inc.), Keiichi Hasebe (Mitsubishi Gas Chemical Company, Inc.), Eisuke Shiga (Mitsubishi Gas Chemical Company, Inc.), Tsuyoshi Kida (Mitsubishi Gas Chemical Company, Inc.), and Syu Yoshida (Mitsubishi Gas Chemical Company, Inc.)*

Demonstration of a Low Latency (<20 ps) Fine-Pitch (≤10 μm) Assembly on the Silicon Interconnect Fabric ........ 1801
*SivaChandra Jangam (University of California, Los Angeles), Uneeb Rathore (University of California, Los Angeles), Sumeet Nagi (University of California, Los Angeles), Dejan Markovic (University of California, Los Angeles), and Subramanian Iyer (University of California, Los Angeles)*

Beamforming Design using Millimeter Wave Dual-Polarized FSS Transmit-Array for 5G Small Cell Base-Station Applications ........ 1806
*Chi-Hau Yang (National Sun Yat-Sen University), Chung-Yi Hsu (National Sun Yat-Sen University), Hung-Wei Chung (National Sun Yat-Sen University), and Lih-Tyng Hwang (National Sun Yat-Sen University)*

Guided-Mode Resonance Filter for Micro-Optic Spectrometer ........ 1812
*Junichi Inoue (Kyoto Institute of Technology), Shogo Ura (Kyoto Institute of Technology), and Kenji Kintaka (National Institute of Advanced Industrial Science and Technology)*

Wideband Low-Profile AMC-Based Patch Antenna for 5G Antenna-in-Package Application .... 1818
*Weikang Wan (Institute of Microelectronics of Chinese Academy of Sciences), Mei Xue (Institute of Microelectronics of Chinese Academy of Sciences), Liqiang Cao (Institute of Microelectronics of Chinese Academy of Sciences), Tianchun Ye (Institute of Microelectronics of Chinese Academy of Sciences), and Qidong Wang (Institute of Microelectronics of Chinese Academy of Sciences)*

Flexible Inkjet-Printed Patch Antenna Array on Mesoporous PET Substrate for 5G Applications with Stable RF Performance After Mechanical Stress Cycling ........ 1824
*Gurvinder Singh Khinda (Binghamton University), Ashraf Umar (Binghamton University), Ryan J. Cadwell (Binghamton University), Mohammed Alhendi (Binghamton University), Nancy C. Stoffel (General Electric Research Center), Peter Borgesen (Binghamton University), and Mark D. Poliks (Binghamton University)*

## Session 39: Current Trends in High Speed Interconnects


High Bandwidth Low Power 2.5D Interconnect Modeling and Design .................................. 1832
*Qian Ding (Intel Corporation), Hui Liu (Intel Corporation), Yee Huan Yew (Intel Corporation), and Jenny Jiang (Intel Corporation)*

Irregular Bumps Design Planning for Modern Ball Grid Array Packages ................................ 1838
*Hsin-Yu Chang (National Chiao Tung University), Hung-Ming Chen (National Chiao Tung University), Yun-Chih Kuo (MediaTek Inc., Taiwan), Hsien-Ting Tsai (MediaTek Inc., Taiwan), Simon Yi-Hung Chen (MediaTek Inc., Taiwan), Jyun-Ru Jiang (National Chiao Tung University), Ya-Ying Chien (National Chiao Tung University), and Yu-Yang Chen (MediaTek Inc., Taiwan)*

3D Composite Glass-Silicon Interposer Integrated with Polymer Arrayed Waveguide Grating 1844
*Ziji Wang (Southeast University) and Jintang Shang (Southeast University)*

Design and Validation of Reliability Physics for Interconnect Architectures Induced from Inclusive TM/SM/EM Effects ........................................................................................ 1849
*Chang-Chun Lee (National Tsing Hua University), Jui-Chang Chuang (National Tsing Hua University), Steve Chiu (Industrial Technology Research Institute), Shau-Fei Cheng (Industrial Technology Research Institute), Chen-Tsai Yang (Industrial Technology Research Institute), and Wei-Yuan Cheng (Industrial Technology Research Institute)*

