WELCOME LETTER

On behalf of the organizing committee it is a great pleasure to welcome you to ITherm 2018, the leading international conference for scientific and engineering exploration of thermal, thermo-mechanical and emerging technology issues associated with electronic devices, packages, and systems. The first ITherm Conference was held in 1988, making this the 30th year of the conference series. ITherm 2018 is being held along with the 68th Electronic Components and Technology Conference (ECTC), a premier electronic packaging conference.

ITherm 2018 is packed with many activities, including 182 Technical Papers in 4 Technical Tracks; 3 Keynote Talks addressing the future of electronics cooling, electronic packaging, and research, such as cryogenic cooling of quantum computers and FPGA modules to accelerate artificial intelligence workloads; 5 Technical Panel Sessions for a highly interactive engagement with experts; 5 Technology-Talk Sessions providing deep dive talks on high profile topics; 65 Student Posters as a highly interactive forum on the latest research; 18 Professional Development Courses including 2 with heavy thermal content; and Vendor Exhibits and Gold/Silver Sponsor Stations. For ITherm 2018, several sessions have identified outstanding papers that will be featured in the sessions with longer presentation times. Other exciting developments are two joint ECTC/ITherm events including a joint Young Professionals Panel on Tuesday evening, and a joint ECTC/ITherm Women’s Panel on Wednesday evening. Furthermore, a second Art-in-Science exhibition will be held during the conference and every vote counts.

Many thanks go to everyone who has contributed to the success of ITherm 2018. We recognize there is more work than any of us could ever hope to handle. Thus, taking time and contributing to ITherm over and above regular everyday responsibilities is highly appreciated. In particular, we would like to thank our track chairs and co-chairs, session chairs/co-chairs, panel/technology-talks organizers, and many others. Last, but not least, the support of our Executive Committee is highly appreciated. A list of key contributors is included later in this program.

We have sought sponsorships to support expanded student participation with opportunities to present their work in oral and poster presentations, as well as other activities at ITherm. This year we have had tremendous sponsorship support from both industry and academia. Our thanks go out to each of this year’s sponsors for the critical role their sponsorship provides to ITherm. Please visit their exhibition booths, benefit from exchange of information, and thank them for their sponsorship.

Thank you for participating in the ITherm 2018 conference and making it possible by your attendance. We hope you will enjoy the conference. If this is not your first time attending ITherm, then welcome back and we hope you will establish new contacts and continue to expand your network of trust. Please help first-time attendees to meet others and generally make people feel at home here. Regardless of whether this is your first time with us or not, we will endeavor to have you come back again in the future. We hope that while you enjoy the wide variety of technical venues that ITherm 2018 offers, you can also take a little extra time to enjoy the uniqueness of the San Diego bay area. ITherm 2019 will be held in Las Vegas, NV on May 28-31, 2019, and we hope that you mark your calendars to be there as well.

Best wishes,

Thomas Brunschwilger, Ph.D.
General Chair

Jeffrey C. Suhling, Ph.D.
Program Chair

Vadim Gektin, Ph.D., P.E.
Vice Program Chair

Justin Weibel, Ph.D.
Communications Chair
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CONFERENCE DESCRIPTION

Sponsored by the IEEE Electronics Packaging Society (EPS), ITherm 2018 is an international conference for scientific and engineering exploration of thermal, thermomechanical, and emerging technology issues associated with electronic devices, packages and systems (http://ieee-itherm.net). ITherm 2018 is being held along with the 68th Electronic Components and Technology Conference (ECTC 2018 - http://www.ectc.net), a premier electronics packaging conference. Dual-registration for ITherm and ECTC is offered at a substantial discount. In addition to oral and poster presentations and vendor exhibits, ITherm 2018 includes panel discussions, keynote lectures by prominent speakers, Technology-Talks on cutting edge topics, and professional development short courses. The ITherm conference series began in 1988, and this year marks the 30th anniversary of ITherm.

GENERAL INFORMATION

REGISTRATION

Location: San Diego Sheraton Hotel & Marina, Bay Tower, Lobby Level, Bel Aire Foyer near Bel Aire Room

Opening Hours:
Tuesday, May 29 3:30 PM – 5:30 PM
Wednesday, May 30 6:30 AM – 5:30 PM
Thursday, May 31 7:00 AM – 5:30 PM
Friday, June 1 7:00 AM – 12:00 Noon

Conference Registration Includes:
• Admission to All Conference Sessions
• Luncheons (Wednesday/Thursday/Friday)
• Memory Stick Conference Proceedings

Fees (Onsite Registration)  
<table>
<thead>
<tr>
<th>IEEE/ASME Member Fee</th>
<th>Non-Member Fee</th>
<th>Student</th>
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<tr>
<td>Joint ITherm/ECTC Registration</td>
<td>1,125 USD</td>
<td>1,335 USD</td>
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<tr>
<td>ITherm Registration</td>
<td>750 USD</td>
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Speakers: On the day of your talk/session, please attend the Speakers’ Breakfast in the Fairbanks Room from 7:00-7:45 AM to meet your session chairs and go over session procedures.
GENERAL INFORMATION (CONTINUED)

MISCELLANEOUS INFORMATION

HOTEL AMENITIES

The San Diego Sheraton Hotel & Marina features:

- Two Towers: Bay (ITherm) and Marina (ECTC)
- Complimentary Airport Shuttle
- 24-Hour Front Desk
- Complimentary Wireless in Lobby Area
- Several Restaurants
- Valet and Self Service Parking (Fee)
- Business Center, Gift Shop, Guest Launderette
- Fitness Center, Pools, Game Rooms

EMERGENCY SERVICES

Automated External Defibrillators (AEDs) are located at the Front Desks. The hotel has a dedicated Emergency Response Team (ERT) that is composed of all hotel security officers and engineers. All members of the ERT are CPR and first aid certified as “first responders”. Several fire extinguishers are spread-out throughout the property. Security can be reached by calling “0” or ext. 2279. The Emergency extension is 2020 or by calling “0”.

COMMITTEE MEETINGS

ITHERM EXECUTIVE COMMITTEE
The ITherm Executive Committee meeting will take place in Del Mar (Lobby Level), on Wednesday May 30th, from 5:00 to 6:00 PM. By invitation only.

ITHERM 2019 PROGRAM PLANNING
The ITherm 2019 Program Planning meeting will take place in Bel Aire, on Thursday May 31st, from 7:00 to 8:00 PM. Open to all current and future contributors.

ITHERM 2018 ORGANIZERS DINNER
The ITherm 2018 Organizers Dinner will take place in the Harbor’s Edge Restaurant, Marina Tower, on Thursday May 31st, from 8:00 to 10:00 PM. By invitation only.

ASME K-16 COMMITTEE
The ASME K-16 Committee meeting will take place in Coronado A on Wednesday May 30th, from 7:30 to 8:30 PM. Open to Committee Members and to all interested in becoming involved in Committee activities.

ASME JOURNAL OF ELECTRONIC PACKAGING
An open meeting for those interested in the Journal of Electronic Packaging hosted by Editor Y. C. Lee will be held in Coronado A on Wednesday May 30th, and will start immediately following the ASME K-16 committee meeting. Open to all.

CONFERENCE SUMMARY

- 182 Technical Papers in 50 Sessions
- 3 Keynote Talks
- 5 Technical Panel Sessions
- 5 Technology-Talk Sessions
- 65 Student Posters
- 18 Professional Development Courses
- Vendor Exhibits and Sponsor Stations
- 36 Featured Presentations
- Art-in-Science Competition
- ECTC/ITherm Joint Women’s Panel
- ECTC/ITherm Young Professionals Panel
- Heterogeneous Integration Workshop
## CONFERENCE ORGANIZATION COMMITTEE

### ORGANIZATION COMMITTEE

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<tr>
<th>Position</th>
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<tr>
<td>General Chair</td>
<td>Thomas Brunschwiler</td>
<td>IBM Research – Zurich</td>
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<td>Program Chair</td>
<td>Jeffrey C. Suhling</td>
<td>Auburn University</td>
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<td>Vice Program Chair</td>
<td>Vadim Gektin</td>
<td>Huawei Technologies</td>
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<tr>
<td>Communications Chair</td>
<td>Justin Weibel</td>
<td>Purdue University</td>
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### COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

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<td>Cisco</td>
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<tr>
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<td>Kamal Sikka</td>
<td>IBM Corporation</td>
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<tr>
<td>Co-Chair</td>
<td>Reza Khiabani</td>
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### SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

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<td>Chair</td>
<td>Mehdi Saeidi</td>
<td>Qualcomm Technologies</td>
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<tr>
<td>Co-Chair</td>
<td>Ashish Gupta</td>
<td>Intel Corporation</td>
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<tr>
<td>Co-Chair</td>
<td>Ali Merrikh</td>
<td>Qualcomm Technologies</td>
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<tr>
<td>Co-Chair</td>
<td>Vivek Sahu</td>
<td>Apple</td>
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### EMERGING TECHNOLOGIES & FUNDAMENTALS TRACK

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<tr>
<td>Chair</td>
<td>Satish Kumar</td>
<td>Georgia Institute of Technology</td>
</tr>
<tr>
<td>Co-Chair</td>
<td>Amir H. Shooshtari</td>
<td>University of Maryland</td>
</tr>
<tr>
<td>Co-Chair</td>
<td>Banafsheh Barabadi</td>
<td>Massachusetts Institute of Technology</td>
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<tr>
<td>Co-Chair</td>
<td>Amy Marconnet</td>
<td>Purdue University</td>
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### MECHANICS & RELIABILITY TRACK

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<tr>
<td>Chair</td>
<td>Jin Yang</td>
<td>Intel Corporation</td>
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<tr>
<td>Co-Chair</td>
<td>Bernhard Wunderle</td>
<td>TU Chemnitz</td>
</tr>
<tr>
<td>Co-Chair</td>
<td>Krishna Tunga</td>
<td>IBM Corporation</td>
</tr>
<tr>
<td>Co-Chair</td>
<td>Pradeep Lall</td>
<td>Auburn University</td>
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### SPECIAL TECHNICAL CONTRIBUTIONS

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
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<tbody>
<tr>
<td>Keynote Chair</td>
<td>John Thome</td>
<td>EPFL</td>
</tr>
<tr>
<td>Keynote Co-Chair</td>
<td>Suresh Garimella</td>
<td>Purdue</td>
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<tr>
<td>Keynote Co-Chair</td>
<td>Lauren Boteler</td>
<td>US Army Research Laboratory</td>
</tr>
<tr>
<td>Technology-Talk Chair</td>
<td>Peter de Bock</td>
<td>GE Global Research</td>
</tr>
<tr>
<td>Technology-Talk Co-Chair</td>
<td>David H. Altman</td>
<td>Raytheon</td>
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<tr>
<td>Technology-Talk Co-Chair</td>
<td>Madhusudan Iyengar</td>
<td>Google</td>
</tr>
<tr>
<td>Panels Chair</td>
<td>Victor Chiriac</td>
<td>Qualcomm Technologies</td>
</tr>
<tr>
<td>Panels Co-Chair</td>
<td>Sung Jin Kim</td>
<td>KAIST</td>
</tr>
<tr>
<td>Student Poster Chair</td>
<td>Mahsa Ebrahim</td>
<td>Villanova University</td>
</tr>
<tr>
<td>Student Poster Co-Chair</td>
<td>Amir H. Shooshtari</td>
<td>University of Maryland</td>
</tr>
<tr>
<td>Student Poster Co-Chair</td>
<td>Milnes David</td>
<td>IBM Corporation</td>
</tr>
<tr>
<td>PDC Short Course Chair</td>
<td>Patrick McCluskey</td>
<td>University of Maryland</td>
</tr>
<tr>
<td>PDC Short Course Co-Chair</td>
<td>Jeffrey Suhling</td>
<td>Auburn University</td>
</tr>
<tr>
<td>Women’s Panel Chair</td>
<td>Cristina Amon</td>
<td>University of Toronto</td>
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IBM Research – Zurich is one of 12 IBM Research laboratories around the globe. It was established in 1956 and is home to world-class scientists representing more than 45 nationalities. Cutting-edge research and outstanding scientific achievements—most notably two Nobel Prizes—are associated with this lab.

As the largest European branch of IBM Research, its mission—in addition to pursuing innovative research for tomorrow’s information technology—is to cultivate close relationships with academic and industrial partners.

IBM Research – Zurich strives to be one of the premier places for top researchers to work, to promote women in IT and science, and to help drive Europe’s innovation agenda.

A new facility for collaborative nano-scale research was opened on the IBM Zurich campus in 2011. The Binnig and Rohrer Nanotechnology Center (top right) is part of a strategic partnership in nanosciences with ETH Zurich, one of the world’s foremost science and engineering universities.

IBM Research – Zurich at a glance

- Founded: 1956
- Director: Dr. Alessandro Curioni
- Nationalities: 45+
- Collaboration H2020: 50+ projects, 500+ partners
- ERC Grants: 7
- Nobel Laureates: 4
  - 1986: Nobel Prize in Physics for the invention of the scanning tunneling microscope by Heinrich Rohrer and Gerd K. Binnig
  - 1987: Nobel Prize in Physics for the discovery of high-temperature superconductivity by K. Alex Müller and J. Georg Bednorz

Research areas

- Cognitive Computing & Industry Solutions
  - Cognitive systems, foundations of cognitive solutions, information analytics, computational sciences, security & privacy, services research, systems biology.

- Cloud & Computing Infrastructure
  - Blockchain, Big Data, storage & memory technologies, security, MicroDataCenter, server I/O links, accelerator technologies.

- Science & Technology

IBM Research worldwide

For more than seven decades, IBM Research has defined the future of information technology with more than 3,000 researchers in 12 labs located across six continents.

For more information: www.zurich.ibm.com
CONFERENCE ORGANIZATION COMMITTEE (Continued)

SPECIAL TECHNICAL CONTRIBUTIONS (Continued)

| Art-in-Science Chair       | Mahsa Ebrahim       | Villanova University |
| Art-in-Science Co-Chair    | Amir H. Shooshtari  | University of Maryland |
| Art-in-Science Co-Chair    | Milnes David       | IBM Corporation      |

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| Administrative Assistant  | Damaris David       | ITherm               |
| Sponsoring & Exhibitor Chair | Joshua Gess     | Oregon State University |
| Sponsoring & Exhibitor Co-Chair | Shlomo Novotny | Nortek                 |
| Sponsoring & Exhibitor Co-Chair | Michael Ellsworth | IBM Corporation      |
| Finance Chair              | Dustin Demetriou  | IBM Corporation      |
| Finance Co-Chair            | Milnes David      | IBM Corporation      |
| Operations Chair            | Pritish Parida    | IBM Research         |
| Operations Co-Chair         | Yoonjin Won       | University of California, Irvine |

COMMUNICATION

| Paper Management Database | Sandeep Tonapi | Anveshak |
| Paper Management Tool Accessibility | Jeffrey Suhling | Auburn University |
| Conference Proceedings Manager | Paul Wesling | ITherm |
| Technical Program and Design | Jeffrey C. Suhling | Auburn University |
| Technical Program and Design | Vadim Gektin | Huawei Technologies |
| Website Design             | Sreekant Narumanchi | NREL |
| Webmaster                  | Shashank Thakur  | Anveshak |
| Webmaster                  | Kedar Khire      | Anveshak |
| Outreach & Engagement      | Vaibhav Bahadur  | University of Texas at Austin |
| Publicity                  | John (Jack) Maddox | University of Kentucky |
| Social & Social Media      | Farah Singer     | University of Maryland |

AWARD COMMITTEE

| Richard Chu ITherm Award Chair | Sushil Bhavnani | Auburn University |
| Richard Chu ITherm Award Co-Chair | Koneru Ramakrishna | Cirrus Logic |
| Best Paper Award Chair         | Yogendra K. Joshi | Georgia Institute of Technology |
| Best Paper Award Co-Chair      | Koneru Ramakrishna | Cirrus Logic |

MOBILE APP AND LINKEDIN

A mobile app (iOS and Android) has been developed to assist you in scheduling your time at ITherm 2018. In addition, the app will provide several interactive social features to help you connect with other attendees. The app can be downloaded at no cost.

You can also follow ITherm activities at LinkedIn: https://www.linkedin.com/groups/8650280
The Executive Committee is made up of past ITherm General Chairs who are willing to assist the conference. It provides the leadership and continuity needed to carry forward the thrust of our Inter Society Conference.

Dereje Agonafer  
University of Texas at Arlington

Cristina H. Amon  
University of Toronto

Mehdi Asheghi  
Stanford University

Avram Bar-Cohen  
University of Maryland

Sushil H. Bhavnani  
Auburn University

Madhusudan Iyengar  
Google

Yogendra K. Joshi  
Georgia Institute of Technology

Gary B. Kromann  
Motorola

Tom Lee  
Xilinx

Michael Ohadi  
University of Maryland

Alfonso Ortega  
Villanova University

Koneru Ramakrishna  
Cirrus Logic

Bahgat Sammakia  
State University of New York at Binghamton

Sandeep Tonapi  
Anveshak

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5 RESEARCH CENTERS AND 7 UNIQUE LABS: PARTNERING WITH ACADEMIA FOR RESEARCH IMPACT

binghamton.edu/s3ip
SPONSORS, EXHIBITORS, AND PARTNERS

For more details on our ITherm 2018 Sponsors, Exhibitors, and Partners, please see http://ieee-itherm.net/itherm/conference/sponsors_and_exhibitors

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<tr>
<th>GOLD SPONSORS</th>
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<td>Dupont</td>
<td>CAVE³ at Auburn University</td>
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<td>Electronic Components and Technology Conference (USA)</td>
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Electronic Components and Technology Conference (USA)

Thermal Investigations of ICs and Systems (Europe)

Electronics Packaging Technology Conference (Asia)
### LAST YEAR’S BEST PAPERS (ITHERM 2017)

#### EMERGING TECHNOLOGIES AND FUNDAMENTALS TRACK

<table>
<thead>
<tr>
<th>BEST PAPER</th>
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<tbody>
<tr>
<td><strong>Accurate Thermoreflectance Imaging of Nano-Features Using Thermal Decay</strong></td>
<td><strong>Design Considerations for a Miniaturized TIM Tester with Extremely High Measurement Resolution</strong></td>
</tr>
<tr>
<td>Dustin Kendig (Microsanj), Gregory Hohensee (Western Digital); Ella Pek (University of Illinois at Urbana-Champaign); Wan Kuang (Western Digital); Kazuaki Yazawa, Ali Shakouri (Purdue University)</td>
<td>Ronald J. Warzoha, Andrew Smith, Ashim Bajwa (United States Naval Academy); Lauren Boteler (Army Research Laboratory)</td>
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#### MECHANICS AND RELIABILITY TRACK

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<tr>
<td><strong>Non-destructive in-situ Monitoring of Delamination of Buried Interfaces by a Thermal Pixel (Thixel) Chip</strong></td>
<td><strong>FE Analyses and Power Cycling Tests on the Thermo-Mechanical Performance of Silver Sintered Power Semiconductors with Different Interconnection Technologies</strong></td>
</tr>
<tr>
<td>Bernhard Wunderle, Daniel May (TU Chemnitz); Mohamad Abo Ras (Nanotest); Juergen Keller (AMIC)</td>
<td>Ranier Dudek, R. Döring, A. Otto, S. Rzepka (Fraunhofer ENAS); S. Stegmeier, S. Kiefl (Siemens AG); A. Lunding (Philips Medical Systems DMC GmbH); R. Eisele (FH Kiel)</td>
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#### COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

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<tr>
<td><strong>High Heat Flux Evaporation from Nanoporous Silicon Membranes</strong></td>
<td><strong>Thermal Model for Embedded Two-Phase Liquid Cooled Microprocessor</strong></td>
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<tr>
<td>Jay Sircar, Daniel Hanks, Zhengmao Lu (Massachusetts Institute of Technology); Todd Salamon (Bell Labs Alcatel-Lucent); Kevin Bagnall, Dion Antao, Banafsheh Barabadi, Evelyn Wang (Massachusetts Institute of Technology)</td>
<td>Pritish Parida, Arvind Sridhar, Augusto Vega, Mark Schultz (IBM Corporation); Michael Gaynes (Universal Instruments Corp); Ozgur Ozsun, Gerard McVicker, Thomas Brunschwiler, Alper Buyuktosunoglu, Timothy Chainer (IBM Corporation)</td>
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#### SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

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<tr>
<td><strong>High Voltage Stacked Diode Package with Integrated Thermal Management</strong></td>
<td><strong>Quasi-Steady Modeling of Data Center Heat Exchanger under Dynamic Conditions</strong></td>
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<tr>
<td>Lauren Boteler, Miguel Hinojosa, Valerie Niemann (US Army Research Laboratory); Steven Miner (US Naval Academy); David Gonzalez Nino (University of Puerto Rico)</td>
<td>Marcelo Del Valle, Carol Caceres, Alfonso Ortega (Villanova University); Kourosh Nemati, Bahgat Sammakia (Binghamton University)</td>
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CUSTOM THERMAL SOLUTIONS

In everything we do, we believe in going the extra mile to make the impossible possible by providing custom thermal and mechanical solutions. COFAN’s strength lies in our ability to offer comprehensive thermal and mechanical solutions with seamless integration of analysis, design, prototyping, and production.