Pressureless Transient Liquid Phase Sintering Bonding using SAC305 with Hybrid Ag Particles for High–Temperature Packaging Applications ...................................................... 1855
*Byeong-Uk Hwang (Sungkyunkwan University), Kyung Deuk Min (Sungkyunkwan University), Kwang-Ho Jung (Sungkyunkwan University), Choong-Jae Lee (Sungkyunkwan University), Jae-Ha Kim (Sungkyunkwan University), and Seung-Boo Jung (Sungkyunkwan University)*

Demonstration of Superconducting Interconnects on the Silicon Interconnect Fabric Using Thermocompression Bonding ......................................................................................... 1861
*Yu-Tao Yang (University of California, Los Angeles), Chaowei Hu (University of California, Los Angeles), Jazmine Green (University of California, Los Angeles), Peng Zhang (University of California, Los Angeles), Niloofar Shakoorzadeh (University of California, Los Angeles), Pranav Ambhore (University of California, Los Angeles), Umesha Mogera (University of California, Los Angeles), Ni Ni (University of California, Los Angeles), Kang L. Wang (University of California, Los Angeles), and Subramanian S. Iyer (University of California, Los Angeles)*

Embedded 3D-IPD Technology Based on Conformal 3D-RDL: Application for Design and Fabrication of Compact, High-Performance Diplexer and Ultra-Wide Band Balun ................. 1867
*Ayad Ghannam (3DiS Technologies S.A.S, France), Alessandro Magnani (3DiS Technologies S.A.S, France), David Bourrier (3DiS Technologies S.A.S, France), and Thierry Parra (3DiS Technologies S.A.S, France)*

Tri-Axis Polarized Loop Antenna for mmWave Wireless Inter/Intra Chip Communications ..... 1875
*Hae-in Kim (University of Florida), Renuka Bowrothu (University of Florida), and Yong-Kyu Yoon (University of Florida)*

Growth Mechanism of Interfacial IMCs on (111) Preferred Orientation Nanotwinned Cu UBM for 3D IC Packaging ........ 1881
*M.L. Huang (Dalian University of Technology) and Y. Wu (Dalian University of Technology)*

3D Micro Bump Interface Enabling Top Die Interconnect to True Circuit Through Silicon Via Wafer ........ 1888
*Nistec Chang (Siliconware Precision Industries Co., Ltd.), C. Key Chung (Siliconware Precision Industries Co., Ltd.), Yu-Po Wang (Siliconware Precision Industries Co., Ltd.), C. F. Lin (Siliconware Precision Industries Co., Ltd.), PJ Su (Siliconware Precision Industries Co., Ltd.), Teny Shih (Siliconware Precision Industries Co., Ltd.), Nicholas Kao (Siliconware Precision Industries Co., Ltd.), and Joe Hung (Siliconware Precision Industries Co., Ltd.)*

Visualization and Modeling of Microstructural Evolution in SAC305 BGA Joints During Extreme High Temperature Aging ........ 1894
*KM Rafidh Hassan (Auburn University), Mohammad Alam (Auburn University), Jing Wu (Auburn University), Jeffrey Suhling (Auburn University), and Pradeep Lall (Auburn University)*

## Session 40: Manufacturing Techniques for Advanced Packaging

Study on Advanced Substrate for Double-Side Package to Reduce Module Size ........ 1904
*Ji-Hee Kim (Daeduck Electronics Co. Ltd.), Kwan-Sun Yoon (Daeduck Electronics Co., Ltd.), Hwa-Dong Oh (Daeduck Electronics Co., Ltd.), Eun-Chul Ahn (Daeduck Electronics Co., Ltd.), Young-Hwan Shin (Daeduck Electronics Co., Ltd.), and Young-Jae Kim (Daeduck Electronics Co., Ltd.)*

A New RDL-First PoP Fan-Out Wafer-Level Package Process with Chip-to-Wafer Bonding Technology ........ 1910
*SeungNam Son (Amkor Technology Korea, Inc.), DongHyun Khim (Amkor Technology Korea, Inc.), SeokHun Yun (Amkor Technology Korea, Inc.), JunHwan Park (Amkor Technology Korea, Inc.), EunTaek Jeong (Amkor Technology Korea, Inc.), JiHun Yi (Amkor Technology Korea, Inc.), JinKun Yoo (Amkor Technology Korea, Inc.), KiYeul Yang (Amkor Technology Korea, Inc.), MinJae Yi (Amkor Technology Korea, Inc.), SangHyoun Lee (Amkor Technology Korea, Inc.), WonChul Do (Amkor Technology Korea, Inc.), and JinYoung Khim (Amkor Technology Korea, Inc.)*