ABOUT COFAN USA

COFAN leads the industry in customized thermal solutions. We are committed to serving our partner’s needs. We service industries ranging from medical manufacturing, aerospace, telecommunications, networking, to electronic manufacturing services (EMS).

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http://cofan-usa.com  thermal@cofan-usa.com
48664 Millmont Drive | Fremont, CA 94538 USA | 1.510.490.7533
PROFESSIONAL DEVELOPMENT COURSES

All Professional Development Courses will be held on Tuesday, May 29th in the Marina Tower of the Sheraton Hotel. The Morning (AM) Courses will be from 8:00 AM to 12:00 PM, and the Afternoon (PM) Courses will be from 1:15 PM to 5:15 PM. Separate registration (includes lunch) for the Tuesday PDC courses is required through the ECTC registration desk in the Marina Tower.

MORNING COURSES (8:00 AM – 12:00 PM)

PDC01: Achieving High Reliability of Lead-Free Solder Joints – Materials Considerations
Course Leader: Ning-Cheng Lee - Indium Corporation

PDC02: Introduction to Fan-Out Wafer Level Packaging
Course Leader: Beth Keser - Intel Corporation

PDC03: Fundamentals of Glass Technology and Applications for Advanced Semiconductor Packaging
Course Leader: Aric Shorey - Corning

PDC04: Future of Device and Systems Packaging in Post Moore’s Law
Course Leader: Rao Tummala - Georgia Institute of Technology

PDC05: Introduction to Mechanics Based Quality and Reliability Assessment Methodology
Course Leaders: Shubhada Sahasrabudhe and Sandeep Sane - Intel Corporation

PDC06: Polymers and Nanocomposites for Electronic and Photonic Packaging
Course Leaders: C. P. Wong - Georgia Institute of Technology; Daniel Lu - Henkel Corporation

PDC07: Fundamentals of RF Design and Fabrication Processes of Fan-Out Wafer Level Packages and Interposers
Course Leaders: Ivan Ndip and Markus Wöhrmann - Fraunhofer IZM

Course Leaders: Ricky Lee - HKUST, and Xuejun Fan - Lamar University

PDC09: Integrated Thermal Packaging and Reliability of Power Electronics
Course Leader: Patrick McCluskey - University of Maryland

AFTERNOON COURSES (1:15 – 5:15 PM)

PDC10: Flip Chip Fabrication and Interconnection
Course Leaders: Eric Perfecto - GlobalFoundries; Shengmin Wen - Synaptics

PDC11: Wafer Level Chip Scale Packaging
Course Leader: Luu Nguyen - Texas Instruments

PDC12: Flexible Hybrid Technologies – Manufacturing and Reliability
Course Leader: Pradeep Lall - Auburn University

PDC13: Fan-Out Wafer-Level Packaging and 3D Packaging
Course Leader: John Lau - ASM Pacific Technology Ltd.

PDC14: Polymers for Electronic Packaging
Course Leader: Jeffrey Gotro - InnoCentrix, LLC

PDC15: Corrosion in Microelectronic Packages
Course Leader: Varughese Matthew - NXP Semiconductors

PDC16: Ageing of Polymers and the Influence on Microelectronic Package Reliability
Course Leaders: Tanja Braun and Ole Hölck - Fraunhofer IZM

PDC17: Package Failure Mechanisms, Reliability, and Solutions
Course Leader: Darvin Edwards - Edwards Enterprises

PDC18: Design and Optimization of Heat Sinks
Course Leaders: Marc Hodes - Tufts University; Georgios Karamanis - Transport Phenomena Technologies, LLC
HETEROGENEOUS INTEGRATION ROADMAP (HIR)

HIR ALL DAY WORKSHOP

TUESDAY, MAY 29, 8:00 AM – 5:00 PM, MARINA TOWER, EXECUTIVE CENTER 1&4

Coordinators: Bill Chen (ASE); Bill Bottoms (Fluence Analytics, Inc.)

All ITherm attendees are invited to attend the Heterogeneous Integration Roadmap (HIR) all-day workshop. This workshop is an important working session for our profession and for our industry, and attendance is complimentary and open to all ITherm and ECTC attendees. Heterogeneous Integration refers to the integration of separately manufactured components into a higher level assembly (SiP) that, in the aggregate, provides enhanced functionality and improved operating characteristics. In this definition components should be taken to mean any unit whether individual die, MEMS device, passive component and assembled package or sub-system that are integrated into a single package. The operating characteristics should also be taken in its broadest meaning including characteristics such as system level performance and cost of ownership.

Our Industry has reinvented itself through multiple disruptive changes in technologies, products and markets. With migration of logic, memory and applications to the Cloud, AI at the Edge, the Internet of Things (IoT) to internet of everything (IOE), smart devices everywhere, and autonomous automotive; the pace of innovation is increasing to meet these challenges. The mission of this Heterogeneous Integration Roadmap is to provide guidance to the profession, industry, academia and government to identify key technical challenges with sufficient lead time that they do not become roadblocks preventing the continued progress in electronics. That progress is essential to the future growth of the industry and the realization of the promise of continued positive impact on mankind. The approach is to identify the requirements for heterogeneous integration in the electronics industry through 2031, determine the difficult challenges that must be overcome to meet these requirements and, where possible, identify potential solutions. The Heterogeneous Integration Technology Roadmap is sponsored by the IEEE EPS Society, IEEE Electron Devices Society (EDS), and IEEE Photonics Society, together with SEMI and ASME EPPD.

For more information, please visit: https://eps.ieee.org/technology/heterogeneous-integration-roadmap.html
ECTC/ITHERM YOUNG PROFESSIONALS PANEL

CAREER DEVELOPMENT FOR YOUNG PROFESSIONALS

TUESDAY, MAY 29, 7:00 – 7:45 PM, MARINA TOWER, HARBOR ISLAND 3

Chair: Yan Liu (Medtronic)

The Executive Committees of ECTC and IThERM cordially invite all young professionals (including current graduate students) to attend this Young Professionals networking event jointly organized by IThERM and ECTC and sponsored by EPS. The two panelists will talk about career development for young professionals based on their experiences and achievements in the industry and academia. A reception for panelists and attendees will follow.

Panelists: Steve Bezuk (Qualcomm); Kathleen Kramer (University of San Diego)

Yan Liu  Steve Bezuk  Kathleen Kramer

RICHARD CHU IThERM AWARD FOR EXCELLENCE

THE HEAT CONDUCTION RENAISSANCE

AWARD LUNCHEON AND TALK, WEDNESDAY, MAY 30, 12:00 PM – 1:30 PM, FAIRBANKS

Presented by 2018 Awardee Dr. Kenneth E. Goodson (Stanford University)

Abstract: Some of the most exciting recent advancements in heat conduction physics have been motivated, enabled, or achieved by the thermal management community that IThERM serves so effectively. In this talk we highlight the resulting renaissance in basic heat conduction research, which is linked to cooling challenges from power transistors to portables. Examples include phonon transport and scattering in nanotransistors, engineered high-conductivity composites, modulated conductivity through phase transitions, as well as the surprising transport properties of low-dimensional (1D and 2D) nanomaterials. This work benefits strongly from decades of collaboration and leadership from the semiconductor industry.

Dr. Kenneth E. Goodson chairs the Mechanical Engineering Department, and holds the Davies Family Provostial Professorship and a courtesy appointment in Materials Science at Stanford University. His lab has graduated 40 PhDs, nearly half of whom are professors at schools including MIT, Stanford, and UC Berkeley. Honors include the Kraus Medal, the Heat Transfer Memorial Award, the AIChE Kern Award, the SRC Technical Excellence Award, the InterPACK Achievement Award, and Fellow grade with ASME, IEEE, APS, and AAAS. Goodson co-founded Cooligy, which built computer heat sinks and was acquired by Emerson in 2006. At Stanford, serving as Mechanical Engineering Chair and Vice Chair since 2008, Goodson led two strategic plans and launched hiring of 15 faculty members who are transforming the department’s scholarship and diversity.
**K-1: FPGAS: THE ACCELERATOR OF CHOICE FROM THE EDGE TO THE CLOUD**

**Presenter:** Ravi Kuppuswamy (Intel)  
**Wednesday, May 30, 9:00-10:00 AM, Bel Aire**

**Abstract:** The computing landscape is dynamically evolving and changing on a real-time basis. With the surge of mobile devices, network infrastructure requirements, edge and data center applications, the need to manage our data-centric connected world is exploding. FPGAs play a critical role in managing and accelerating hardware and software workloads across platforms, efficiently meeting the needs of customers to deliver rapid innovation in their markets. In particular, we’re just now scratching the surface of what’s possible with Artificial Intelligence (AI). From self-driving cars to precision medicine to military defense, AI is poised to impact every industry and facet of life. It has the potential to dramatically improve - and even save - lives for people in every part of the world. But before we can harness AI for the greater good of humanity, we’ll need to turn theory into practice, bring machine learning models out of training, and put them to the test. In short, we need to understand how to make AI work in the field. This Conference keynote will cover how FPGAs help in deploying AI and accelerating the new ecosystem needed to support these applications.

**Ravishankar (Ravi) Kuppuswamy** is vice president and general manager of the Engineering in the Programmable Solutions Group at Intel. He is responsible for product engineering, organizational development, business-enabling operations, and innovation initiatives inside the FPGA business. Kuppuswamy served previously as vice president in the Intel Platform Engineering Group and director of Many Integrated Core and Intel® Xeon® processor product development. He first joined Intel in 1996 as an analog design engineer, and subsequently held various technical and management positions spanning five generations of Intel lead process technology microprocessors. In 2006, he relocated to Bangalore, India, to lead execution on the 6-core Intel Xeon processor for servers, formerly code-named “Dunnington.” In 2008, India’s National Association of Software and Services Companies bestowed its Innovation of the Year Award on the Dunnington program. From 2008 to 2010, Kuppuswamy served as design manager for the 10-core Intel Xeon processor for servers, formerly code-named “Eagleton.” Before assuming his current role in 2014 and relocating to Oregon, he spent 3 years in the Intel Architecture Group as director of microprocessor and graphics product development in India. A frequent speaker and industry contributor in very-large-scale integrated circuit development, Kuppuswamy has two patents and several published papers in the field. He earned his bachelor’s degree in electrical engineering and master’s degree in chemistry, both from Birla Institute of Technology and Science in Pilani, India. He also holds a master’s degree in electrical engineering from Arizona State University.
K-2: TRANSITIONING DIRECTED ENERGY WEAPONS FROM THE LABORATORY TO THE TACTICAL EDGE: THE THERMAL INTERFACE

Presenter: Sean Ross (Air Force Research Laboratory)
Thursday, May 31, 9:00-10:00 AM, Bel Aire

Abstract: Healthy systems engineering begins with an examination of the impact of the operating requirements on the components and interfaces of the proposed system. Thermal management leads the list of challenges to the integration of high energy laser systems on weight and volume constrained platforms, especially smaller aircraft. This presentation will introduce the generic architectures of High Energy Lasers and High Power Microwaves and cover the major issues and trades involved and summarize some current efforts to mature the Directed Energy system - thermal management interface.

Dr. Sean Ross has worked at the Air Force Research Laboratory, Directed Energy Directorate, since 1994. Currently, he is the directed energy deputy at the office of the Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering. Dr. Ross is a board member of the Directed Energy Professional Society. He is the author of “Laser Beam Quality Metrics” textbook and frequently teaches courses on the subject. Dr. Ross led the creation of the Environmental Laser Test Facility to test high-energy laser systems and components in simulated flight environments prior to flight testing. He has been involved in power, thermal, structural and other high-energy laser integration issues for over a decade. Dr. Ross holds a BS and MS in Physics from Brigham Young University, and a PhD in Optical Science and Engineering from the Center for Research and Education in Optics and Lasers (CREOL), College of Optics and Photonics, University of Central Florida.

K-3: DETECTOR THERMAL MANAGEMENT WITH CO2 BOILING SYSTEMS AT CERN

Presenter: Paolo Petagna (CERN)
Friday, June 1, 9:00-10:00 AM, Bel Aire

Abstract: For the thermal management of silicon detectors in the next generation of particle physics experiments, total powers well in excess of 100 kW with volumetric densities up to 100 W/dm³ must be removed from sealed volumes, where the detectors are organized in convoluted surfaces. In order to ensure their required operational life of 10 years, the silicon sensors, submitted to high radiation levels, must be maintained at temperatures well below 0 °C. Furthermore, the mass of the support structures and ancillary systems must be minimized, while large temperature gradients, both in time and space, should be avoided. The most demanding applications already implement boiling flows of CO₂ in small diameter evaporators: CO₂ presents extremely favorable thermo-physical properties, is radiation hard and environmentally friendly. The typical geometry of a silicon detector’s CO₂ evaporator is a few meters long pipe, 1.0 to 2.5 mm in I.D. However, after a recent successful application of silicon micro-structured cold plates in liquid phase, one experiment will implement for the first time in 2019 a cooling system based on CO₂ boiling in silicon micro-channels. The talk will review the achievements and the ongoing R&D at CERN on both the local evaporators and global system design.

Paolo Petagna received a Master’s degree cum laude in Aeronautical Engineering from the University of Pisa in 1989, obtaining a research grant with the Department of Aerospace Engineering (DIA) on wake flows, 3D turbulent mixing and coaxial jets. In 1991, he founded ARIA (Aerodynamics Research for Industrial Applications), an applied research spin-off of DIA. From 1991 to 1995, he worked as consultant on applied R&D problems for industrial partners including Ferrari, Brembo, and Piaggio, among others. In 1996 Paolo joined CERN (the European Organization for Nuclear Research), where he participated in the design and commissioning of the Central Tracker Detector of the CMS experiment. As a member of the CMS, NA62 and ALICE collaborations at CERN, he co-authored more than 50 papers. From 2009, Petagna has led the Detector Cooling Project of the CERN Physics Department, with major R&D areas including CO₂-based cooling systems, micro-channel cooling devices, and optical fibre sensors for relative humidity. He has co-authored more than 30 publications in these research areas.
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ECTC/ITHERM JOINT WOMEN’S PANEL

ENHANCING WOMEN’S PARTICIPATION IN ENGINEERING – A VIEW AROUND THE GLOBE

WEDNESDAY, MAY 30, 6:30 – 7:30 PM, MARINA TOWER, HARBOR ISLAND 3

Moderators: Cristina Amon (University of Toronto); Tanja Braun (Fraunhofer IZM)

The Executive Committees of ECTC and ITherm cordially invite all ITherm attendees to our fourth annual Women’s Panel and Reception jointly organized by ITherm and ECTC and sponsored by EPS. The four panelists will speak on their experiences and achievements in the microelectronics industry and provide insights into enhancing women’s participation in engineering around globe. A Q&A session and reception for panelists and attendees will follow.

Panelists: Kawthar (Kat) Kasim (Engineer, Boeing Research and Technology, USA); Jayathi Murthy (Dean of Engineering, UCLA, USA); Ming Li (R&D Director, Enabling Technologies at ASM Pacific Technology, Hong Kong)

Panelists’ Bios

Kawthar Kasim is a Thermal Design and Analysis Engineer at Boeing Research and Technology working on additive manufacturing of thermal management devices such as cold plates, heat exchangers, and heat pipes. She has been with the Boeing Company for 12 years and has worked in other positions at Boeing such as in the R&D Acoustics and Aerosciences Division and in the Flight and Controls Division of Boeing Satellites. She has a MS in Mechanical Engineering from Stanford University and BS in Applied Math from UC Berkeley.

Jayathi Murthy is the Ronald and Valerie Sugar Dean of the Henry Samueli School of Engineering and Applied Science at the University of California, Los Angeles. Previously she held the Ernest Cockrell Jr. Chair and served as Department Chair of Mechanical Engineering at The University of Texas at Austin. She also served as Director of the Center Prediction of Reliability, Integrity, and Survivability of Microsystems (PRISM) at Purdue from 2008-2014. She received her Ph.D degree from the University of Minnesota in the area of numerical heat transfer and has worked in both academia and in industry. She was an early employee of Fluent Inc., where she developed the widely-used unstructured solution-adaptive finite volume methods that underlie their flagship software Fluent, and the electronics cooling software package ICEPAK. More recently, her research has addressed sub-micron thermal transport, multiscale multiphysics simulations of MEMS and NEMS and uncertainty quantification in these systems. She is the recipient of several awards including the 2012 ASME EPPD Clock Award, and 2016 ASME Heat Transfer Memorial Award, for her contributions to the development of advanced computational techniques.

Ming Li was awarded BSc and MSc in Materials Science and Engineering by Shanghai Jiao Tong University, China, and earned her PhD in Materials Science from the University of London, UK. Before joining ASM in June 2004, Dr Li worked in the University of London (UK), the Institute of Materials Research and Engineering (Singapore), and Chinese University of Hong Kong (Hong Kong). Currently, working in ASM as a R&D Director for Enabling Technology, Dr. Li is heading the Process and Packaging Technology Development Team to improve current processes and explore advanced packaging technologies. Dr. Li has published near 100 papers in leading journals and technical conferences.
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TECHNOLOGY-TALK SESSIONS

TT-3: CRYOGENIC COOLING FOR QUANTUM COMPUTING AND EMBEDDED COOLING ENABLED ELECTRIC MOTORS (MAY 30, WED, 1:30 – 3:00 PM), BEL AIRE SOUTH

Session Chairs: Thomas Brunschwiler (IBM); Peter de Bock (GE Global Research)

COOLING FOR QUANTUM COMPUTERS, TECHNOLOGY AND CHALLENGES

Speaker: Matti S. Manninen (BlueFors Cryogenics Oy, Finland)

Abstract: In this talk I will briefly introduce dilution refrigeration, the only continuous cooling technology to reach temperatures below 0.01 Kelvin. Dilution refrigerators are used in a wide range of applications from astronomy (to cool down detectors in telescopes), to the length scales of an atom (graphene, nanotubes). Currently, the research on solid state quantum computing is one of the main applications that uses this cooling technology. I will discuss general challenges related to the low temperature and also future challenges with the number of qubits in quantum computing going up.

Dr. Matti S. Manninen received his Ph.D degree from Aalto University in Finland for his research on superfluid helium and helium crystals at ultra-low temperatures. After completing his degree he started working as an R&D scientist for BlueFors. BlueFors is a Finland-based company that specializes in ultra-low temperature refrigeration with a strong focus on the field of quantum computing, where BlueFors has established themselves as the main cryogenic supplier.

HIGHLY EFFICIENT, DRIVE AND ELECTRONICS-INTEGRATED EMBEDDED COOLING ENABLED ELECTRIC MOTORS

Speaker: Michael Ohadi (Advanced Research Projects Agency-Energy (ARPA-e), US DoE)

Abstract: Electric motors are ubiquitous. It is estimated they consume nearly half of the electricity produced in the United States and their importance is expected to grow with the continued adoption of more electrification and automation in various sectors, including ground and air transportation. While they exhibit superior efficiency compared to thermal engines, electric motors still generate a sizable amount of heat that needs to be managed to preserve the motor’s integrity. Until recently, air cooling was an adequate solution for constant speed motors. However, recent advances, including emerging variable speed motors require more robust thermal management solutions. In this presentation I will review the critical role of thermal management on electric motors’ performance improvement and increased power density and volumetric specific power. Furthermore, will briefly discuss recent advances in compact, high-temperature, power electronics and how they can pave the way for complete drive and electronics integration with the motor, thereby enabling further performance improvement and compactness of next generation electric motors.

Dr. Michael Ohadi is serving as a Program Director at U.S. department of energy (ARPA-E division) while on assigned professional leave from the University of Maryland, College Park, where he serves as a professor of mechanical engineering. He is a Fellow of ASME and ASHRAE and Past Conference General Chair of ITherm.
TECHNOLOGY-TALK SESSIONS (Continued)

**TT-5: HETEROGENEOUS INTEGRATION (MAY 31, THU, 8:00 – 9:00 AM), BEL AIRE**

Session Chairs: David Altman (Raytheon); Madhusudan Iyengar (Google)

**MATERIALS & MICROFLUIDICS – THERMAL STRATEGIES FOR HETEROGENEOUS INTEGRATION**

Speaker: Ken Goodson (Stanford)

**Abstract:** Thermal management is a limiting challenge for the most important electronic components of our day, from portables to power devices, and poses barriers to the heterogeneous integration. This talk highlights recent enabling research based on materials engineering, with applications including improved heat spreaders, microfluidic heat sinks, thermal switches, and capillary devices. Highlights include a benchmark diamond-copper heat sink using laser etching, template-fabricated inverse opals, and 3D manifolding, as well as thermal regulators and switches for temperature management in power electronics based on phase change. Developed together with partner semiconductor companies, recent advances feature back-side (2D) embedded silicon microchannel cooling with vertical manifolds as well as and narrow gap embedded cooling (with TSV/pin fin array) module for 3D-chip stack for energy-efficient computing.

Prof. Ken Goodson chairs the Mechanical Engineering Department at Stanford, where he holds the Davies Family Provostial Professorship and a courtesy appointment in Materials Science. He specializes in electronics cooling from nano conduction and packaging to heat sinks. His lab has graduated 40 PhDs, nearly half of whom are professors at schools including MIT, Stanford, and UC Berkeley. Honors include the Kraus Medal, the Heat Transfer Memorial Award, the AIChE Kern Award, and Fellow grade with ASME, IEEE, APS, and AAAS. Goodson received the PhD (1993) from MIT and co-founded Cooligy, which built microfluidic cooling systems for the Apple G5 and was acquired by Emerson in 2006. At Stanford, serving as Mechanical Engineering Chair and Vice Chair since 2008, Goodson led two strategic plans and launched the hiring of 15 new faculty who are transforming the department’s scholarship and diversity.

**THERMAL-MECHANICAL OPPORTUNITIES FOR HETEROGENEOUS INTEGRATION PACKAGING**

Speaker: Kamal Sikka (IBM)

**Abstract:** Heterogeneous Integration Packaging involves integration of chips and packages into a singular package. The chips and packages can from different technology nodes and from different vendors. In some ways, this creation of heterogeneous multi-chip packages (MCMs) harks back to the past where complex MCMS were used in high-end server systems. Starting with a history of the high-end server MCMS, the technical talk will focus on the challenges or opportunities associated with heterogeneous integration. These challenges include more-constrained thermal and mechanical applications, and new materials and metrology requirements. The talk will also describe how silicon-processing techniques are being increasingly used for package integration.

Dr. Kamal Sikka is a researcher at IBM’s Semiconductor Technology Research Center in Albany, NY where he is focused on researching novel heterogeneous integration packaging techniques. Prior to that, he managed the Package-level Systems development team in East Fishkill, NY. He has been involved in interconnect pitch reduction, silicon and glass interposers new laminate materials and thermal technology development. For the latter, projects have included introduction of new thermal interface and heat spreader materials, and techniques for interface gap reduction.
TECHNOLOGY-TALK SESSIONS (Continued)

TT-7: THERMAL MANAGEMENT IN AEROSPACE/AUTOMOTIVE (MAY 31, THU, 1:30 – 3:00 PM), BEL AIRE SOUTH

Session Chair: David Altman (Raytheon)

MORE ELECTRIC AIRCRAFT THERMAL CHALLENGES

Speaker: Ram Ranjan (UTRC)

Abstract: More electrification of aircrafts demands higher power density in electrical machines and power converters. The electric drive train or electric energy & power storage, conversion and distribution (ESC&D) system of a hybrid electric or more electric (HE/ME) aircraft, even at high efficiency, will reject significant heat at relatively low temperature. Thus, effective thermal management of the ESC&D system is critical to realizing the potential benefits of a HE/ME aircraft as the thermal management system (TMS) can add excessive weight (heat exchangers and pumps) and impose excessive parasitic power consumption (pumps and fans) and drag (engine fan stream air and ram air) on the aircraft. This talk will discuss the challenges and approaches for cooling the electric drive train, including motor drives, motors, and batteries of a ME/HE aircraft. Particular focus will be spent on advanced thermal architectures for power converters which can improve their power density by 5X over SOA.

Dr. Ram Ranjan is a Principal Engineer and Project Leader in the UTC Aerospace Systems program office at UTRC. Over the past several years, he has been leading the development of advanced component design methods and power electronics thermal management technologies for UTC businesses. He received a Ph.D. in Mechanical Engineering from Purdue University in 2011 and his BS/MS degrees in Mechanical Engineering from the Indian Institute of Technology Kanpur in 2007. Dr. Ranjan has published his research findings in more than 25 peer-reviewed journal and conference articles, and holds several patents in the area of thermal management technologies.

THERMAL DESIGN OPTIMIZATION IN ELECTRONIC SYSTEMS

Speaker: Ercan Dede (Toyota)

Abstract: Higher power with increased efficiency in a smaller space is a predominant theme for future vehicle electronic systems. To enable greater integration and electronics power density plus high temperature operation, design optimization is a critical tool in maximizing functionality within a given volume. In this technology talk, these challenges and opportunities are briefly outlined. Then, structural topology optimization for thermal design in electronics is explained including applications to planar circuit board heat spreader layout, three-dimensional (3-D) heat flow structure synthesis, and 3-D air-cooled heat sink design. Extension of the method to additional single-physics (e.g., fluid flow) and multi-physics (e.g., electro-thermal) design problems is further covered. Finally, a concise survey of recent major advancements available in the state-of-the-art literature for thermal design optimization in electronic systems is provided to motivate future research efforts in this field.

Dr. Ercan M. Dede received his B.S. degree and Ph.D. in mechanical engineering from the University of Michigan and an M.S. degree in mechanical engineering from Stanford University. Currently, he is a Senior Research Manager in the Electronics Research Department at the Toyota Research Institute of North America. His group focuses on vehicle systems involving power semiconductors, advanced circuits, packaging, and thermal
TECHNOLOGY-TALK SESSIONS  (Continued)

management technology. He has over 50 issued patents and has published more than 50 articles in archival journals and conference proceedings on topics related to design and structural optimization of thermal, mechanical, and electromagnetic systems. He is an author of a book entitled, *Multiphysics Simulation: Electromechanical System Applications and Optimization*. His team has received two R&D 100 Awards for the development of technologies related to next-generation power electronics for electrified vehicles.

### THERMAL CHALLENGES FOR FUTURE MILITARY PLATFORMS

**Speaker: Mark Spector (ONR)**

![Mark Spector](image)

**Dr. Mark S. Spector** is a Program Officer in the Ship Systems and Engineering Research Division at the Office of Naval Research where he manages programs in thermal science, metamaterials, and energy conversion. In addition, he sits on the Steering Committee of the Department of Defense Energy and Power Community of Interest, the Interagency Advanced Power Group, and the NATO Applied Vehicle Technology Power and Propulsion Systems Technical Committee. Previously, he worked as a Research Physicist in the Center for Bio/Molecular Science and Engineering at the Naval Research Laboratory. He received his Ph.D. in Physics from the Massachusetts Institute of Technology and his A.B. in Physics and Applied Mathematics from University of California at Berkeley. Dr. Spector has coauthored 52 journal publications, 3 invited book chapters, and holds 4 patents.

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TT-9: ADDITIVE MANUFACTURING/THERMAL TOPOLOGY OPTIMIZATION (JUNE 1, FRI, 8:00 – 9:00 AM), BEL AIRE

Session Chair: William D. Gerstler (GE Global Research)

MULTI-PHYSICS TOPOLOGY OPTIMIZATION AND ADDITIVE MANUFACTURING

Speaker: Xiaoping Qian (University of Wisconsin-Madison)

Abstract: Topology optimization and additive manufacturing have the potential to fundamentally transform our thermal management systems, due to their capabilities in designing and fabricating structures of complex shapes and topologies. I show how to conduct multi-physics topology optimization, including optimization of thermoelastic and thermofluid systems. I will also describe how to account for additive manufacturing constraints during topology optimization. Examples on controlling the undercut and the overhang angle in realizing self-supporting structures will be demonstrated.

Prof. Xiaoping Qian is a full professor in the Department of Mechanical Engineering at the University of Wisconsin-Madison. His research interests focus on computational design of multi-physics systems, topology optimization, shape optimization, digital design and manufacturing. He has served as an associate editor for several ASME journals. He is an ASME fellow.

TOPOLOGY OPTIMIZATION OF FLUID-BASED AND CONJUGATE HEAT TRANSFER PROBLEMS

Speaker: Joe Alexandersen (Technical University of Denmark (DTU))

Abstract: Increased power density and performance of electronic components increases the need for efficient cooling. This spans computers, consumer electronics, tele-communication devices, and lighting. Topology optimization provides the ultimate design freedom and provides insight into optimal design of heat sinks and other thermal and uid-based applications. The presentation covers topology optimization of fluid-based and conjugate heat transfer problems. It will focus on applications and work on large-scale high-performance computations, but also the need for interactivity and user-friendly dissemination to industry. Combining the thoughts behind our apps with conjugate heat transfer is the ultimate dream. Thus, simplified models and efficient computational methods are thus important.

Dr. Joe Alexandersen is a Postdoctoral Researcher at the Technical University of Denmark (DTU). He has been part of Professor Old Sigmund's TopOpt-group for 8 years. He completed his Ph.D. degree in 2016, and researches topology optimization of thermal energy systems, with special focus on natural convection and passive cooling. He performs research within method development and high-performance computing, as well as applies the developed methodologies to practical problems. He received the 2015 ISSMO-Springer Prize for Young Scientists as well as a 2017 DTU Young Researcher Award.
ADDITIVE MANUFACTURED THERMAL MANAGEMENT PRODUCTS AND FEATURES: EXPERIENCES AND FUTURE CHALLENGES

Speaker: Jared Wolfe (GE Additive)

Abstract: Additive manufacturing is a game changer for thermal management products, unlocking design freedoms that enable improved performance, reliability, and speed to market. The presentation will cover trends for thermal management applications in aerospace, such as performance compared to conventionally manufactured products, considerations for using additive effectively, and limitations with today’s technology.

Jared Wolfe joined GE in 2005 with a Bachelor’s Degree in Mechanical Engineering from the University of Kentucky. Since joining GE, Jared has fulfilled roles of increasing responsibilities in the design and qualification of aircraft engine components. He has worked in the additive technology field by designing additive components since 2012. In his current role, Jared is an Engineering Leader with GE Additive focused on accelerating the adoption of additive, specifically in the area of thermal management where he leads a team of designers including mechanical, aero, and thermal design engineers.
TECHNOLOGY-TALK SESSIONS (Continued)

**TT-11: NEXT GENERATION CHALLENGES IN NUMERICAL MODELING: SPECIAL TECH-TALKS IN HONOR OF PROF. JAYATHI MURTHY (JUNE 1, FRI, 1:30 – 3:00 PM), BEL AIRE SOUTH**

Session Chairs: Cristina Amon (University of Toronto); Tim Fisher (UCLA)

**VALIDATION OF DIRECT NUMERICAL SIMULATIONS OF TWO-PHASE SLUG FLOW BOILING**

Speaker: Suresh Garimella (Purdue)

Abstract: The insertion of embedded two-phase microchannel cooling technologies requires the development of multiphase numerical simulations that account for complex vapor-liquid interfacial transport phenomena, which can improve the understanding of key transport mechanisms as well as accurately predict heat sink performance. Further, there is a clear need for high-fidelity benchmark experimental data that can be used as a common basis for validation of flow boiling models. Our numerically-stabilized saturated-interface-volume phase change model is implemented to predict phase change at the interface in order to simulate two-phase flow heat transfer in microchannels at low computational cost. A test facility is developed that has the unique ability to generate microchannel slug flow in a precisely controlled manner that is free from flow instabilities, which enables direct comparison to numerical flow boiling models. An approach for direct comparison of the benchmark experimental data to numerical flow boiling simulations is demonstrated.

Prof. Suresh V. Garimella is Purdue University’s Executive Vice President for Research and Partnerships, and the Goodson Distinguished Professor of Mechanical Engineering. He is also Director of the NSF Cooling Technologies Research Center. The co-author of over 525 widely cited archival publications and 13 patents, Garimella is an expert in micro- and nano-scale transport phenomena, thermal management and energy efficiency in electronics systems, and renewable and sustainable energy systems technology and policy. He is Fellow of the NAI, AAAS, and ASME. He received the 2016 ITherm Achievement Award.

**NEXT GENERATION ATOMIC MODELING OF THERMAL TRANSPORT**

Speaker: Alan McGaughey (CMU)

Abstract: Accurate device-level thermal models require specification of the thermal conductivities of the constituent materials and the thermal conductances of the interfaces between them. The use of first principles density functional theory calculations and the advent of new theoretical formulations based in lattice dynamics calculations and the Boltzmann transport equation have revolutionized thermal conductivity prediction. These calculations provide key insights into the how thermal conductivity is controlled by crystal structure, defects, nanostructuring, and boundaries. Progress on predicting interface thermal conductance, however, has been much slower. As feature sizes push well below 100 nm, interfaces may dominate thermal resistance and accurate predictions are central to designing effective thermal management strategies. I will discuss the challenges associated with building realistic interface structures, the limitations of available theories and computational techniques, and the advances that need to be made.

Prof. Alan McGaughey is a Professor of Mechanical Engineering at Carnegie Mellon University with a courtesy appointment in Materials Science & Engineering. He holds B.Eng., M.A.Sc. and Ph.D. degrees in mechanical engineering from McMaster University, the University of Toronto, and the University of Michigan. He won the Air Force Office of Scientific Research Young Investigator Program award, was a Harrington Faculty Fellow at the University of Texas at Austin, and won the Teare Teaching Award at CMU. He was voted "Professor of the Year" by the CMU mechanical engineering senior class in 2012, 2015, and 2017.
MacroFlow™
A Software Tool for Rapid Thermal Design of Electronics Cooling Systems

MacroFlow utilizes the Flow Network Modeling (FNM) technique for enabling rapid and accurate analysis of air and liquid-cooling systems for electronics.

Capabilities
- Intuitive Graphical User Interface
- Extensive Component Library with Built-In Correlations, Vendor Databases, and User-Specifiable Flow and Thermal Characteristics
- Efficient Treatment of Unique Aspects of Both Air and Liquid-Cooling Systems
- Rapid and Robust Solution
- Display of System Behavior in Terms Directly Relevant for Engineering Design

Benefits
- Quick Exploration of Design Options
- Investigation of "What-if" Scenarios
- Identification of Performance-Limiting Components
- Complementary Use with Computational Fluid Dynamics (CFD) Analysis
- Shortened Design Cycle

Applications
- Avionics and Defense Electronics
- Air and Liquid-Cooled Servers
- Data Center Liquid Cooling
- Storage and Automatic Test Equipment
- Industrial Drives

Visit us at our exhibit for an in-depth discussion about MacroFlow. We will provide an overview of the capabilities of MacroFlow, discuss details of cooling systems of your interest, and illustrate the use of MacroFlow for their design and optimization.
PANEL SESSIONS

P-2: MICRO-TWO-PHASE LIQUID COOLING SYSTEMS FOR ELECTRONICS (MAY 30, WED, 10:30 AM – 12:00 PM), BEL AIRE SOUTH

Moderator: John R. Thome (Ecole Polytechnique Federale de Lausanne)

MICRO-TWO-PHASE LIQUID COOLING SYSTEMS FOR ELECTRONICS

Abstract: Two-phase cooling continues to gain traction in the cooling of electronics (IGBT’s, CPU’s, LED’s, optical lasers, etc.). The panel will address technical developments, special issues and concerns on two-phase cooling systems. The panel will also cover some case studies on existing and pending applications and an overview of methods and simulators for designing of two-phase cold plates and their cooling systems (thermosyphon and pump-driven systems). The panel will furthermore address the pros/cons when choosing the best working fluid for applications.