Growth Kinetics of Intermetallic Compound Layers at the Interface During Laser-Assisted Bonding Depending on Surface Finish ........ 1916
*Hong-Sub Joo (Sungkyunkwan University, SAMSUNG Electronics), Kyung Deuk Min (Sungkyunkwan University), Choong-Jae Lee (Sungkyunkwan University), Byeong-Uk Hwang (Sungkyunkwan University), and Seung-Boo Jung (Sungkyunkwan University)*

Processing Glass Substrate for Advanced Packaging using Laser Induced Deep Etching ........ 1922
*Rafael Santos (LPKF Laser & Electronics AG, Germany), Jean-Pol Delrue (LPKF Laser & Electronics AG, Germany), Norbert Ambrosius (LPKF Laser & Electronics AG, Germany), Roman Ostholt (LPKF Laser & Electronics AG, Germany), and Stephan Schmidt (LPKF Laser & Electronics AG, Germany)*

A Study on Laser-Assisted Bonding (LAB) and Its Influence on Luminescence Characteristics of Blue and YAG Phosphor Encapsulated InGaN LEDs ........ 1928
*Matthias Fettke (PacTech GmbH), Andrej Kolbasow (PacTech GmbH), Vinith Bejugam (PacTech GmbH), Timo Kubsch (PacTech GmbH), Alexander Frick (PacTech GmbH), Thorsten Teutsch (PacTech GmbH), Yu-Chung Wang (Inkron Limited), and Juha Rantala (Inkron Limited)*

Study of Solder Interconnect Configurations and Performance of Vertical Laser Assisted Assembled "3.5D" Packages ........ 1936
*Kolbasow Andrej (Pac Tech GmbH), Fettke Matthias (Pac Tech GmbH), Kubsch Timo (Pac Tech GmbH), Bejugam Vinith (Pac Tech GmbH), and Teutsch Thorsten (Pac Tech GmbH)*

High-Speed Ultra-Accurate Direct C2W Bonding ........ 1943
*Birgit Brandstätter (Besi Austria GmbH), Daniel Aschenwald (Besi Austria GmbH), Benedikt Auer (Besi Austria GmbH), Norbert Bilewicz (Besi Austria GmbH), Ruurd Boomsma (Besi Austria GmbH), Christoph Kröll (Besi Austria GmbH), Andreas Mayr (Besi Austria GmbH), Richard Neumayr (Besi Austria GmbH), Hannes Rieser (Besi Austria GmbH), Mario Schernthaner (Besi Austria GmbH), Hubert Selhofer (Besi Austria GmbH), Florian Speer (Besi Austria GmbH), Peter Unterwaditzer (Besi Austria GmbH), András Vidéki (Besi Austria GmbH), Martin Widauer (Besi Austria GmbH), and Thomas Widmann (Besi Austria GmbH)*

Strategies Relating to CMP for Die to Wafer Interconnects Utilizing Hybrid Direct Bonding .... 1950
*Jonatan A. Sierra Suarez (Sandia National Laboratories), John P. Mudrick (Sandia National Laboratories), Crystal C. Sennett (Sandia National Laboratories), T. A. Friedmann (Sandia National Laboratories), Shawn Arterburn (Sandia National Laboratories), Matthew B. Jordan (Sandia National Laboratories), Lisa Caravello (Sandia National Laboratories), Jordan E. Gutierrez (Sandia National Laboratories), and M. David Henry (Sandia National Laboratories)*

New Molding Technology Enabling Advanced Packaging Technology ........ 1957
*Takashi Saito (APIC YAMADA Corporation), Tokuyuki Kitajima (APIC YAMADA Corporation), Makoto Kawaguchi (APIC YAMADA Corporation), Shinya Tajima (APIC YAMADA Corporation), and Masashi Okamoto (APIC YAMADA Corporation)*

Development of Compression Molding Process for Fan-Out Wafer Level Packaging ........ 1965
*Julien Bertheau (IMEC), Fabrice Duval (IMEC), Tadashi Kubota (Towa), Bex Pieter (IMEC), Koen Kennes (IMEC), Alain Phommahaxay (IMEC), Arnita Podpod (IMEC), Eric Beyne (IMEC), Andy Miller (IMEC), and Gerald Beyer (IMEC)*