Panelists: Scott Holland (Wolverine Microcool) Paolo Petagna (CERN) Samuel Yana Motta (Honeywell)

Devdatta Kulkarni (Intel) Todd Salamon (Nokia Bell Labs) Ahmed Zaghlol (Mersen)

P-4: THERMO-FLUIDIC CHALLENGES IN HEALTHCARE (MAY 30, WED, 3:30 – 5:00 PM), BEL AIRE SOUTH

Moderators: Peter de Bock (GE Global Research); Ali Khounsary (Illinois Institute of Technology)

THERMO-FLUIDIC CHALLENGES IN HEALTHCARE

Abstract: Thermofluidics are an integral part of most biological systems and are present in a significant number of the systems and devices used in medicine. For example, the PCR (Polymerase Chain Reaction) technique used to reproduce millions of DNA copies from one or a few samples is principally a thermal process (Nobel Prize in chemistry 1973) while the dialysis system (artificial kidney) is essentially a fluidic system. This panel session focuses on several thermal and fluidic challenges in the development of novel medical devices and techniques, presents the current status, and provides an opportunity for the panelists and the audience to brainstorm about possible solutions.

Panelists: Guillermo Aguilar (U of California, Riverside) Sung Jin Kim (KAIST) Bruce Guenin (Consultant) Y. C. Lee (University of Colorado)
PANEL SESSIONS (Continued)

P-6: THERMAL MANAGEMENT OF MOBILE/IOT DEVICES (MAY 31, THU, 10:30 AM – 12:00 PM), BEL AIRE SOUTH

Moderator: Victor Chiriac (Qualcomm)

THERMAL MANAGEMENT OF MOBILE/IOT DEVICES

Abstract: In the last few years there has been a significant growth in computing platforms ranging from handhelds to IoT devices and everything in between. In the mobile/portable space, the device skin is equally challenging to cool. In handheld devices, passive dissipation is the most preferred, and sometimes the only possible cooling solution available. A different thermal landscape is now opening with the IoT devices and other adjacent high power areas. A panel of experts will discuss these aspects and will share their vision on the future of small to large electronics thermal management and other advanced system level cooling solutions.

Panelists: Rick Beyerle (NeoGraf Solutions)  Ken Goodson (Stanford University)
Yogendra Joshi (Georgia Tech)  Mark Hartman (Outlast Technologies)
Ioan Sauciuc (Intel)  John Thome (EPFL)

P-8: EMERGING TRENDS IN ENERGY MANAGEMENT AND THERMAL PACKAGING OF DATA CENTERS (MAY 31, THU, 3:30 – 5:00 PM), BEL AIRE SOUTH

Moderator: Yogendra Joshi (Georgia Institute of Technology)

EMERGING TRENDS IN ENERGY MANAGEMENT AND THERMAL PACKAGING OF DATA CENTERS

Abstract: This panel will explore multi-scale challenges in data centers being driven simultaneously by the rapid expected growth of internet of things (IOT), and computing hardware trends such as heterogeneous integration. Approaches for computing load balance, and improvement of energy efficiency, under realistic data center operational scenarios will be explored. The panel will also discuss recent advances in heterogeneous integration. Advances in thermal management technologies to enable future computing hardware will be presented.

Panelists: Muhammed Bakir (Georgia Tech)  Ali Merrikh (Qualcomm)
Saeed Moghaddam (University of Florida)  Hiroaki Nishi (Keio University)
Herman Oprins (IMEC)
PANEL SESSIONS (Continued)

P-10: THERMAL MANAGEMENT IN ELECTRONICS: MATERIALS, DEVICES, AND DATA CENTERS: SPECIAL PANEL IN HONOR OF PROF. JAYATHI MURTHY (JUNE 1, FRI, 10:30 AM – 12:00 PM), BEL AIRE SOUTH

Moderator: Dhruv Singh (GlobalFoundries)

THERMAL MANAGEMENT IN ELECTRONICS: MATERIALS, DEVICES, AND DATA CENTERS: SPECIAL PANEL IN HONOR OF PROF. JAYATHI MURTHY

Abstract: This special panel is a part of Prof. Jayathi Y. Murthy’s 60th birthday celebration at ITherm 2018, commemorating her numerous contributions and fundamental developments to heat transfer and thermal management. Over the past decades, research progress from her team has touched every facet of electronics thermal management – from fundamental physics of energy transport in materials, electron-phonon transport in ultrascaled devices to electronics cooling solutions spanning myriad applications. In tandem, the advances led by her in the development of large scale numerical methods have brought software tools to the forefront of industry enabling the necessary cross-disciplinary solutions. The panel puts forth a discussion of these challenges in the domain of electronics thermal management from transistors to data centers, their implications and a hierarchical view of scientific and engineering solutions needed to achieve them.

Panelists: Vaibhav Bahadur (University of Texas) Satish Kumar (Georgia Tech) Sreekant Narumanchi (NREL) Madhusudan Iyengar (Google) Amy Marconnet (Purdue University) Metin Ozen (Ozen Engineering)
Smart and Small Thermal Systems Laboratory (S2TS)

PI: Prof. Michael M. Ohadi; University of Maryland
ohadi@umd.edu

S2TS Laboratory at the University of Maryland, College Park, utilize innovative design/optimization, materials, and manufacturing techniques to introduce the next generation thermal management systems. S2TS R&D areas of focus:

- Advanced heat exchangers
- Electronics cooling
- Micro/Nano systems for process intensification/optimization

If you can imagine it we can deliver it!

Contact Prof. Michael M. Ohadi: ohadi@umd.edu
Dr. Farah Singer: fsinger@umd.edu

**Additively Manufactured Record High Thermal Conductivity Polymer Composite Heat Exchanger for Dry Cooling Applications**

OBJECTIVE: Develop a novel composite polymer based air-cooled heat exchanger using Novel additive manufacturing machine, for indirect cooling in power plants, HVAC systems, electronics cooling, and waste heat recovery. Cu-Abs & Al-Abs heat exchangers are fabricated with performance exceeding that of conventional heat exchangers by multiple orders of magnitude. A significant reduction in mass and weight is achieved.

**Additively Manufactured High Temperature Manifold-Microchannel Heat Exchangers for Aerospace Applications**

OBJECTIVE: Develop next-generation pre-cooler heat exchangers for aircraft and dry cooling applications using additive manufacturing. An innovative high temperature gas-to-gas cross flow heat exchanger of operating temperatures 600°C to 1000°C using was designed and developed using additive manufacturing for Waste heat recovery, Power generation, and Pre-cooler HX.

- Successfully designed, fabricated, and tested Manifold Microchannel HX with thermal resistance reduced by 50% compared to conventional HXs.

**A Rotary Absorber For Enhanced Heat/Mass Transfer in Absorption Systems**

OBJECTIVE: Develop an absorption cooling system using refrigerant (water) in liquid state in a novel rotary absorber. COP potentially triples with condenser eliminated.

- Spinning disc absorber has been fabricated; overall heat transfer efficient at 400 rpm surpasses average performance of conventional tube absorbers by 100%.

- Power consumption at 400 rpm is 1% of expected heat removal rate in absorption process.

**Embedded Cooling of High Flux Electronics via Micro-Enabled Surfaces**

OBJECTIVE: Develop a two-phase, embedded manifold-microchannel cooler for cooling of high-flux electronics. Microchannels are embedded directly onto the back of an electronic chip to eliminate thermal resistance and a specially designed manifold-microchannel named FEEDS (Film-Evaporation and Enhanced fluid Delivery System) is used to improve the cooling capacity even further.

- A heat flux of 1 kW/m² was achieved at 90% vapor quality and a COP of ~1000.

**Packaging and Thermal Decoupling of Optical Array using TECs**

OBJECTIVE: Use thermoelectric coolers (TECs) to thermally-decouple and cool an optical array (85°C) from an electronic die (105°C).

- Applications: Overcool electronic die (T< 85°C) and active cooling using TEC (T< 85°C).

- Device- and System-Level Models were developed and novel solutions to thermal short-circuiting were identified. The COP requirement was exceeded and necessary interfacial resistance was achieved using TIM.
The Student Poster and Networking Session is a forum for students to present their research and interact with other conference attendees from industry and academia. In addition, interested students will have their resume available to get connected to potential employers from industry. The event features a poster contest where the outstanding posters will be recognized by the conference. Evaluation of the posters is conducted in two rounds. The first round was conducted in advance of the conference and involves evaluation of the posters in electronic format. In the second round, on-site evaluations are performed of the student presentations during the poster session event. The posters are judged based on technical merit, clarity and self-sufficiency of the content, originality of the work, visual presentation and impact of the poster display, and oral presentation at the poster session. A combination of the scores received in both rounds is used to determine the winners. In addition, travel grants for the student poster presenters have been provided by the conference sponsors in the form of several nights of hotel accommodations at the conference hotel. All conference attendees are invited to attend the session and get involved in discussion with the next generation of thermal, reliability, and electronic packaging experts!

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<td>P180</td>
<td>A System-Level Thermal Simulator with Automatic Meshing Techniques</td>
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<tr>
<td>61</td>
<td>Jing Wu</td>
<td>Auburn University</td>
<td>P352</td>
<td>Investigation and Comparison of Aging Induced Microstructural Evolution of Doped SAC+X Solders</td>
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<td>62</td>
<td>Vikas Yadav</td>
<td>Auburn University</td>
<td>P329</td>
<td>Reliability of SAC leadfree solders in automotive underhood temperature-vibration</td>
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<td>63</td>
<td>Luke Yates</td>
<td>Georgia Institute of Technology</td>
<td>P311</td>
<td>Electrical and Thermal Analysis of Vertical GaN-on-GaN P-N Diodes</td>
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<td>64</td>
<td>Ziqi Yu</td>
<td>University of California, Irvine</td>
<td>P206</td>
<td>Temperature-dependent Thermoelectric Properties of Electrodeposited Antimony Telluride Films</td>
</tr>
<tr>
<td>65</td>
<td>Shi Zeng</td>
<td>National University of Singapore</td>
<td>P111</td>
<td>A header design method for target flow distribution among parallel channels based on topology optimization</td>
</tr>
</tbody>
</table>
Power Electronics Integrated Thermal Packaging Reliability Research

Glass Interposer Thermal Isolation Research: Low-k glass interposers equipped with copper thermal vias are being developed as part of a 2.5D packaging approach to inhibit lateral spreading of heat between devices, facilitating heterogeneous integration.

Erosion/Corrosion and Clogging/Fouling: Micro-channel coolers are susceptible to erosion/corrosion and clogging/fouling that change the shape, size, roughness, and thus heat transfer of channels. Research and test capabilities to address these failure mechanisms are present at the university, including a slurry erosion test apparatus that exposes metal, ceramic, and semiconductor channels to slurries of abrasive particles from 0.1 to 10 µm in size at speeds of 5-60 m/s.

Thermo-mechanical and Vibration Testing: University of Maryland/CALCE has a full suite of environmental testing equipment to provide thermal cycling, power cycling, temperature aging, temperature-humidity-bias, thermal cycling with vibration, shock, 1D and 6D electrodynamic vibration and altitude cycling with electrical and thermal characterization using the T3ster and Keysight 1505A curve tracer.

Prognostics and Health Management: CALCE has unique capabilities for assessing the health status of power electronics and determining remaining unit life by fusing fundamental failure physics with data analytics.

Structural Incorporation: Reliability of various attachment methods and additive manufacturing techniques for incorporating thermal management devices into 3D power packaging are being investigated.

For further information, contact: Dr. Patrick McCluskey (mcclupa@umd.edu)
ART-IN-SCIENCE EXHIBITION

MAY 30 THROUGH JUNE 1, CATALINA

The second annual Art-in-Science exhibition provides a fun opportunity for the ITherm community to showcase the artistic side of their work. Authors share their joy and excitement through images and artwork produced during the course of scientific explorations and technical implementations, displaying heat and mass transfer, as well as thermo-mechanical phenomena. Entries will be judged on several criteria such as originality and creativity, aesthetics, visual impact and relevance. Conference attendees will be able to vote for their favorite artwork using the conference mobile App. Winners will be announced during the awards luncheon on Friday.

ITherm 2017 Art-in-Science Winners

Katherine Copenhaver, GTRI

Johannes Jörg, Aachen University

Crystallites in devitrified sodium borosilicate and annealed pyrolytic graphite glass composite

“Birth of Vortices” in the wall shear layer of an originally undisturbed submerged laminar impinging jet

Art-in-Science Entries from ITherm 2017
PAPER REVIEWERS

Aaron Wemhoff
Aashutosh Mistry
Abdy Fazeli
Abhijit Dasgupta
A. Sirimamilla
Abhra Chatterjee
A. Tamraparni
Ajay Vadakkepatt
Ajit Vallabhaneni
Akhilesh Rallabandi
Alberto Bassanese
Alex Massicotte
Ali Akbar Merrikh
Ali Ebrahimi
Ali Kalantarian
Ali Moradi
Alicja Palczynska
Alison Hoe
Allison Mahvi
Alperen Gunay
Amir Shooshtari
Amy Xia
An Zou
Andrew Poynot
Anil Yuksel
Ankit Verma
Ankur Jain
Anurag Goyal
Arash N. Lahouti
Arjang Shahriari
A. Sengupta
Arnab Roy
Arpit Dwivedi
A. Krishnamoorthy
Arunima Panigrahi
Ashish Sinha
Ashwin Vutha
Atul Bhargav
Aydin Nabovati
Babak Fakhim
Banafsheh Barabadi
Be-Nazar Khan
Beenoit Foisy
Benoit Chan
Bernhard Wunderle
Betty Yeung
Bharat Penmecha
B. Ramakrishnan
Bingxiao Zhao
Bladimir Alvarado
Bohan Yan

Brian Foley
C. Gonzalez Valle
Chao Yuan
Charandeeprk Singh
Charles Reynolds
Chingchi Chen
Chris Healey
Dajjiao Wang
Damena Agonafer
Daniel Moser
Daniel B. Brown
David Danovitch
David Deisenroth
Dustin Demetriou
E. Del Los Heros
Edvin Cetegen
Emad Al-Momanii
Emil Rahim
Emmy Cousinsau
Eric Heller
Erich Ewy
Evan Fleming
Frank He
Frank Robinson
Ganesh Subbarayan
Gary Mandrusiak
Genevieve Martin
Georges Pavlidis
Guoping Xu
Hadi Ghasemi
Hao Wang
Hadi Karlman
Huayan Wang
Hung-Yun Lin
Husam Alissa
Jack Lombardi
Jacob Vehonsky
Jae-Ho Lee
James Pomeroy
James Petroski
Javier Avalos Garcia
Jayati Athavale
Jeffrey Zitz
Jeroen Zaal

Ji Zhang
Jiajun Xu
Jiamin Ni
 Jihoon Jeong
Jin Yang
Joe Ross
John Tencer
Jon Summers
Jonathan Felts
Joshua Gess
Kalyan Dornala
Kamal Sikka
Karthik Remella
Kaushik Mysore
Ke Chen
Kerry Maize
Kevin Drummond
Khosrow Ebrahimi
Kimia Montazeri
K. Ramachandran
Koustav Sinha
Krishna Tunga
Krishna Valavala
Kritika Upreti
Kuan-Lin Lee
Kysong Choo
Lakshmi Maganti
Lee Jones
Leila Choobineh
Luis Paniagua
Luis Silva-Llanca
Luisa C. Maynez
Maan Kokash
Mahsa Ebrahimi
Mandar Kulkarni
M. C. Rajagopal
Marc Hodes
Marcelo Delvalle
Marin Janicki
M-C. Paquet
Mark Schultz
Mark North
Martinus Arie
Max Cioban
Mehmet Arik
Michael Deckard
M. J. Ellsworth
M. Van Soestbergen
Milad Yarali
Milnes David
M. Hamdan

Mohammad Parhiz
M. R. Kholghy
M. R. Shaeri
M. Ababneh
Monika Sharma
Munshi Basit
Mustafa Akbulut
Mustafa Koz
Navin Kumar
Nazli Donmez
Nenad Miljkovic
Nicholas Neal
Nitsch Kumar
Pablo Hidalgo
Pascale Gagnon
Patrick Shamberger
Peng Wang
Pengtao Wang
Phil Barletta
Philip Piper
P. Marepalli
P. Subrahmanyam
Prahald Kulkarni
Prithish Parida
Promod Chowdhury
P. Gromala
Raj Ganguli
Ralph Schacht
Randi Williams
Raphael Mandel
Ratnesh Tiwari
Ridvan Sahan
Robert Bennett
Robert Wang
Roozbeh Salary
Ross Wilcoxon
Ryan Enright
Sameer Rao
Sameh Saad
Sami Alkharabsheh
Sandeep B. Sane
Sandeep Shantaram
Satish Kandlikar
Sevket U. Yuruker
Shailaesh Joshi
Shankar Narayanan
Shanshan Xu
Shidong Li
Shitiz Sehgal
S. Bindiganavale
S. Swaminathan
S. Harish
Solomon Adera
Sriniivas Damaraaju
Stephanie Allard
Stephen A Solovitz
Subhasis Mukherjee
S. Sadasiva
Sukesh Shenoy
Sukwon Choi
Suraush Khambati
S. Parameswaran
Sushil Bhavnani
Sylvain Ouimet
Sylvain Pharan
Tao Song
Taravat Khadivi
Ther Alghoul
Thomas Lombardi
Thomas Sarvey
Tony Chao
Tuvin Sinha
Vaibhav Agrawal
Vaibhav Arghode
Valerie Oberson
Vibhash Jha
Vijay Subramanian
Vivek Khaire
Vivek Sahu
Wei Li
Wei Tian
Wei Xing
Wenming Li
Wenqing Shen
Xiangfei Yu
Xianghai Meng
Yagu Wang
Yangyin Zhu
Yaser Hadad
Yi Xu
Ying Feng Pang
Ying Zheng
Yingying Wang
Yoonjin Won
Youmin Yu
Yuanchen Hu
Yuqiang Zeng
Zeyong Wang
Zhengmao Lu
Zhitiz Sehgal
Zhou Yang
Ziqi Yu
CONFERENCE TECHNICAL PROGRAM