LTCC PoP Technology Based Novel Approach for mm-Wave 5G System for Next Generation Communication System ........ 1973
*Surender Singh (Cadence Design System) and Taranjit Kukal (Cadence Design System)*

## Session 41: Characterization and Analysis of Packaging Materials


Autocatalytic Tin – How to Overcome Process Limitations to Introduce a New Solution for Thick Tin Plating ..... 1979
*Kuldip Johal (Atotech USA LLC), Britta Schafsteller (Atotech Deutschland GmbH), Gustavo Ramos (Atotech Deutschland GmbH), Kadir Tuna (Atotech Deutschland GmbH), and Sandra Nelle (Atotech Deutschland GmbH)*

A Handling Solution for Easy Processing of Thin Glass with TGV ..... 1986
*Shelby F Nelson (Mosaic Microsystems), David H Levy (Mosaic Microsystems), and Aric B Shorey (Mosaic Microsystems)*

Printing Unifrom QDs Polymer Thin Film for QLED Application ..... 1992
*Ning Tu (The Hong Kong University of Science and Technology), Jeffery C.C. Lo (The Hong Kong University of Science and Technology), and Shi Wei Lee (The Hong Kong University of Science and Technology)*

Ultrasonic-Assisted Nano Ag-Al Alloy Sintering to Enable High-Temperature Electronic Interconnections ..... 1999
*Canyu Liu (Loughborough University), Allan Liu (Loughborough University), Yi Zhong (Loughborough University), Stuart Robertson (Loughborough University), Zhaoxia Zhou (Loughborough University), and Changqing Liu (Loughborough University)*

The Influence of Different-Sized Ni Micro-and Nanopowders on the Processing and Microstructural Properties of Sn-Ag-Cu-Solder with Low Ag Content ..... 2005
*Simon Keim (Technische Hochschule Ingolstadt), Ulrich Tetzlaff (Technische Hochschule Ingolstadt), and Gordon Elger (Technische Hochschule Ingolstadt)*

Effective Thermal Solution via Wafer Level Packaging Materials ..... 2013
*Junghwa Kim (Samsung SDI), Wool-Chul Na (Samsung SDI), JungSeob Kim (Samsung SDI), Sumi Im (Samsung SDI), Dong-Hwan Lee (Samsung SDI), Sanghak Lim (Samsung SDI), and Sang-Kyun Kim (Samsung SDI)*

Synthesis of Boron Nitride Coated Silica Filler for Preparing Thermally Conductive Epoxy Composites ..... 2019
*Jiaxiong Li (Georgia Institute of Technology), Yanjuan Ren (Georgia Institute of Technology), Dong An (Georgia Institute of Technology), Kyoung-sik Moon (Georgia Institute of Technology), and Ching-ping Wong (Georgia Institute of Technology)*

Characteristics of Plasma-Activated Dielectric Film Surfaces for Direct Wafer Bonding ..... 2025
*Seongmin Son (Samsung Electronics Co., Ltd), Junhong Min (Samsung Electronics Co., Ltd), Eunsuk Jung (Samsung Electronics Co., Ltd), Hoechul Kim (Samsung Electronics Co., Ltd), Taeyeong Kim (Samsung Electronics Co., Ltd), Hyungjun Jeon (Samsung Electronics Co., Ltd), Jinnam Kim (Samsung Electronics Co., Ltd), Seokho Kim (Samsung Electronics Co., Ltd), Kwangjin Moon (Samsung Electronics Co., Ltd), Hoonjoo Na (Samsung Electronics Co., Ltd), Kihyun Hwang (Samsung Electronics Co., Ltd), and Geun Young Yeom (Sungkyunkwan University)*

Molecular Dynamics Study of the Influence of Aggregation and Percolation in Al2O3/polyethylene Oxide Nanofluids on the Effective Thermal Conductivity. ........ 2033
*Barbara Poliks (Binghamton University) and Bahgat Sammaki (Binghamton University)*

Curekinetic Modeling of Interfacial Reactions between Epoxy and Silica Filler Suspension System in Non-Conductive Paste (NCP) for 3DIC Packaging ........ 2040
*Min Woo Rhee (Mechatronics R&D Center, Samsung Electronics)*

Evolution of the Properties of SAC-Bi-Ni-Sb Lead Free Solder During Mechanical Cycling ........ 2048
*Mohd Aminul Hoque (Auburn University), Mohammad Ashraful Haq (Auburn University), Md Mahmudur Chowdhury (Auburn University), Jeffrey C. Suhling (Auburn University), and Pradeep Lall (Auburn University)*

## Session 42: Thermo-Mechanical Effects in Packaging

Turbulent Flows Impinging on High Power Multi-chip Bare Die Package ........ 2058
*Prabhakar Subrahmanyam (Intel Corporation) and Ying-Feng Pang (Intel Corporation)*

Warpage and Void Simulation of System in Package ........ 2066
*Eric Ouyang (JCETglobal), Yonghyuk Jeong (JCET Group), JaeMyong Kim (JCET Group), Susan Lin (Moldex3D), Jay Vang (Moldex3D), and Anthony Yang (Moldex3D)*

Thermal and Power Delivery Aware Floorplanning for Heterogeneous Multi Core Design ........ 2072
*Yunhyeok Im (Samsung Electronics), Young-Sang Cho (Samsung Electronics), Jisoo Hwang (Samsung Electronics), Heeseok Lee (Samsung Electronics), Jongkyu Yoo (Samsung Electronics), James Jung (Samsung Electronics), Heejung Choi (Samsung Electronics), Yohan Kwon (Samsung Electronics), Hoi-Jin Lee (Samsung Electronics), and Youngmin Shin (Samsung Electronics)*

Thermal Analysis, Characterization and Material Selection for SiC Based Intelligent Power Modules ........ 2078
*Gongyue Tang (Institute of Microelectronics), Leong Ching Wai (Institute of Microelectronics), Siak Boon Lim (Institute of Microelectronics), Boon Long Lau (Institute of Microelectronics), Kazunori Yamamoto (Institute of Microelectronics), and Xiao Wu Zhang (Institute of Microelectronics)*

Finite Element Modeling Methodology for Monotonic Bend Test of Flip-Chip BGA Package ........ 2086
*Scott McCann (Xilinx, Inc.), Tom Lee (Xilinx, Inc.), and Suresh Ramalingam (Xilinx, Inc.)*

Constant Poisson's Ratio of Thermosetting Polymers: Is it Reasonable for Accurate Thermal Stress Analysis? ........ 2092
*Hyun Lee (University of Maryland), Sukrut Phansalkar (University of Maryland), and Bongtae Han (University of Maryland)*

Panel Warpage and Die Shift Simulation and Characterization of Fan-Out Panel-Level Packaging ........ 2097
*Che Faxing (Institute of Microelectronics, A*STAR), Kazunori Yamamoto (Institute of Microelectronics, A*STAR), and Vempati Srinivasa Rao (Institute of Microelectronics, A*STAR)*

Thermal Management of Glass Panel Embedded Packages: Package Architecture vs. Power Density ........ 2105
*Ryan Wong (Georgia Institute of Technology), Siddharth Ravichandran (Georgia Institute of Technology), Haksun Lee (Georgia Institute of Technology), and Vanessa Smet (Georgia Institute of Technology)*

Electromechanical Finite Element Analysis for Designed Low-Frequency MEMS Piezoelectric Vibration Energy Harvester ........ 2112
*Ling Xu (Fudan University, China), Shengrui Zhou (Fudan University, China), Yingfei Xiang (Fudan University, China), and Yinglin Yang (Fudan University, China)*

## Session 43: Reliability and Failure Analyses of Emerging Materials

The Board Level Reliability Performance and Process Challenges of Ultra-Thin WLP (Package Height < 250 μm) ........ 2118
*Kuei Hsiao Kuo Frank (SPIL, Taiwan R.O.C.), Chun Yi Chiang (SPIL, Taiwan R.O.C.), Kuang Hsin Chen (SPIL, Taiwan R.O.C.), Ting-en Lin (SPIL, Taiwan R.O.C.), Stan Chen (SPIL, Taiwan R.O.C.), and Feng Lung Chien (SPIL, Taiwan R.O.C.)*

Moisture Effect on Physical Failure of Plastic Molded SiP Module ........ 2124
*Jeffrey ChangBing Lee (iST), Cheng-Chih Chen (iST), Dem Lee (iST), and Jess Chen (iST)*

Outstanding Reliability Performances of Silicon Capacitors for 200°C Automotive Applications ........ 2133
*Sebastien Jacqueline (Murata Integrated Passive Solutions), Catherine Bunel (Murata Integrated Passive Solutions), and Laurent Lengignon (Murata Integrated Passive Solutions)*