TRACKS & SESSIONS

COMPONENT-LEVEL THERMAL MANAGEMENT
- TI-1A: 3D Packaging / 3D Embedded Cooling I
- TI-1B: Vapor Chambers and Heat Pipes
- TI-2: 3D Packaging / 3D Embedded Cooling II
- TI-3: Single/Multi Chip Module (MCM) and System in Package (SIP) I
- TI-4: Single/Multi Chip Module (MCM) and System in Package (SIP) II
- TI-5: Hot Spot Cooling and Jet Impingement II
- TI-6: Hot Spot Cooling and Jet Impingement I
- TI-7A: Thermal Interface Materials, Heat Spreaders, and Thermal Ground Planes
- TI-7B: Air Cooling and Heat Exchangers
- TI-8A: Novel Air Cooling Devices and Systems
- TI-8B: Characterization of Materials and Structures for Thermal Management of Electronics
- TI-9: Board-Level Liquid Cooling Solutions
- TI-10: Boiling, Condensation, Evaporation, and Microgap Cooling I
- TI-11: Boiling, Condensation, Evaporation, and Microgap Cooling II
- TI-12A: Single/Two-Phase Flow in Microchannels and Cold Plates
- TI-12B: Thermoelectricity, TEC, and Peltier Devices

SYSTEM-LEVEL THERMAL MANAGEMENT
- TII-1: Data Center Energy Efficiency I
- TII-2: Data Center Energy Efficiency II
- TII-3: LEDs and Photovoltaics
- TII-4: Power Electronics
- TII-5: Immersion Cooling and Refrigeration
- TII-6: Data Center and Energy Efficiency III
- TII-8: Space, Aerospace, and Telecommunications
- TII-9: Automotive, Batteries, and Thermal Storage
- TII-10: Data Center Energy Efficiency IV
- TII-11: Mobile, Internet of Things I
- TII-12: Mobile, Internet of Things II

EMERGING TECHNOLOGIES & FUNDAMENTALS
- E-1: Fundamentals of Boiling and Condensation
- E-2: Flexible Electronics
- E-3: Thermal Transport in Nanotechnology
- E-4: Thermal Numerical Methods, Nano-To-Macro Scale
- E-5: Thermal Interface Materials and Phase Change Materials I
- E-6: Thermal Interface Materials and Phase Change Materials II
- E-7: Convection in Channels and Jets
- E-9: Thermal Experimental Methods, Nano-To-Macro Scale I
- E-10: Thermal Experimental Methods, Nano-To-Macro Scale II
- E-11: Emerging Materials and Thermal Phenomena I
- E-12: Emerging Materials and Thermal Phenomena II

MECHANICS & RELIABILITY
- M-1: Applied Reliability and Failure Analysis
- M-2: Advanced Methodologies for Reliability
- M-3: Mechanics in Assembly and Packaging I
- M-4: Mechanics in Assembly and Packaging II
- M-6: Modeling and Analytical Methods for Mechanics and Reliability of Electronic Packaging II
- M-7: Solder Joint Reliability I
- M-8: Solder Joint Reliability II
- M-9: Solder Characterization and Modeling I
- M-10: Solder Characterization and Modeling II
- M-11: Thermal-Mechanical Interactions in Microelectronics Packages and Systems
- M-12: Thermal-Mechanical Interactions in Microelectronics Packages and Systems II
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Location</th>
<th>Session Chairs</th>
<th>Session Chairs</th>
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</thead>
<tbody>
<tr>
<td>7:00 AM</td>
<td>E-1: Fundamentals of Boiling and Condensation</td>
<td>Point Loma B</td>
<td>Session Chairs: Amir Shooshtari (University of Maryland), Farah Singer (University of Maryland)</td>
<td>Session Chairs: Bidzina Kekelia (NREL), Timothy Chainer (IBM Research)</td>
</tr>
<tr>
<td></td>
<td>Boiling Heat Transfer Performance of Three-dimensionally Ordered Microporous Copper with Modulated Pore Diameters (p122)</td>
<td>Coronado A</td>
<td>Sim2Cool: A Two-Phase Cooling System Simulator and Design Tool (p268)</td>
<td></td>
</tr>
<tr>
<td>8:00 AM</td>
<td>Boiling Heat Transfer Performance of Three-dimensionally Ordered Microporous Copper with Modulated Pore Diameters (p122)</td>
<td>Coronado A</td>
<td>Pritish Parida, Mark Schultz, Timothy Chainer (IBM Research)</td>
<td></td>
</tr>
<tr>
<td>8:20 AM</td>
<td>Physics of Transition to Annular Flow in Microchannel Flow Boiling Process (p343)</td>
<td>Coronado A</td>
<td>Thermal Performance Comparison of Advanced 3D Packaging Concepts for Logic and Memory Integration in Mobile Cooling Conditions (p139)</td>
<td>Herman Oprins, Vladimir Cherman, Eric Beyne (IMEC)</td>
</tr>
<tr>
<td>8:40 AM</td>
<td>Two-Level Copper Oxide Nanostructured Surfaces for Condensation Heat Transfer (p163)</td>
<td>Coronado A</td>
<td>Embedded Fluid Cooling of Close-packed Via Arrays in Glass (p319)</td>
<td>Michael Fish, Bradley Martinis, Patrick McCluskey, Avram Bar-Cohen (University of Maryland)</td>
</tr>
<tr>
<td>9:00 AM</td>
<td>K-1 Keynote: FPGAS: The Accelerator of Choice from the Edge to the Cloud</td>
<td>Bel Aire</td>
<td></td>
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<tr>
<td></td>
<td>Bel Aire</td>
<td></td>
<td>Ravi Kuppuswamy (Intel)</td>
<td></td>
</tr>
<tr>
<td>10:00 AM</td>
<td>Refreshment Break, Catalina Ballroom</td>
<td></td>
<td></td>
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</table>
## DAY 1 SESSIONS: WEDNESDAY, MAY 30, 7:00 - 10:30 AM

#### Speakers’ Breakfast, Fairbanks

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<th>Session</th>
<th>Title</th>
<th>Room</th>
<th>Abstract Chairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>TI-1B: Vapor Chambers and Heat Pipes</td>
<td>Bel Aire</td>
<td></td>
<td>Sukhvinder Kang (Boyd), Kamal Sikka (IBM)</td>
</tr>
<tr>
<td>TII-I: Data Center Energy Efficiency II</td>
<td>Coronado B</td>
<td></td>
<td>Ali Akbar Merrikh (Qualcomm), Ali Kalantarian (Advanced Micro Devices)</td>
</tr>
<tr>
<td>M-1: Applied Reliability and Failure Analysis</td>
<td>Point Loma A</td>
<td></td>
<td>Tuhin Sinha (IBM), Kritika Upreti (Intel)</td>
</tr>
</tbody>
</table>

### KEYNOTE: FPGAS: The Accelerator of Choice from the Edge to the Cloud

**Bel Aire**

**Ravi Kuppuswamy (Intel)**

**Abstract:** The computing landscape is dynamically evolving and changing on a real-time basis. With the surge of mobile devices, network infrastructure requirements, edge and data center applications, the need to manage our data-centric connected world is exploding. FPGAs play a critical role in managing and accelerating hardware and software workloads across platforms, efficiently meeting the needs of customers to deliver rapid innovation in their markets.

In particular, we’re just now scratching the surface of what’s possible with Artificial Intelligence (AI). From self-driving cars to precision medicine to military defense, AI is poised to impact every industry and facet of life. It has the potential to dramatically improve - and even save - lives for people in every part of the world. But before we can harness AI for the greater good of humanity, we’ll need to turn theory into practice, bring machine learning models out of training, and put them to the test. In short, we need to understand how to make AI work in the field.

This Conference keynote will cover how FPGAs help in deploying AI and accelerating the new ecosystem needed to support these applications.

---

**Refreshment Break, Catalina Ballroom**
## E-2: Flexible Electronics

**Point Loma B**

Session Chairs:
- Banafsheh Barabadi (MIT), Mahsa Ebrahim (Villanova University), Aydin Nabovati (Tesla)

<table>
<thead>
<tr>
<th>Time</th>
<th>Session Title</th>
<th>Paper Details</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30</td>
<td><strong>Featured Paper Presentation</strong></td>
<td>Thermo-mechanical Deformation in Flexible-board Assemblies during Reflow and Post-assembly Usage (p322)</td>
<td>Pradeep Lall, Kartik Goyal (Auburn University); Ben Leever (US Air Force Research Labs); Jason Marsh (NextFlex)</td>
</tr>
<tr>
<td>11:00</td>
<td><strong>Kapton RS Flexible Heaters – Design and Applications (p126)</strong></td>
<td></td>
<td>Kalyan Rapolu, Shannon Dugan, Matthew Manelis, Jonathan Weldon, Richard Wessel (DuPont)</td>
</tr>
<tr>
<td>11:20</td>
<td><strong>Highly Stretchable Metal Films on Polymer Substrates: Mechanics and Mechanisms (p210)</strong></td>
<td></td>
<td>Yeasir Arafat (Washington State University); Rahul Panat (Carnegie Mellon University); Indranath Dutta (Washington State University)</td>
</tr>
<tr>
<td>11:40</td>
<td><strong>Novel Flexible Bioelectronics Device and Software Application for Prevention of Sudden Causes of Death (p331)</strong></td>
<td></td>
<td>Pradeep Lall, Hao Zhang (Auburn University); Rahul Lall (Stanford University)</td>
</tr>
</tbody>
</table>

## TI-2: 3D Packaging / 3D Embedded Cooling II

**Coronado A**

Session Chairs:
- Timothy Chainer (IBM Research), Bidzina Kekelia (NREL)

<table>
<thead>
<tr>
<th>Time</th>
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<th>Paper Details</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30</td>
<td><strong>Featured Paper Presentation</strong></td>
<td>Dual-Side Heat Removal by Silicon Cold Plate and Interposer with Embedded Fluid Channels (p121)</td>
<td>Thomas Brunschwieler (IBM Research Zurich); Wolfram Steller, Hermann Oppermann, Jessica Kleff (Fraunhofer); Stephen Robertson (Optocap Ltd); Raul Mrossko, Juergen Keller (AMIC); Gerd Schlottig (IBM Research Zurich)</td>
</tr>
<tr>
<td>11:00</td>
<td><strong>Two-Phase Flow Characteristics in Radial Expanding Channels with Embedded Pin Fins (p270)</strong></td>
<td></td>
<td>Mark Schultz (IBM Research); Michael Gaynes (Universal Instruments); Prithish Parida (IBM Research); Fanghao Yang (Princeton Plasma Physics Lab); Gerard McVicker (IBM Research); Ozgur Ozsun (IBM Research Zurich); Timothy Chainer (IBM Research)</td>
</tr>
<tr>
<td>11:20</td>
<td><strong>Methodology for 3D Package Selection Using a Power-temperature Distribution Map (p308)</strong></td>
<td></td>
<td>Yunhyeok Im, Kyoung Min Lee, Heeseok Lee, Junho Huh (Samsung Electronics)</td>
</tr>
<tr>
<td>11:40</td>
<td><strong>Cooling of Miniature Electronic Systems Using Diamond Circuit Boards (p158)</strong></td>
<td></td>
<td>Nicholas Apollo, Arman Ahnood, Hualin Zhan, Kumar Ganesan, Alan Smith, Steven Prawer, David Garrett (University of Melbourne)</td>
</tr>
</tbody>
</table>

### Luncheon & Richard Chu ITherm Award for Excellence Presentation, Fairbanks

Ken Goodson (Stanford University)

Ken Goodson chairs the Mechanical Engineering Department and holds the Davies Family Provostial Professorship and a courtesy appointment in Materials Science at Stanford University. His lab has graduated 40 PhDs, nearly half of whom are professors at schools including MIT, Stanford, and UC Berkeley. Honors include the Kraus Medal, the Heat Transfer Memorial Award, the AIChE Kern Award, the SRC Technical Excellence Award, the INTERPACK Achievement Award, and Fellow grade with ASME, IEEE, APS, and AAAS. Goodson co-founded Cooligy, which built computer heat sinks and was acquired by Emerson in 2006. At Stanford, serving as Mechanical Engineering Chair and Vice Chair since 2008, Goodson led two strategic plans and launched hiring of 15 faculty who are transforming the department’s scholarship and diversity.
### DAY 1 SESSIONS: WEDNESDAY, MAY 30, 10:30 – 1:30 PM

| TII-2: Data Center Energy Efficiency II  
Coronado B | M-2: Advanced Methodologies for Reliability  
Point Loma A | P-2: Micro-two-phase Liquid Cooling Systems for Electronics  
Bel Aire South |
|--------------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| **Session Chairs:**  
Ajay Vadakkepatt (Qualcomm), Rajat Mittal (Oculus) | **Session Chairs:**  
Przemyslaw Gromala (Robert Bosch GmbH), Jin Yang (Intel) | **Moderator:**  
John R. Thome (Ecole Polytechnique Federale de Lausanne) |
| **Featured Paper Presentation**  
An Experimental Analysis of Hot Aisle Containment Systems (p259)  
Sadegh Khalili (Binghamton University); Husam Alissa (Microsoft); Anuroop Desu, Bahgat Sammakia, Kanad Ghose (Binghamton University) | **Featured Paper Presentation**  
A Novel Concept for Accelerated Stress Testing of Thermal Greases and In-situ Observation of Thermal Contact Degradation (p170)  
Bernhard Wunderle, Daniel May, Jens Heilmann, Joerg Arnold, Josef Hirschieder (Chemnitz University of Technology); Joerg Bauer (Fraunhofer IZM); Mohamad Abo Ras (Berliner Nanotest and Design GmbH) | **Micro-two-phase Liquid Cooling Systems for Electronics**  
Abstract: Two-phase cooling continues to gain traction in the cooling of electronics (IGBT’s, CPU’s, LED’s, optical lasers, etc.). The panel will address technical developments, special issues and concerns on two-phase cooling systems. The panel will also cover some case studies on existing and pending applications and an overview of methods and simulators for designing of two-phase cold plates and their cooling systems (thermosyphon and pump-driven systems). The panel will furthermore address the pros/cons when choosing the best working fluid for applications. |
| **Algorithm for Simultaneous Optimization of an Array of Heat Sinks (p225)**  
Georgios Karamanis, Marc Hodes (Tufts University) | **Damage Evolution in MEMS Pressure Sensors during High Temperature Operating Life and Prolonged Storage at Sub-Zero Temperature (p318)**  
Pradeep Lall, Amrit Abrol (Auburn University); David Locker, Bruce Hughes (US Army AMRDEC) | **Panelists:**  
Scott Holland (Wolverine Microcool)  
Devdatta Kulkarni (Intel)  
Paolo Petagna (CERN)  
Todd Salamon (Nokia Bell Labs)  
Samuel Yana Motta (Honeywell)  
Ahmed Zaghlol (Mersen) |
| **A Test Study of Technology Cooling Loop in a Liquid Cooling System (p246)**  
Tianyi Gao, Hu Tang, Yan Cui, Zhiming Luo (Baidu) | **Evaluation of Aging Induced Microstructural Evolution in Lead Free Solders Using Scanning Probe Microscopy (p337)**  
Sudan Ahmed, Jeffrey Suhling, Pradeep Lall (Auburn University) | |
| **Exploration of a Hybrid Analytical Thermal Topology Optimization Method for an Additively Manufactured Heat Sink (p379)**  
Peter de Bock (GE Global Research) | **Mechanical Characterization of Intermetallic Compounds in SAC Solder Joints at Elevated Temperatures (p346)**  
Abdullah Fahim, Sudan Ahmed, Jeffrey Suhling, Pradeep Lall (Auburn University) | |

**Luncheon & Richard Chu ITherm Award for Excellence Presentation**  
Fairbanks  
Ken Goodson (Stanford University)

**The Heat Conduction Renaissance**

Some of the most exciting recent advancements in heat conduction physics have been motivated, enabled, or achieved by the thermal management community that ITherm serves so effectively. In this talk we highlight the resulting renaissance in basic heat conduction research, which is linked to cooling challenges from power transistors to portables. Examples include phonon transport and scattering in nanotransistors, engineered high-conductivity composites, modulated conductivity through phase transitions, as well as the surprising transport properties of low-dimensional (1D and 2D) nanomaterials. This work benefits strongly from decades of collaboration and leadership from the semiconductor industry.
<table>
<thead>
<tr>
<th>Time</th>
<th>Session A</th>
<th>Session B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:30 PM</td>
<td><strong>Featured Paper Presentation</strong></td>
<td><strong>Featured Paper Presentation</strong></td>
</tr>
</tbody>
</table>
|        | Thermal Boundary Conductance Mapping at Metal-MoSe2 Interface (p373)  
David B. Brown (Georgia Institute of Technology); Xufan Li, Kai Xiao, David B. Geohegan (Oak Ridge National Laboratory); Satish Kumar (Georgia Institute of Technology) | Thermal Co-design of Exascale Computing System in Packages (SiPs) (p127)  
Koosha Nassiri Nazif (Stanford University); Niru Kumari, Sarah Silverthorn (Hewlett Packard Enterprise) |
| 2:00 PM| Uncertainty Analysis of Near-Field Thermal Energy within Nanoparticle Packings (p195)  
Anil Yuksel, Edward Yu, Michael Cullinan (University of Texas at Austin); Jayathi Murthy (UCLA) | Novel Programmable Package-level Thermal Evaluation System (p380)  
Suresh Parameswaran, Gamal Refai-Ahmed, Suresh Ramalingam, Boon Ang (Xilinx) |
| 2:20 PM| Thermal Transport Analysis of Heterostructured Nanowires with Metal-Semiconductor Interfaces (p198)  
Nadji Motley, Jaeho Lee (University of California, Irvine) | Warpage Management for Fan-Out Packaging Moving from Wafer Level to Panel Level (p146)  
Mei-Chien Lu (Monte Rosa Technology) |
| 2:40 PM| Optical Pump-Probe Thermoreflectance Imaging for Anisotropic Heat Diffusion (p240)  
Kazuaki Yazawa (Microsanj); Jesus Armando Leon Gil (CIMAV); Kerry Maize (Purdue University); Dustin Kendig (Microsanj); Ali Shakouri (Purdue University) | Hybridizing Nature-inspired Algorithms to Derive Accurate Surrogate Thermal Model: Genetic Algorithm and Particle Swarm Optimization (p199)  
Eric Monier-Vinard, Olivier Daniel, Valentin Bissuel, Brice Rogié, Minh-Nhat Nguyen (Thales Corporate Engineering); Brice Rogié, Minh-Nhat Nguyen, Najib Laraqi (Université Paris Ouest); Ismaël Aliouat (Université Paris-Saclay) |
<p>| 3:00 PM| Refreshment Break, Catalina Ballroom |       |</p>
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<tr>
<th>TII-3: LEDs and Photovoltaics</th>
<th>M-3: Mechanics in Assembly and Packaging I</th>
<th>TT-3: Cryogenic Cooling for Quantum Computing and Embedded Cooling Enabled Electric Motors</th>
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<td>Point Loma A</td>
<td>Bel Aire South</td>
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<td>Session Chairs:</td>
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<td>Session Chairs:</td>
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<tr>
<td>Ashish Gupta (Intel), Vibhash Jha (NXP Semiconductors), Vikram Manthri (Amazon)</td>
<td>Bernhard Wunderle (Chemnitz University of Technology), Vibhash Jha (NXP Semiconductors), Sami Alkharabsheh (Ford)</td>
<td>Thomas Brunschwiler (IBM); Peter de Bock (GE Global Research)</td>
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<tr>
<td><strong>Featured Paper Presentation</strong></td>
<td><strong>Featured Paper Presentation</strong></td>
<td><strong>Cooling for Quantum Computers, Technology and Challenges</strong></td>
</tr>
<tr>
<td>A Comparative Study of Reflective and Transmissive Phosphor-converted Laser-based White Lighting (p186)</td>
<td>Strength Analysis of Resin Delamination of Packaging Structure of Power Module (p176)</td>
<td>Matti S. Manninen (BlueFors Cryogenics Oy, Finland)</td>
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<tr>
<td>Yupu Ma, Xiaobing Luo (Huazhong University of Science and Technology)</td>
<td>Sho Teradaira, Yukichi Furuyama, Qiang Yu (Yokohama National University)</td>
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<td>Tomasz Torzewicz, Marcin Janicki, Andrzej Napieralski Napieralski (Lodz University of Technology)</td>
<td>Pradeep Lall, Kalyan Dornala (Auburn University); John Deep (US AFRL); Ryan Lowe (ARA Associates)</td>
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<tr>
<td>Design Considerations Based on the Effects of Varying Temperature Conditions on the Efficiency of Size Constrained Electronic Power Supplies for CubeSat Applications (p232)</td>
<td>Reaction Kinetics and Rheological Model Coefficient Extraction for Epoxy Mold Compounds (p251)</td>
<td>Highly Efficient, Drive and Electronics-Integrated Embedded Cooling Enabled Electric Motors</td>
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<tr>
<td>Luis Silva-Llanca, Carolina Ponce, Manuel Araya (Universidad de la Serena); Andres J. Diaz (Universidad Diego Portales)</td>
<td>Jun Chen, Quang Nguyen, Jordan Roberts, Jeffrey Suhling, Richard Jaeger, Pradeep Lall (Auburn University)</td>
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**Refreshment Break, Catalina Ballroom**
### E-4: Thermal Numerical Methods, Nano-to-macro Scale
Point Loma B