Robustness of Carbon Nanofiber-Based MIM Capacitors with Ultra-High Capacitance Density to Electrical and Thermal Stress ........ 2139
*Maria Bylund (Smoltek AB), Rickard Andersson (Smoltek AB), Sascha Krause (Smoltek AB), Amin M Saleem (Smoltek AB), Victor Marknäs (Smoltek AB), Elisa Passalacqua (Smoltek AB), M Shafiq Kabir (Smoltek AB), and Vincent Desmaris (Smoltek AB)*

Assembly Technologies for Piezoelectric Sensors up to 1000 °C ........ 2145
*Fabian Kohler (University of Freiburg, IMTEK) and Jürgen Wilde (University of Freiburg, IMTEK)*

45RFSOI WLCSP Board Level Package Risk Assessment and Solder Joint Reliability Performance Improvement ........ 2151
*Haojun Zhang (GlobalFoundries US Inc.), Zhuo-Jie Wu (GlobalFoundries US Inc.), John Malinowski (GlobalFoundries US Inc.), Millete Carino (GlobalFoundries US Inc.), Kristina Young-Fisher (GlobalFoundries US Inc.), Jean Trewhella (GlobalFoundries US Inc.), and Patrick Justiso (GlobalFoundries US Inc.)*

A Study of Electromechanical Behaviors of Printed Conductive Leads on Stretchable Textiles for Smart Clothing ........ 2157
*K. U. S. Somarathna (The State University of New York at Binghanton), B. Garakani (The State University of New York at Binghamton), M. Alhendi (The State University of New York at Binghamton), E. Enakerakpo (The State University of New York at Binghamton), P. Borgesen (The State University of New York at Binghamton), M.D. Poliks (The State University of New York at Binghamton), and A. Alizadeh (General Electric Global Research)*

Effects of Process Parameters and Isothermal Fatigue Cycling on Electromechanical Properties of Screen-Printed Interconnect on Nonwovens for Wearable Electronics ........ 2167
*Behnam Garakani (Binghamton University), Kankanige Udara S. Somarathna (Binghamton University), Gurvinder Singh Khinda (Binghamton University), Emuobosan Enakerakpo (Binghamton University), Mohammed Alhendi (Binghamton University), Mark D. Poliks (Binghamton University), Peter Borgesen (Binghamton University), and Azar Alizadeh (General Electric Global Research Center)*

Investigation of the Mechanical Behavior of SAC305 Solder Joints at Extreme High Temperatures Using Nanoindentation ........ 2175
*Mohammad S. Alam (Auburn University), KM Rafidh Hassan (Auburn University), Abdullah Fahim (Auburn University), Jing Wu (Auburn University), Jeffrey C. Suhling (Auburn University), Pradeep Lall (Auburn University), and Sudan Ahmed (Auburn University)*

## Session 44: Optoelectronics, Flex and Emerging Technologies

Controls on the Transport of Particles/Cells in Deterministic Lateral Displacement via Symmetric Airfoil with Angle of Attacks ........ 2185
*Kawkab Ahasan (Washington State University), Brian Senf (Washington State University), and Jong-Hoon Kim (Washington State University)*

Optical Platform for Highly Precise Optical Components ........ 2191
*Sebastian Bengsch (Leibniz University Hannover), Eike Fischer (Leibniz University Hannover), Sascha de Wall (Leibniz University Hannover), Timo Schelm (Leibniz University Hannover), Matthias Arndt (Leibniz University Hannover), and Marc Christopher Wurz (Leibniz University Hannover)*

A Design and Fabrication of Transmission Line for eSiFO in Millimeter-Wave Applications ........ 2197
*Shengjuan Zhou (Tsinghua University), Jian Cai (Tsinghua University; Beijing National Research Center for Information Science and Technology), Qian Wang (Tsinghua University; Beijing National Research Center for Information Science and Technology), Xiuyu Shi (Tsinghua University), Xuesong Zhang (Tsinghua University), Changming Song (Tsinghua University), and Yu Chen (Tsinghua University)*