**Session Chairs:**
Bladimir Ramos-Alvarado (Penn State University), Farah Singer (University of Maryland)

<table>
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<tr>
<th>Time</th>
<th>Session</th>
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</table>
| 3:30 PM| **Featured Paper Presentation**
Interfacial Liquid Structuring at SiC-water Interfaces and its Effects on Heat Transfer (p383)
C. Ulises Gonzalez-Valle, Bladimir Ramos-Alvarado (Penn State University) |
| 4:00 PM| **Experimental and Numerical Investigation on Liquid Assisted Air Cooling Solution** (p168)
Wenbin Tian, Devdatta Kulkarni, Ming Zhang, Yuehong Fan (Intel) |
| 4:20 PM| **Morpho Butterfly-inspired Spectral Emissivity of Metallic Microstructures for Radiative Cooling** (p209)
Anirudh Krishna, Jonathan Sullivan, Shiva Farzinazar, Jaeho Lee, Anirudh Krishna (University of California, Irvine) |
| 4:40 PM| **Model-based Comparison of Thermo-hydraulic Performance of Various Cooling Methods for Power Electronics of Electric Vehicles** (p273)
Jasper Nonneman, Ilya Tjollyn, Nils Clarie (Ghent University); Sam Weckx (Flanders Make); Peter Sergeant, Michel De Paepe (Ghent University) |

### TI-4: Single/Multi Chip Module (MCM) and System in Package (SIP) II
Coronado A

**Session Chairs:**
Sami Alkharabsheh (Ford), Stephanie Allard (IBM)

<table>
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<th>Time</th>
<th>Session</th>
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| 3:30 PM| **Featured Paper Presentation**
Analysis of Thermal Characteristics of Gallium Oxide Field-effect-transistors (p256)
Jialuo Chen, Satish Kumar (Georgia Institute of Technology); Zhanbo Xia, Siddharth Rajan (Ohio State University) |
| 4:00 PM| **Design and Parametric Study of Microfluidic Cooling Manifold for 2.5D-SICs with Dielectric Coolant** (p234)
Yuanchen Hu, Thomas Sarvey, Muhammad Bakir, Yogendra Joshi (Georgia Institute of Technology) |
| 4:20 PM| **An Innovative Heterogeneous SoC Thermal Model for Smartphone System** (p239)
Sheng-Liang Kuo, Chi-Wen Pan, Pei-Yu Huang, Chien-Tse Fang, Shin-Yu Hsiau, Tai-Yu Chen (MediaTek) |
| 4:40 PM| **Model-based Comparison of Thermo-hydraulic Performance of Various Cooling Methods for Power Electronics of Electric Vehicles** (p273)
Jasper Nonneman, Ilya Tjollyn, Nils Clarie (Ghent University); Sam Weckx (Flanders Make); Peter Sergeant, Michel De Paepe (Ghent University) |

### 6:30 PM
ECTC/ITHERM Joint Women’s Panel & Reception,
Marina Tower, Harbor Island 3
Moderators: Cristina Amon (University of Toronto); Tanja Braun (Fraunhofer IZM)

The Executive Committees of ECTC and IThERM cordially invite all IThERM attendees to our fourth annual Women’s Panel and Reception jointly organized by IThERM and ECTC and sponsored by EPS. The four panelists will speak on their experiences and achievements in the microelectronics industry and provide insights into enhancing women’s participation in engineering around globe. A Q&A session and reception for panelists and attendees will follow.

**Panelists:**
Kawthar (Kat) Kasim (Boeing Research and Technology, USA); Jayath Murthy (UCLA Dean of Engineering, USA); Li Ming (R&D Director, Enabling Technologies at ASM Pacific Technology, Hong Kong)
### Day 1 Sessions: Wednesday, May 30, 3:30 – 7:30 PM

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<th>M-4: Mechanics in Assembly and Packaging II</th>
<th>P-4: Thermo-fluidic Challenges in Healthcare</th>
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<td>Session Chairs: Bernhard Wunderle (Chemnitz University of Technology), Vibhash Jha (NXP Semiconductors), Sami Alkharabsheh (Ford)</td>
<td>Moderators: Peter de Bock (GE Global Research), Ali Khounsary (Illinois Institute of Technology)</td>
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<tr>
<td><strong>Featured Paper Presentation</strong></td>
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<td><strong>Featured Paper Presentation</strong></td>
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<tr>
<td>Electrical and Thermal Analysis of Vertical GaN-on-GaN PN Diodes (p311)</td>
<td>Mechanical Response of Assemblies Bonded with Double-layered Pressure-sensitive Adhesives (PSAs) (p315)</td>
<td>Thermo-fluidic Challenges in Healthcare</td>
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<tr>
<td>Luke Yates, Georges Pavlidis, Samuel Graham (Georgia Institute of Technology); Shigeyosi Usami, Kentaro Nagamatsu, Yoshio Honda; Hiroshi Amano (Nagoya University)</td>
<td>Hao Huang, Abhijit Dasgupta (University of Maryland); Ehsan Mirbagheri, Krishna Darbha (Microsoft)</td>
<td>Abstract: Advances in medicine and the development of many novel diagnostic and therapeutic modalities have brought about a slew of challenges in many engineering fields including thermofluidics. As they relate to human health and well-being on the one hand, and to the biological systems on the other, these challenges are both critical and complex when compared to the electronic systems that are the main focus of ITherm conferences. Thermofluidics are an integral part of most biological systems and are present in a significant number of the systems and devices used in medicine. For example, the PCR (Polymerase chain reaction) technique used to reproduce millions of DNA copies from one or a few samples is principally a thermal process (Nobel Prize in chemistry 1973) while the dialysis system (artificial kidney) is essentially a fluidic system. This panel session focuses on several thermal and fluidic challenges in the development of novel medical devices and techniques, presents the current status, and provides an opportunity for the panelists and the audience to brainstorm about possible solutions. <strong>Panelists:</strong> Guillermo Aguilar (UC Riverside) Bruce Guenin (Consultant) Sung Jin Kim (KAIST) Y. C. Lee (University of Colorado)</td>
</tr>
<tr>
<td>Khosrow Ebrahimi (Boise State University), Alfonso Ortega (Santa Clara University), Calvin Li (Villanova University), Kazuaki Yazawa (Purdue University), Sean James (Microsoft)</td>
<td>Pradeep Lall, Jinesh Narangaparambil, Amrit Abrol (Auburn University); Ben Leever (USAF Research Labs); Jason Marsh (NextFlex Manufacturing Institute)</td>
<td>Promod Chowdhury, Jeffrey Suhling, Pradeep Lall (Auburn University)</td>
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<td>Simulation, Testing and Implementation of Temperature-reduction Solutions on a High-power Thermal Demonstrator (p179)</td>
<td>Simulation Improved Testing of Fan-out Packaging (p282)</td>
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<td>Andy Heinig, Dimitrios Papaoannou (Fraunhofer Institute, EAS)</td>
<td>Chun-Wei Hsiao, Mei-Ling Wu (National Sun Yat-Sen University); Shang Lee, Shiny Huang, Chiyu Wang, Brain Wu (Advanced Semiconductor Engineering)</td>
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<td>Co-designed High Voltage Module (p310)</td>
<td>Co-designed High Voltage Module (p310)</td>
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<tr>
<td>Lauren Boteler (US Army Research Laboratory), Steven Miner (US Naval Academy), Miguel Hinojosa (US Army Research Laboratory)</td>
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**ECTC/ITherm Joint Women’s Panel & Reception,**
Marina Tower, Harbor Island 3
Moderators: Cristina Amon (University of Toronto); Tanja Braun (Fraunhofer IZM)

The Executive Committees of ECTC and ITherm cordially invite all ITherm attendees to our fourth annual Women’s Panel and Reception jointly organized by ITherm and ECTC and sponsored by EPS. The four panelists will speak on their experiences and achievements in the microelectronics industry and provide insights into enhancing women’s participation in engineering around globe. A Q&A session and reception for panelists and attendees will follow.

**Panelists:** Kawthar (Kat) Kasim (Boeing Research and Technology, USA); Jayathi Murthy (UCLA Dean of Engineering, USA); Li Ming (R&D Director, Enabling Technologies at ASM Pacific Technology, Hong Kong)
### DAY 2 SESSIONS: THURSDAY, MAY 31, 7:00 - 10:30 AM

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<tr>
<th>Time</th>
<th>Session Chairs</th>
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<tr>
<td>7:00 AM</td>
<td><strong>E-5: Thermal Interface Materials and Phase Change Materials I</strong>&lt;br&gt;Point Loma B</td>
<td><strong>TI-5: Hot Spot Cooling and Jet Impingement I</strong>&lt;br&gt;Coronado A</td>
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<td></td>
<td>Session Chairs: Amy Marconnet (Purdue University), Leila Choobineh (SUNY Polytechnic Institute)</td>
<td>Session Chairs: Nicholas Haehn (Intel), Mohammed Ababneh (ACT)</td>
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<td>8:00 AM</td>
<td>Phase Change Materials for Thermal Peak Management Applications with Specific Temperature Ranges (p211)&lt;br&gt;Jacob Maxa, Andrej Novikov, Mathias Nowotnick (Rostock University); Matthias Heimann, Kay Jarchoff (Siemens AG)</td>
<td>Staggered and In-line Submerged Liquid Jet Arrays for Power Electronics Using Variable Area Discharge Manifolds: Part I – Experimental (p123)&lt;br&gt;Michael Henry, Kayla Reid, Sushil Bhavnani, Roy Knight, William D. Brannon (Auburn University); John Maddox (University of Kentucky)</td>
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<td>8:20 AM</td>
<td>Chemical Modification of High Performance Metal-based Nanocomposite Thermal Interface Materials Toward Efficient Cooling in Electronic Systems (p275)&lt;br&gt;Cengiz Yegin, Nirup Nagabandi, Kevin Holder, Elisa Teipel (Incendium Technologies LLC); Mustafa Akbulut (Texas A&amp;M University)</td>
<td>Staggered and In-line Submerged Liquid Jet Arrays for Power Electronics Using Variable Area Discharge Manifolds: Part II – Numerical (p192)&lt;br&gt;Kayla Reid, Michael Henry, Roy Knight, Sushil Bhavnani (Auburn University); John Maddox (University of Kentucky)</td>
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<tr>
<td>8:40 AM</td>
<td>Cooling Power and Thermal Buffering in Composite Heatsinks (p285)&lt;br&gt;Michael Deckard, Jonathan Felts, Patrick Shamberger (Texas A&amp;M University)</td>
<td>Identification of the Dominant Heat Transfer Mechanisms During Confined Two-phase Jet Impingement (p136)&lt;br&gt;Matthew Clark, Justin Weibel, Suresh Garimella (Purdue University)</td>
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<tr>
<td>9:00 AM</td>
<td><strong>K-2 Keynote:</strong> Transitioning Directed Energy Weapons from the Laboratory to the Tactical Edge: The Thermal Interface&lt;br&gt;Bel Aire&lt;br&gt;Sean Ross (Air Force Research Laboratory)</td>
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Dr. Sean Ross has worked at the Air Force Research Laboratory, Directed Energy Directorate, since 1994. Since July 2017, he has been the directed energy deputy at the office of the Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering. Dr. Ross is a board member of the Directed Energy Professional Society. He is the author of *Laser Beam Quality Metrics* textbook and frequently teaches courses on the subject. Dr. Ross led the creation of the Environmental Laser Test Facility to test high-energy laser systems and components in simulated flight environments prior to flight testing. He has been involved in power, thermal, structural and other high-energy laser integration issues for over a decade. Dr. Ross holds a BS and MS in Physics from Brigham Young University and a PhD in Optical Science and Engineering from the Center for Research and Education in Optics and Lasers, College of Optics and Photonics, University of Central Florida.
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<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tr>
<td>7:00 AM - 10:30 AM</td>
<td>Speakers’ Breakfast</td>
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<td>Andrew McNamara (Advanced Micro Devices), Vivek Sahu (Apple), Ajay Vadakkepatt (Qualcomm)</td>
<td>Shidong Li (IBM), Meriem Akin (IMPT)</td>
<td>David Altman (Raytheon); Madhusudan Iyengar (Google)</td>
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<td>M-5: Modeling and Analytical Methods for Mechanics and Reliability of Electronic Packaging I</td>
<td>Point Loma A</td>
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<td>TT-5: Heterogeneous Integration</td>
<td>Bel Aire</td>
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<td>Coronado B</td>
<td>TII-5: Immersion Cooling and Refrigeration</td>
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<td>Coronado B</td>
<td>Hydrodynamic Patterns of a Droplet Train Impinging onto Superheated Nanotube Surfaces (p162)</td>
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<td>Wei Tong, Zhen Qin, Fei Duan (Nanyang Technological University)</td>
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<td>Coronado B</td>
<td>Analysis and Active Control of Pressure Drop Oscillation in Microchannel Vapor Compression Cycle (p226)</td>
<td>Coronado B</td>
<td>Jin Qi, John Wen, Shankar Narayanan (Rensselaer Polytechnic Institute)</td>
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<tr>
<td>Bel Aire</td>
<td>Materials &amp; Microfluidics – Thermal Strategies for Heterogeneous Integration</td>
<td>Bel Aire</td>
<td>Ken Goodson, Stanford</td>
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<td>Bel Aire</td>
<td>Organic Rankine Cycle as Waste Heat Recovery System in Data Centers: Design and Construction of a Prototype (p250)</td>
<td>Bel Aire</td>
<td>Sebastian Araya, Gerard Jones, Amy Fleischer (Villanova University)</td>
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<td>Bel Aire</td>
<td>Analysis of Progressive Damage in Fuze Electronics using Micro-computed Tomography and Finite Element Models (p323)</td>
<td>Bel Aire</td>
<td>Pradeep Lall, Nakul Kothari (Auburn University); John Deep (US AFRL); Ryan Lowe (ARA Associates)</td>
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<tr>
<td>Bel Aire</td>
<td>K-2 Keynote: Transitioning Directed Energy Weapons from the Laboratory to the Tactical Edge: The Thermal Interface</td>
<td>Bel Aire</td>
<td>Sean Ross (Air Force Research Laboratory)</td>
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**Abstract:** Abstract: Healthy systems engineering begins with an examination of the impact of the operating requirements on the components and interfaces of the proposed system. Thermal management leads the list of challenges to the integration of high energy laser systems on weight and volume constrained platforms, especially smaller aircraft. This presentation will introduce the generic architectures of High Energy Lasers and High Power Microwaves and cover the major issues and trades involved and summarize some current efforts to mature the Directed Energy system - thermal management interface.
# DAY 2 SESSIONS: THURSDAY, MAY 31, 10:30 – 1:30 PM