Low Power SOC Based on High Density MIM Capacitor for Beyond Moore Era by Robust Power Integrity Achievement ........ 2203
*Jisoo Hwang (Samsung Electronics, Co. Ltd.), Hoi-Jin Lee (Samsung Electronics, Co. Ltd.), Hyun-Jong Lee (Samsung Electronics, Co. Ltd.), Heeseok Lee (Samsung Electronics, Co. Ltd.), Minkyu Mike Kim (Samsung Electronics, Co. Ltd.), and Youngmin Shin (Samsung Electronics, Co. Ltd.)*

Design of Optical Transmitter Module for O-Band Silicon Photonic Engine ........ 2209
*Hsien Wu (National Kaohsiung University of Science and Technology), Pei-Hao Tseng (Teratech Optical Communication Inc.), Chun-Nien Liu (National Chung Hsing University), Jau-Ji Jou (National Kaohsiung University of Science and Technology), Wood - Hi Cheng (National Chung Hsing University), Yaw-Dung Wu (National Kaohsiung University of Science and Technology), Po-Jui Chiang (National Kaohsiung University of Science and Technology), Ting-Jen Hsueh (National Kaohsiung University of Science and Technology), and Tien-Tsorng Shih (National Kaohsiung University of Science and Technology)*

Flexible Batteries Under Dynamic Folding and Flex-to-Install with Varying C-Rates and Temperatures ........ 2215
*Pradeep Lall (Auburn University), Ved Soni (Auburn University), and Scott Miller (NextFlex National Manufacturing Institute)*

An Embedded SiC Module with Using NMPB Interconnection for Chevron Shaped Cu Lead and Electrodes ........ 2226
*Naoki Fukui (Waseda University), Keiko Koshiba (Waseda University), Itaru Miyazaki (Waseda University), Isamu Morisako (Waseda University), Tomonori Iizuka (Waseda University), Tomoya Itose (Kyushu Institute of Technology), Masayuki Hikita (Kyushu Institute of Technology), Rikiya Kamimura (Kitakyushu Foundation for the Advancement of Industry, Science and Technology, Japan), and Kohei Tatsumi (Waseda University)*

Design, Fabrication and Characterization of a Q-Band Patch Antenna Integrated on Stacked Interposers ........ 2230
*Yunheng Sun (Peking University), Yufeng Jin (Peking University), Tingting Lian (Xiamen University), Shenglin Ma (Xiamen University), Yuchi Yang (Peking University), Wei Wang (Peking University), Liulin Hu (Chengdu Ganide Technology CO., Ltd), and Shuwei He (Chengdu Ganide Technology CO., Ltd)*

## Session 45: Student Session

A Design Flow for Micro Bump and Stripe Planning on Modern Chip-Package Co-Design ........ 2236
*Ming-Yu Huang (National Chiao Tung University), Hung-Ming Chen (National Chiao Tung University), Kuan-Neng Chen (National Chiao Tung University), Shih-Hsien Wu (Industrial Technology Research Institute), Yu-Min Lee (National Chiao Tung University), and An-Yu Su (National Chiao Tung University)*

Planar-Radial Structured Thermoelectric Cooler for Local Hot Spot Cooling in Mobile Electronics ........ 2242
*Cheol Kim (Seoul National University, Republic of Korea), Haishan Shen (Sungkyunkwan University, Republic of Korea), Jeonglim Yoon (Soonchunhyang University, Republic of Korea), Min-Woo Jeong (Seoul National University, Republic of Korea), Sungtae Kim (Seoul National University, Republic of Korea), Seung-Hyun Oh (Seoul National University, Republic of Korea), So-Yeon Lee (Seoul National University, Republic of Korea), Hoojeong Lee (Sungkyunkwan University, Republic of Korea), Youngcheol Joo (Soonchunhyang University, Republic of Korea), and Young-Chang Joo (Seoul National University, Republic of Korea)*

Preparation of Autonomously Self-Healing Electrode Based on Double Network Supramolecular Elastomer ........ 2247
*Miao Tang (Fudan University), Jianing Wu (Fudan University), Kaiqing Wang (Fudan University), Mingliang Ying (State Grid Zhejiang Electric Research Institute), Hongkun Lv (State Grid Zhejiang Electric Research Institute), and Zhuo Li (Fudan University)*

Investigation of Underfilling BGAs Packages – Thermal Fatigue ........ 2252
*Van Lai Pham (Binghamton University), Jiefeng Xu (Binghamton University), Huayan Wang (Xilinx), Ke Pan (Binghamton University), Charandeep Singh (Corning), Jing Wang (Binghamton University), and Seungbae Park (Binghamton University)*