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<td>10:30 AM</td>
<td><strong>Featured Paper Presentation</strong>&lt;br&gt;Influence of Structure and Wettability of&lt;br&gt;Porous Silver Surfaces on Enhancing Phase&lt;br&gt;Change Heat Transfer (p159)&lt;br&gt;Gideon Gouws, Ben Sherson, Arwin&lt;br&gt;Sinnathambi, Roshni Babu, Ciaran Moore&lt;br&gt;(Victoria University of Wellington)&lt;br&gt;<strong>Featured Paper Presentation</strong>&lt;br&gt;Measuring Heat Transfer Coefficients for Microchannel Jet Impingement Using Time-domain Thermoreflectance (p269)&lt;br&gt;Thomas Germain, Tanvir Chowdhury, Jake Carter, Shawn Putnam (University of Central Florida)</td>
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<td>11:00 AM</td>
<td>**Experimental Measurement of Corrosion Involving Inorganics (Salt Hydrates) Phase Change Materials (PCM) for Thermal Energy Storage (TES) Applications (p138)&lt;br&gt;Navin Kumar, Reynaldo Chavez Jr, Debjyoti Banerjee (Texas A&amp;M University)&lt;br&gt;**Impingement Cooling Using a Variable-diameter Synthetic Jet (p124)&lt;br&gt;Alexander Zielinski, Monique Embury, Stephen Solovitz (Washington State University Vancouver)</td>
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<td>11:20 AM</td>
<td>**Design Architectures for Compliant High Temperature Thermal Interface Materials (p147)&lt;br&gt;Mei-Chien Lu (Monte Rosa Technology)&lt;br&gt;**Flow Field Characteristics of Multiple Impinging Tapered Nozzles in Confined Channels for High Heat Flux Applications (p284)&lt;br&gt;Prabhakar Subrahmanyam, Arun Krishnamoorthy (Intel); Jared Harvest (ANSYS)</td>
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<tr>
<td>11:40 AM</td>
<td>**Numerical and Experimental Investigation of Vertically Aligned Carbon Nanotube-phase Change Material Composites for Thermal Management of Electronics (p400)&lt;br&gt;Makita Phillips, Craig Green, Baratunde Cola (Carbice)&lt;br&gt;**Numerical Investigation of Thermal Transport in Confined Single and Multiple Jet Impingements Through Porous Filled Non-uniform Cross Section Channels (p314)&lt;br&gt;Carlos Zing, Shadi Mahjoob (California State University Northridge)</td>
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<td>12:00 PM</td>
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<td>Fairbanks</td>
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<td><strong>TII-6: Data Center Energy Efficiency III</strong></td>
<td><strong>Featured Paper Presentation</strong></td>
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<td>An Advanced Data Center Multi-chiller Dynamic Load Distribution Methodology and Engineering Practice (p205)</td>
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<td>Bel Aire South</td>
<td><strong>M-6: Modeling and Analytical Methods for Mechanics and Reliability of Electronic Packaging II</strong>.</td>
<td><strong>Featured Paper Presentation</strong></td>
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<td>Fatigue Life Predictive Model and Acceleration factor Development for Decoupling Capacitors (p241)</td>
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|         |                                                                   |                                                                          | "Abstract: In the last few years there has been a significant growth in computing platforms ranging from handhelds to IoT devices and everything in between. This is associated with increasingly high thermal management and other packaging issues ranging from low to high form factors. Majority of research today is CPU-centric whereas in the mobile/portable space, the device skin as well as the other components, which do not have dedicated thermal solutions, are equally challenging to cool. In products like handheld devices and mobile phones, passive dissipation is the most preferred and sometimes, the only possible cooling solution available. A different thermal landscape is now opening with the IoT devices and other adjacent high power areas. A panel of experts will discuss these aspects and will share their vision on the future of small to large electronics thermal management and other advanced system level cooling solutions."
|         |                                                                   |                                                                          | "Panelists:"                                                              |
|         |                                                                   |                                                                          | "Rick Beyerle (NeoGraf Solutions)                                          |
|         |                                                                   |                                                                          | "Ken Goodson (Stanford University)                                          |
|         |                                                                   |                                                                          | "Yogendra Joshi (Georgia Tech)                                              |
|         |                                                                   |                                                                          | "Mark Hartman (Outlast Technologies)                                        |
|         |                                                                   |                                                                          | "Ioan Savauciuc (Intel)                                                     |
|         |                                                                   |                                                                          | "John Thome (EPFL)                                                         |
| Coronado B | **P-6: Thermal Management of Mobile / IoT Devices**                  | **Luncheon: ITherm Sponsors, Exhibitors, and Partners**                   | ""Luncheon: ITherm Sponsors, Exhibitors, and Partners"                       |
|         |                                                                   |                                                                          | Fairbanks                                                                 |

**Featured Paper Presentation**

- **An Advanced Data Center Multi-chiller Dynamic Load Distribution Methodology and Engineering Practice (p205)**
  - Yiming Luo, Jianchao Cao, Biao Li, Yahui Zhao, Tangbo Jing, Lifei Zhang (Baidu);
  - Nishi Ahuja, Jun Zhang, Yuyang Xia, Xiang Zhou (Intel)

- **Fatigue Life Predictive Model and Acceleration factor Development for Decoupling Capacitors (p241)**
  - Krishna Tunga, Joseph Ross, Kamal Sikka, Thomas Lombardi, Bakul Parikh, Eric Turcotte, Catherine Dufort, David Turnbull (IBM)

**Development of a Computational Modeling and Experimental Validation Approach for KSF LED Packages in a 65" Ultra-Thin LED TV System (p265)**

- Metehan Elibol, Mustafa Caglar Ozaydin (Vestel Electronics);
- Mehmet Arik (Ozyegin University)

**Artificial Neural Network Based Prediction of Temperature and Flow Profile in Data Centers (p288)**

- Jayati Athavale, Yogendra Joshi, Minami Yoda (Georgia Institute of Technology)

**Transient Data Center Temperatures after a Primary Power Outage (p283)**

- Christopher Healey, James VanGilder, Michael Condor, Wei Tian (Schneider Electric)


- Pradeep Lall, Yihua Luo (Auburn University);
- Luu Nguyen (Texas Instruments)

**Development of a Computational Modeling and Experimental Validation Approach for KSF LED Packages in a 65 Ultra-Thin LED TV System (p265)**

- Metehan Elibol, Mustafa Caglar Ozaydin (Vestel Electronics);
- Mehmet Arik (Ozyegin University)

**Thermoelectric On-spot Energy Harvesting for Diagnostics of Water Service Pipelines (p183)**

- Kazuaki Yazawa (Purdue University), Katsuhiko Tanaka, Takashi Yajima (Tokyo Electric Power Company)

**Comparison of FEA Modeling Techniques for Plastic Ball Grid Array Assemblies (p395)**

- Chienchih Chen, Jeffrey Suhling, Pradeep Lall (Auburn University)

**Comparison of FEA Modeling Techniques for Plastic Ball Grid Array Assemblies (p395)**

- Chienchih Chen, Jeffrey Suhling, Pradeep Lall (Auburn University)
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<th>Paper Title</th>
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<td><strong>Featured Paper Presentation</strong></td>
<td>Point Loma B</td>
<td>Bladimir Ramos-Alvarado (Penn State University); Farah Singer, Amir Shooshtari (University of Maryland)</td>
<td>Experimental Characterization of a Microchannel Heat Sink Made by Additive Manufacturing (p135)</td>
<td>Ivel Collins, Justin Weibel, Liang Pan, Suresh Garimella (Purdue University)</td>
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<td>1:30 PM</td>
<td><strong>Featured Paper Presentation</strong></td>
<td>Coronado A</td>
<td>Ridvan Sahan (Intel), Baris Dogruoz (Cisco)</td>
<td>Highly Anisotropic Thermal Conductivity in Spin-cast Polystyrene Nano-films (p272)</td>
<td>Joseph Katz (Stanford University); Michael Barako (Northrop Grumman); Woosung Park, Aditya Sood, Mehdi Asheghi, Kenneth E. Goodson (Stanford University)</td>
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<tr>
<td>2:00 PM</td>
<td><strong>A Heat Spreading Model for Double-sided, Cross-flow, Manifold-microchannel Heat Exchangers (p228)</strong></td>
<td>Coronado A</td>
<td>Ridvan Sahan (Intel), Baris Dogruoz (Cisco)</td>
<td>Combined Experimental-numerical Investigation of Metal-wax Interactions for Phase Change Thermal Energy Storage (p151)</td>
<td>Prahlad Kulkarni, Prachi Kale, Collier Miers, Amy Marconnet (Purdue University)</td>
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<td>2:00 PM</td>
<td><strong>Combined Experimental-numerical Investigation of Metal-wax Interactions for Phase Change Thermal Energy Storage (p151)</strong></td>
<td>Coronado A</td>
<td>Ridvan Sahan (Intel), Baris Dogruoz (Cisco)</td>
<td>Combined Experimental-numerical Investigation of Metal-wax Interactions for Phase Change Thermal Energy Storage (p151)</td>
<td>Prahlad Kulkarni, Prachi Kale, Collier Miers, Amy Marconnet (Purdue University)</td>
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<td>2:20 PM</td>
<td><strong>A Header Design Method for Target Flow Distribution among Parallel Channels Based on Topology Optimization (p111)</strong></td>
<td>Coronado A</td>
<td>Ridvan Sahan (Intel), Baris Dogruoz (Cisco)</td>
<td>Investigation of Atomistic-scale Thin-film Evaporation (p248)</td>
<td>Kimia Montazeri, Shiwei Zhang, Mohammad Javad Abdolhosseini Qomi, Yoonjin Won (University of California, Irvine)</td>
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<td>2:40 PM</td>
<td><strong>Impact of Orifice Size over Mechanical, Flow and Thermal Performances of Synthetic Jets (p120)</strong></td>
<td>Coronado A</td>
<td>Ridvan Sahan (Intel), Baris Dogruoz (Cisco)</td>
<td>Synthesis of Thermal Compound and Its Application as a Thermal Interface Material of Power Module (p398)</td>
<td>Seonja Song, Changkook Jang (Youngyiel Precision Co Ltd); Kyeongho Shin, Joohyung Kim (Inha University); Youngseok Kim (Hyundai Motor Company); Jaeuk Chu (Youngyiel Precision Co Ltd)</td>
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<td>3:00 PM</td>
<td><strong>Refreshment Break, Catalina Ballroom</strong></td>
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<td>DAY 2 SESSIONS: THURSDAY, MAY 31, 1:30 – 3:30 PM</td>
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<tr>
<td><strong>TI-7B: Air Cooling and Heat Exchangers</strong></td>
<td><strong>M-7: Solder Joint Reliability I</strong></td>
<td><strong>TT-7: Thermal Management in Aerospace/Automotive</strong></td>
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<td>Bel Aire North</td>
<td>Point Loma A</td>
<td>Bel Aire South</td>
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<td>Session Chairs: Ashish Sinha (Chowbotics), Salih Erden (Istanbul Technical University)</td>
<td>Session Chairs: Chandradip Patel (Schlumberger), Quang Nguyen (Micron)</td>
<td>Session Chair: David Altman (Raytheon)</td>
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<tr>
<td><strong>Featured Paper Presentation</strong></td>
<td><strong>Featured Paper Presentation</strong></td>
<td><strong>More Electric Aircraft Thermal Challenges</strong></td>
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<tr>
<td>Two-phase Flow Simulations Within Plate Heat Exchangers (p105)</td>
<td>Investigation of Microstructural Evolution in SAC Solders Exposed to Short-term and Long-term Aging (p352)</td>
<td>Ram Ranjan (UTRC)</td>
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<td>Raffaele Luca Amalfi, John Richard Thome (Ecole Polytechnique Federale de Lausanne)</td>
<td>Jing Wu, Jeffrey Suhling, Pradeep Lall (Auburn University)</td>
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<tr>
<td><strong>Experimental and Numerical Investigation of Liquid-to-Air Heat Exchangers (p154)</strong></td>
<td>The Influence of Poisson’s Ratio on the Reliability of SAC Lead Free Solder Joints (p349)</td>
<td><strong>Thermal Challenges for Future Military Platforms</strong></td>
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<td>Jaime Sanchez, Devdatta Kulkarni, Xudong Tang, Casey Winkel (Intel)</td>
<td>KM Rafidh Hassan, Jeffrey Suhling, Pradeep Lall (Auburn University)</td>
<td>Mark Spector (ONR)</td>
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<td>Matthew Blaser, Agustinus Lawandy, Bahman Abbasi (Oregon State University)</td>
<td>Mahesh Pallapothu, Mugdha Chaudhari, Unique Rahangdale, Abel Misrak, Dereje Agonafer (University of Texas at Arlington)</td>
<td>Ercan Dede (Toyota)</td>
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<td><strong>A Numerical Study of Heat Transfer and Fluid Flow in a Channel with an Array of Pin Fins in Aligned and Staggered Configurations (p361)</strong></td>
<td>SMT/PTH Solder Joint Reliability under Extreme Cold Thermal Cycles (p150)</td>
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<td>Johnny Issa, Najib Saliba (University of Balamand); Amina El Cheikh (Lebanese American University)</td>
<td>Reza Ghaffarian (JPL)</td>
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Refreshment Break, Catalina Ballroom
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<tr>
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<tr>
<td>3:30 PM</td>
<td>TI-8A</td>
<td><strong>Featured Paper Presentation</strong>&lt;br&gt;Fluid Dynamics and Heat Transfer&lt;br&gt;Generated by a Pair of Adjacent Impinging Synthetic Jets (p302)&lt;br&gt;Jean Paul D’Alencon, David Gallardo, Luis Silva-Llanca (Universidad de la Serena)</td>
<td>Coronado A</td>
<td>Bladimir Ramos-Alvarado (Penn State), Salih Erden (Istanbul Technical University), Ashish Sinha (Chowbotics)</td>
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<td>3:30 PM</td>
<td>TI-8B</td>
<td><strong>Featured Paper Presentation</strong>&lt;br&gt;Rapid Thermal Characterization of Materials with Ultra-high Resolution of Droplet Size Specimens Using the Three Omega Method (p392)&lt;br&gt;Corinna Grosse, Mohamad Abo Ras, Daniel May, Karim Elabshihy (Berliner Nanotest und Design GmbH); Kestutis Grigoras, Aapo Varpula, Mika Prunnila (VTT Technical Research Centre of Finland Ltd); Daniel May, Bernhard Wunderle (Chemnitz University of Technology)</td>
<td>Bel Aire North</td>
<td>Baris Dogruoz (Cisco), Ridvan Sahan (Intel)</td>
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<td>4:00 PM</td>
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<td><strong>Featured Paper Presentation</strong>&lt;br&gt;Thermal and Exergy Analysis in UPS and Battery Rooms by Numerical Simulations (p355)&lt;br&gt;Carol Caceres (Villanova University); Alfonso Ortega (Santa Clara University); Luis Silva-Llanca (Universidad de la Serena); Gerard Jones (Villanova University); Nicholas Sapia (Verizon Wireless)</td>
<td>Coronado B</td>
<td>Andy Slippery, William Anderson, Michael Ellis, Clayton Hose, James Schmidt, Jens Weyant (ACT)</td>
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<td>4:00 PM</td>
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<td><strong>Featured Paper Presentation</strong>&lt;br&gt;Thermal Management Technologies for Embedded Cooling Application (p292)&lt;br&gt;Andy Slippey, William Anderson, Michael Ellis, Clayton Hose, James Schmidt, Jens Weyant (ACT)</td>
<td>Coronado B</td>
<td>Andy Slippery, William Anderson, Michael Ellis, Clayton Hose, James Schmidt, Jens Weyant (ACT)</td>
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<td>4:20 PM</td>
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<td>**Impact of Orifice Location on the Mechanical Response of Side and Central Orifice Synthetic Jets (p112)&lt;br&gt;Mohammad Zohaib Naseem, Polat Sendur, Mehmet Arik (Ozyegin University)</td>
<td>Coronado B</td>
<td>Henry Aller, Xiaoxiao Yu, Andrew Gellman, Jonathan Malen, Alan McGaughey (Carnegie Mellon University)</td>
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<td>4:40 PM</td>
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<td>**An Investigation of Performance of Synthetic Jets Emanating from Circular, Elliptical and Rectangular Nozzles (p386)&lt;br&gt;Onuralp Isil (Ozyegin University); Baris Dogruoz (Cisco); Mehmet Arik (Ozyegin University)</td>
<td>Coronado B</td>
<td>Collier Miers, Amy Marconnet (Purdue University)</td>
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<td>4:40 PM</td>
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<td>**Uncertainty Quantification for a High Temperature Z-meter Characterization System (p134)&lt;br&gt;Collier Miers, Amy Marconnet (Purdue University)</td>
<td>Coronado B</td>
<td>Collier Miers, Amy Marconnet (Purdue University)</td>
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<td>5:00 PM</td>
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<td><strong>Student Poster Networking Session and Reception</strong>&lt;br&gt;Fairbanks</td>
<td>Coronado B</td>
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<td><strong>TII-8: Space, Aerospace, and Telecommunications</strong></td>
<td><strong>M-8: Solder Joint Reliability II</strong></td>
<td><strong>P-8: Emerging Trends in Energy Management and Thermal Packaging of Data Centers</strong></td>
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<td><strong>Session Chairs:</strong> Shima Hajimirza (Texas A&amp;M University), Andrew Poynot (Signature Science, LLC)</td>
<td><strong>Session Chairs:</strong> Chandradip Patel (Schlumberger), Cong Zhao (Apple)</td>
<td><strong>Moderator:</strong> Yogendra Joshi (Georgia Institute of Technology)</td>
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<td><strong>Featured Paper Presentation</strong> Transient Electro-thermal Coupled System Simulation – Modeling Approach and Experimental Validation (p109) Ralph Schacht (Brandenburg Technology University); Sven Rzepka (Fraunhofer Institute ENAS)</td>
<td><strong>Featured Paper Presentation</strong> Reliability of SAC Leadfree Solders in Automotive Underhood Temperature-Vibration (p329) Pradeep Lall, Vikas Yadav, Di Zhang, Jeff Suhling (Auburn University)</td>
<td><strong>Emerging Trends in Energy Management and Thermal Packaging of Data Centers</strong></td>
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<tr>
<td><strong>A Novel Networking Box System Architecture and Design for Data Center Energy Efficiency</strong> (p187) Chuansheng Cheng, Hua Chen, Biquan Liang, Ning Liu, Chao Liu (Baidu); Jun Zhang, Nishi Ahuja, Jialiang Xu, Xiang Zhou (Intel)</td>
<td><strong>Life Expectancies of Ni-doped SAC Solder Alloy Subjected to Drop Test Loading</strong> (p280) Jia-Shen Lan, Mei-Ling Wu (National Sun Yat-Sen University)</td>
<td><strong>Abstract:</strong> This panel will explore multi-scale challenges in data centers being driven simultaneously by the rapid expected growth of internet of things (IOT), and computing hardware trends such as heterogeneous integration. Approaches for computing load balance, and improvement of energy efficiency, under realistic data center operational scenarios will be explored. The panel will also discuss recent advances in heterogeneous integration in computing hardware. Advances in thermal management technologies to enable future computing hardware will be presented.</td>
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| **Thermal Interface Material Enablement of Off-board Two-phase Cooling** (p220) Matthew Smith (Georgia Institute of Technology); Raffaele Amalfi (Ecole Polytechnique Federale de Lausanne); Todd Salamon (Nokia Bell Labs); John Thome (Ecole Polytechnique Federale de Lausanne) | **Fatigue Properties of Lead-free Doped Solder Joints** (p253) Sinan Su, Francy Akkara, Mohammed Abueed, Minghong Jian, Sa’d Hamasha, Jeffrey Suhling, Pradeep Lall (Auburn University) | **Panelists:**
Muhannad Bakir (Georgia Tech)  
Ali Merrikh (Qualcomm)  
Saeed Moghaddam (Univ. of Florida)  
Hiroaki Nishi (Keio University)  
Herman Oprins (IMEC) |
| **Porous Nickel as a Selective Emitter for Surface Cooling in Various Environments** (p274) Jonathan Sullivan, Anirudh Krishna, Jaeho Lee (University of California, Irvine) | **Student Poster Networking Session and Reception** | Fairbanks |
### DAY 3 SESSIONS: FRIDAY, JUNE 1, 7:00 - 10:30 AM