Design and Fabrication of an Ultra-Thin Silicon Vapor Chamber for Compact Electronic Cooling ........ 2259
*Quentin Struss (Université de Sherbrooke, Canada), Perceval Coudrain (CEA-LETI, France), Jean-Philippe Colonna (CEA-LETI, France), Abdelkader Souifi (Institut des Nanotechnologies de Lyon, France), Christian Gontrand (Institut des Nanotechnologies de Lyon, France), Édouard Deschaseaux (CEA-LETI, France), Gaëlle Mauguen (CEA-LETI, France), Vincent Mathieu (CEA-LETI, France), Thomas Magis (CEA-LETI, France), Gilles Simon (CEA-LETI, France), and Luc G. Fréchette (Université de Sherbrooke, Canada)*

Impact of Viscoelastic Properties of Low Loss Printed Circuit Boards (PCBs) on Reliability of WCSP Packages Under Drop Test ........ 2266
*Akshay Lakshminarayana (University of Texas at Arlington), Abel Misrak (University of Texas at Arlington), Rabin Bhandari (University of Texas at Arlington), Tushar Chauhan (University of Texas at Arlington), A S M Raufur Chowdhury (University of Texas at Arlington), and Dereje Agonafer (University of Texas at Arlington)*

Design of 4-Channel 25 Gbaud/s PAM-4 Optical Transmitter Module for Short Reach Applications ........ 2272
*I-Cheng Hou (National Kaohsiung University of Science and Technology), Pei-Hao Tseng (Teratech Optical Communication Inc.), Jau-Ji Jou (National Kaohsiung University of Science and Technology), Chung-Han Chang (National Kaohsiung University of Science and Technology), Yaw-Dung Wu (National Kaohsiung University of Science and Technology), Po-Jui Chiang (National Kaohsiung University of Science and Technology), Ting-Jen Hsueh (National Kaohsiung University of Science and Technology), and Tien-Tsorng Shih (National Kaohsiung University of Science and Technology)*

First Principle Analysis of Li-Doped Armchair Graphene Nanoribbons for Nanoscale Metal Interconnect Applications ........ 2278
*Vipul Kumar Nishad (IIT Ropar) and Rohit Sharma (Indian Institute of Technology Ropar)*

A Semi-Hemispherical High Q-Factor Resonators Fabricated using a Hybrid Rigid-Flex Process ........ 2284
*Vincens Gjokaj (Michigan State University) and Premjeet Chahal (Michigan State University)*

A Wireless Battery-Less Seat Sensor for Autonomous Vehicles ........ 2289
*Saikat Mondal (Michigan State University), Kanishka Wijewardena (Michigan State University), Saranraj Karrapuswami (Michigan State University), Deepak Kumar (Michigan State University), Premjeet Chahal (Michigan State University), Mahmoud Ghannam (Ford Motor Company), and Mark Cuddihy (Ford Motor Company)*

Deep Trench Capacitors in Silicon Interconnect Fabric ........ 2295
*Kannan Kalappurakal Thankappan (University of California, Los Angeles) and Subramanian Iyer (University of California, Los Angeles)*

Strain and Surface Warping Detection of Interconnect Microstructures via Laser Diffraction ........ 2302
*Todd Houghton (Arizona State University) and Hongbin Yu (Arizona State University)*

Inverse Design of Substrate from Warpage Surrogate Model Using Global Optimisation Algorithms in Ultra-Thin Packages ........ 2309
*Cheryl Selvanayagam (Singapore University of Technology and Design (SUTD)), Pham Luu Trung Duong (Singapore University of Technology and Design (SUTD)), and Nagarajan Raghavan (Singapore University of Technology and Design (SUTD))*

Identification of Polymer Materials in Electronic Packages Including Counterfeit Prevention ........ 2317
*Junbo Yang (SUNY Binghamton), Jiefeng Xu (SUNY Binghamton), and Seungbae Park (SUNY Binghamton)*

Screen-Printed Inductive Silver Ink Strain Sensor on Stretchable TPU Substrate ........ 2325
*Connor S. Smith (University of Florida), Kartik Sondhi (University of Florida), Beatriz Jimenez (University of Florida), Z. Hugh Fan (University of Florida), Toshikazu Nishida (University of Florida), and David P. Arnold (University of Florida)*

**Author Index** . . . . . . . . . . 2331