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<td>7:00 AM</td>
<td><strong>Speakers’ Breakfast, Fairbanks</strong></td>
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<td></td>
<td><strong>E-9: Thermal Experimental Methods, Nano-to-macro Scale I</strong></td>
<td>Point Loma B</td>
<td>Amy Marconnet (Purdue University), Patrick Shamberger (Texas A&amp;M University)</td>
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<td>8:00 AM</td>
<td><strong>Estimation of Measurement Uncertainties for Thermal Conductivity of Nanofluids Using Transient Plane Source (TPS) Technique (p137)</strong></td>
<td>Coronado A</td>
<td>Anil Yuksel (IBM), Prabhakar Subrahmanyam (Intel)</td>
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<td><strong>K-3 Keynote: Detector Thermal Management with CO2 Boiling Systems at CERN</strong></td>
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<td>Paolo Petagna (CERN)</td>
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<td>Paolo Petagna received a Master’s degree cum laude in Aeronautical Engineering from the University of Pisa in 1989, obtaining a research grant with the Department of Aerospace Engineering (DIA) on wake flows, 3D turbulent mixing and coaxial jets. In 1991, he founded ARIA (Aerodynamics Research for Industrial Applications), an applied research spin-off of DIA. From 1991 to 1995, he worked as consultant on applied R&amp;D problems for industrial partners including Ferrari, Brembo, and Piaggio, among others. In 1996 Paolo joined CERN (the European Organization for Nuclear Research), where he participated in the design and commissioning of the Central Tracker Detector of the CMS experiment. As a member of the CMS, NA62 and ALICE collaborations at CERN, he co-authored more than 50 papers. From 2009, Petagna has led the Detector Cooling Project of the CERN Physics Department, with major R&amp;D areas including CO2-based cooling systems, micro-channel cooling devices, and optical fibre sensors for relative humidity. He has co-authored more than 30 publications in these research areas.</td>
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<td>8:20 AM</td>
<td><strong>Measurement of Intrinsic Meniscus Profile near an Evaporating Contact Line in Partial Wetting Regime (p375)</strong></td>
<td>Coronado A</td>
<td>Yuehong Fan, Casey Winkel, Devdatta Kulkarni, Wenbin Tian (Intel)</td>
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<td>9:00 AM</td>
<td><strong>Analytical Design Methodology for Liquid Based Cooling Solution for High TDP CPUs (p132)</strong></td>
<td>Coronado A</td>
<td>Yuehong Fan, Casey Winkel, Devdatta Kulkarni, Wenbin Tian (Intel)</td>
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<td><strong>Design of a Two-phase Gravity-driven Micro-scale Thermosyphon Cooling System for High-performance Computing Data Centers (p177)</strong></td>
<td>Coronado A</td>
<td>Yuehong Fan, Casey Winkel, Devdatta Kulkarni, Wenbin Tian (Intel)</td>
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<td><strong>Experimental Study of Two-phase Cooling to Enable Large-scale System Computing Performance (p200)</strong></td>
<td>Coronado A</td>
<td>Devdatta Kulkarni, Xudong Tang, Sandeep Ahuja, Richard Dischler, Ravi Mahajan (Intel)</td>
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<td>10:00 AM</td>
<td><strong>Refreshment Break, Catalina &amp; Coronado Foyers</strong></td>
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# DAY 3 SESSIONS: FRIDAY, JUNE 1, 7:00 - 10:30 AM

| Coronado B |Point Loma A | Bel Aire |
| **Session Chairs:** Aydin Nabovati (Tesla), Man Prakash Gupta (Ford) | **Session Chairs:** Krishna Tunga (IBM), Sandeep Shantaram (NXP Semiconductors) | **Session Chair:** William D. Gerstler (GE Global Research) |
| **Thermal Management within Multi-disciplinary System Design of a Rubik's-cube-sized 2kW Power Inverter (p362)** David Guirguis, Miad Nasr, Samantha Murray, Hirokazu Matsumoto, Olivier Trescases, Cristina Amon (University of Toronto) | **Feature Extraction and RUL Prediction of SAC Solder Alloy Packages by Different Statistical and Time-frequency Analysis Techniques under Simultaneous Temperature-vibration Loads (p327)** Pradeep Lall, Tony Thomas, Jeff Suhling (Auburn University) | **Multi-physics Topology Optimization and Additive Manufacturing** Xiaoping Qian (University of Wisconsin-Madison) |
| **Experimental Validation of Thermal Performance of a Plate Heat Exchanger (PHX) with Phase Change Materials (PCM) for Thermal Energy Storage (TES) (p141)** Navin Kumar, Reynaldo Chavez, Debjyoti Banerjee (Texas A&M University) | **Temperature-dependent Electrical and Thermal Conductivity of Glassy Carbon Wires (p148)** Laia Ferrer-Argemi, Albert Cisquella-Serra, Marc Madou, Jaeho Lee (University of California, Irvine) | **Topology Optimization of Fluid-based and Conjugate Heat Transfer Problems** Joe Alexandersen (Technical University of Denmark (DTU)) |
| **Thermal Management Strategies for a High-frequency, Bi-directional, On-board Electric Vehicle Charger (p344)** Kshitij Gupta, Carlos Da Silva, Miad Nasr, Amir Assadi, Hirokazu Matsumoto, Olivier Trescases, Cristina Amon (University of Toronto) | **Board Level Solder Joint Reliability Assessment Study of Megtron 6 vs. FR-4 under Power Cycling and Thermal Cycling (p312)** Jyotirmoy Denria, Pavan Rajmane, Dereje Agonafer (University of Texas at Arlington) | **Additive Manufactured Thermal Management Products and Features: Experiences and Future Challenges** Jared Wolfe (GE Additive) |

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**K-3 Keynote: Detector Thermal Management with CO2 Boiling Systems at CERN**

Bel Aire
Paolo Petagna (CERN)

**Abstract:** For the thermal management of silicon detectors in the next generation of particle physics experiments, total powers well in excess of 100 kW with volumetric densities up to 100 W/dm³ must be removed from sealed volumes, where the detectors are organized in convoluted surfaces. In order to ensure their required operational life of 10 years, the silicon sensors, submitted to high radiation levels, must be maintained at temperatures well below 0° C. Furthermore, the mass of the support structures and ancillary systems must be minimized, while large temperature gradients, both in time and space, should be avoided.

The most demanding applications already implement boiling flows of CO₂ in small diameter evaporators: CO₂ presents extremely favourable thermo-physical properties, is radiation hard and environmentally friendly. The typical geometry of a silicon detector’s CO₂ evaporator is a few metres long pipe, 1.0 to 2.5 mm in I.D. However, after a recent successful application of silicon micro-structured cold plates in liquid phase, one experiment will implement for the first time in 2019 a cooling system based on CO₂ boiling in silicon micro-channels.

The talk will review the achievements and the ongoing R&D at CERN on both the local evaporators and global system design.

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Refreshment Break, Catalina & Coronado Foyers
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<td>10:30 AM</td>
<td><strong>E-10</strong>: Thermal Experimental Methods, Nano-to-macro Scale II</td>
<td>Point Loma B</td>
<td>Session Chairs: Amy Marconnet (Purdue University), Patrick Shamberger (Texas A&amp;M University)</td>
<td>Improving the Transient Thermal Characterization of GaN HEMTs (p307) Georges Pavlidis, Dustin Kendig, Luke Yates, Samuel Graham (Georgia Institute of Technology)</td>
<td>Nanoelectrosprayed Liquid Jets for Evaporative Heat Transfer Enhancement (p114) Joel Chapman, Peter Kottke, Andrei Fedorov (Georgia Institute of Technology)</td>
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<td>11:00 AM</td>
<td><strong>TI-10</strong>: Boiling, Condensation, Evaporation, and Microgap Cooling I</td>
<td>Coronado A</td>
<td>Session Chairs: Mehmet Arik (Ozyegin University), Emil Rahim (Google)</td>
<td>Measurement and Modeling of Heat Conduction in MEMS Nanostructures (p174) Marcin Janicki, Piotr Pietrzak, Piotr Zajac, Grzegorz Jablonski (Lodz University of Technology); Pawel Janus (Institute of Electron Technology)</td>
<td>3D Numerical Analysis of Phase Change Immersion Cooling for Electronic Components (p115) Xudong An, Manish Arora, Wei Huang, William C. Brantley, Joseph L. Greathouse (Advanced Micro Devices)</td>
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<tr>
<td>11:20 AM</td>
<td><strong>E-10</strong>: Thermal Experimental Methods, Nano-to-macro Scale II</td>
<td>Point Loma B</td>
<td>Session Chairs: Amy Marconnet (Purdue University), Patrick Shamberger (Texas A&amp;M University)</td>
<td>Temperature and Stress Metrology of Ultra-wide Bandgap $\beta$-Ga$_2$O$_3$ Thin Films (p289) Bikramjit Chatterjee (Pennsylvania State University); Jacob Leach (Kyma Technologies); Sarit Dhar (Auburn University); Sukwon Choi (Pennsylvania State University)</td>
<td>High Heat Flux Boiling Heat Transfer Through Nanoporous Membranes (p164) Qingyang Wang, Renkun Chen (University of California San Diego)</td>
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<td>12:00 PM</td>
<td>Luncheon: ITherm Best Paper Awards &amp; Organizer Recognitions</td>
<td>Fairbanks</td>
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<td>TII-10</td>
<td>Data Center Energy Efficiency IV</td>
<td>Coronado B</td>
<td>Prabhakar Marepalli (Intel), Mehdi Saeidi (Qualcomm)</td>
<td>Impact of Static Pressure Differential between Supply Air and Return Exhaust on Server Level Performance (p356) Ashwin Siddarth, Richard Eiland, John Fernandes, Dereje Agonafer (University of Texas at Arlington)</td>
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<td>M-10</td>
<td>Solder Characterization and Modeling II</td>
<td>Point Loma A</td>
<td>Krishna Tunga (IBM), Sandeep Shantaram (NXP Semiconductors)</td>
<td>A Comparative Study of the High Temperature Mechanical Behavior of Lead Free Solders (p338) Mohammad Alam, Jeffrey Suhling, Pradeep Lall (Auburn University)</td>
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<td>P-10</td>
<td>Thermal Management in Electronics: Materials, Devices, and Data Centers: Special Panel in Honor of Prof. Jayathi Murthy</td>
<td>Bel Aire South</td>
<td>Dhruv Singh (GlobalFoundries)</td>
<td>Thermal Management in Electronics: Materials, Devices, and Data Centers: Special Panel in Honor of Prof. Jayathi Murthy</td>
<td>Abstract: This special panel is a part of Prof. Jayathi Y. Murthy’s 60th birthday celebration at ITherm 2018, commemorating her numerous contributions and fundamental developments to heat transfer and thermal management. Over the past decades, research progress from her team has touched every facet of electronics thermal management – from fundamental physics of energy transport in materials, electron-phonon transport in ultrascaled devices to electronics cooling solutions spanning myriad applications. In tandem, the advances led by her in the development of large scale numerical methods have brought software tools to the forefront of industry enabling the necessary cross-disciplinary solutions. The panel puts forth a discussion of these challenges in the domain of electronics thermal management from transistors to data centers, their implications and a hierarchical view of scientific and engineering solutions needed to achieve them.</td>
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<td>The Impact of Cold Aisle Containment Pressure Relief on IT Availability (p324) Mohammad Tradat, Udaya Puvvadi, Bahgat Sammakia, Kanad Ghose (SUNY Binghamton); Mahmoud Ibrahim, Andrew Calder, Thomas Peddle (Panduit); Mark Seymour (Future Facilities); Husam Alissa (Microsoft)</td>
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<td>Effect of Prolonged Storage on High Strain Rate Mechanical Properties of SAC-Q Leadfree Solder at High Operating Temperature (p328) Pradeep Lall, Vikas Yadav, Jeff Suhling (Auburn University); David Locker (US Army AMRDEC)</td>
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<td>CFD Simulation and Optimization of the Cooling of Open Compute Machine Learning “Big Sur” Server (p357) Mangesh Dhadve, Jimil Shah, Dereje Agonafer (University of Texas at Arlington)</td>
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<td>A Joint-Scale Test Specimen for Tensile Properties of Solder Alloys (p267) Abhishek Deshpande, Qian Jiang, Abhijit Dasgupta (University of Maryland)</td>
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<td>Experimental Characterization of Vertically Split Distribution Wet-cooling Media Used in the Direct Evaporative Cooling of Data Centers (p377) Ahmed Al Khazraji, Ashwin Siddarth, Mullaivendhan Varadarasan (University of Texas at Arlington); Abhishek Guhe (Mestek); Dereje Agonafer (University of Texas at Arlington); James Hoverson, Mike Kaler (Mestek)</td>
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<td>Effects of Mechanical Cycling on the Microstructure of SAC305 Lead Free Solder (p397) Md Mahmudur Chowdhury, Nianjun Fu, Mohd Aminul Hoque, Sudan Ahmed. Jeffrey Suhling, Sa’d Hamasha, Pradeep Lall (Auburn University)</td>
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<td>Luncheon: ITherm Best Paper Awards &amp; Organizer Recognitions</td>
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Luncheon: ITherm Best Paper Awards & Organizer Recognitions
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<td><strong>Thermal Conductivity of Electrically Conductive Highly Boron Doped Diamond and its Applications at High Frequencies (p213)</strong> by Gruffudd Williams et al.</td>
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<td>2:00 PM</td>
<td><strong>First Demonstration of a Bendiang-Mode Elastocaloric Cooling 'Loop'</strong></td>
<td><strong>Flow Boiling Heat Transfer of HFE7000 in Manifold Microchannels Through Integrating Three-dimensional Flow and Silicon Nanowires (p185)</strong> by Sheng Wang et al.</td>
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<td>2:40 PM</td>
<td><strong>Temperature-dependent Adhesion Mechanisms of Metal and Insulator Probe-sample Contact Pairs (p242)</strong></td>
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<td>3:00 PM</td>
<td>Refreshment Break, Catalina &amp; Coronado Foyers</td>
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<td>Session Chairs: Krishna Valvala (Intel), Youmin Yu (Qualcomm)</td>
<td>Session Chairs: Vibhash Jha (NXP Semiconductors), Jaeho Lee (UC Irvine), Yingying Wang (Qualcomm)</td>
<td>Session Chairs: Cristina Amon (University of Toronto); Tim Fisher (UCLA)</td>
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| **Featured Paper Presentation**  
A System-Level Thermal Simulator with Automatic Meshing Techniques (p180)  
Jui-Hung Wang, Yu-Min Lee, Hsuan-Hsuan Hsiao (National Chiao Tung University); Liang-Chia Cheng (Industrial Technology Research Institute) | **Featured Paper Presentation**  
A Study on Die Stresses in Flip Chip Packages Subjected to Various Hygrothermal Exposures (p399)  
Quang Nguyen, Jordan Roberts, Jeffrey Suhling, Richard Jaeger, Pradeep Lall (Auburn University) | Validation of Direct Numerical Simulations of Two-phase Slug Flow Boiling  
Suresh Garimella (Purdue) |
| **Experimental Determination of Junction-Thermal Challenges and Solutions of M.2 Solid State Drive (p129)**  
Ning Ye, Yangming Liu, Zhongli Ji, Dmitry Vaysman, In-Soo Yoon, Hem Takiar (Western Digital) | **Thermal Expansion Investigation of Liquid Cold Plate with Varying Ambient Temperature at Storage (p108)**  
Murat Parlak (Aselsan / University of Gazi-Ankara); Vedat Yagci (Aselsan / Middle East Technical University-Ankara) |  |
| **Designing a Temperature Model to Understand the Thermal Challenges of Portable Computing Platforms (p118)**  
Ying-Ju Yu, Carole-Jean Wu (Arizona State University) | **Thermal Performance Evaluation and Reliability Analysis of Air-cooled Power Modules (p173)**  
Koichi Ishiyama, Shingo Nakayama, Qiang Yu (Yokohama National University) | **Next Generation Atomistic Modeling of Thermal Transport**  
Alan McGaughey (CMU) |
| **Impact of Chipset Configuration on Thermal Performance in Smartphones (p247)**  
Youmin Yu, Nader Nikfar, Todd Sutton (Qualcomm) | **Effect of Thermal Cycling on Reliability of QFN Packages (p326)**  
Pradeep Lall, Shantanu Deshpande, Nakul Kothari (Auburn University); Luu Nguyen (Texas Instruments) |  |
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<td>3:30 PM</td>
<td><strong>E-12:</strong> Emerging Materials and Thermal Phenomena II</td>
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<td>Sukwon Choi (Pennsylvania State University), Yaguo Wang (UT Austin), and Banafsheh Barabadi (MIT)</td>
<td><strong>Featured Paper Presentation</strong> Feature Paper within the Delphi4LED Project (p393) Gabor Farkas, Lajos Gaal, Marton Bein, Andras Poppe, Sandor Ress, Marta Rencz (Mentor)</td>
<td><strong>Featured Paper Presentation</strong> Experimental Characterization of Cold Plates Used in Cooling Multi Chip Server Modules (MCM) (p227) Bharath Ramakrishnan, Yaser Hadad (SUNY Binghamton); Sami Alkharabsheh (Ford); Paul Chiarot, Kanad Ghose, Bahgat Samnakia (SUNY Binghamton); Vadim Gektin, Wang Chao (Huawei Technologies)</td>
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<td>4:00 PM</td>
<td>Experimental Measurement of the Effect of Particle Concentration on the Specific Heat Capacity of Silica Nanofluids (p143)</td>
<td>Coronado A</td>
<td>**Maldistribution of Two-Phase Flow in Parallel Channel Heat Sinks: Effects of Thermal Connection between Channels (p128) Gaurav Patankar, Todd Salamon (Nokia Bell Labs)</td>
<td>**Experimental Measurement of the Effect of Particle Concentration on the Specific Heat Capacity of Silica Nanofluids (p143) Binjian Ma, Navin Kumar, Aditya Kuchibhotla, Debjyoti Banerjee (Texas A&amp;M University)</td>
<td>**Maldistribution of Two-Phase Flow in Parallel Channel Heat Sinks: Effects of Thermal Connection between Channels (p128) Gaurav Patankar, Todd Salamon (Nokia Bell Labs)</td>
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<td>Amy Xia (Intel), Mark North (Aavid)</td>
<td>Packaging and Thermal Decoupling of an Optical Array Using a Thermoelectric Cooler (p279)</td>
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<td>Sandeep Shantaram, A. R. Nazmus Sakib, Nishant Lakhera (NXP Semiconductors)</td>
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<td>Jaime Sanchez (Intel)</td>
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<td>Simulation Driven Design of Novel Integrated Circuits – Part 4: Method of Validation of Coupled Thermal And Thermo-mechanical Simulation (p276)</td>
<td>Przemyslaw Gromala, Alicja Palczynska (Robert Bosch GmbH); Bulong Wu, Bongtae Han (University of Maryland)</td>
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<td>Thermoelectric Cooling Device Based on Holey Silicon (p196)</td>
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<td>Effect of Solder Sphere Alloys and Surface Finishes on the Reliability of Lead-free Solder Joints in Accelerated Thermal Cycling (p258)</td>
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<td>Hedan Zhang (Western Digital); Hainan Wang (Cadence); Shay Braha, Ernold Thompson, Ning Ye (Western Digital); Nathan Ai, C. T. Kao (Cadence); Nir Amir (Western Digital)</td>
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Abstracts Due: September 3, 2018

ITherm 2019 is the leading international conference for scientific and engineering exploration of thermal, thermomechanical and emerging technology issues associated with electronic devices, the 69th ECTC 2019, at the Cosmopolitan of Las Vegas. Joint registrations are available at a discounted rate.

18th Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems

May 28 – 31, 2019
Cosmopolitan of Las Vegas
Las Vegas, NV, USA

Call for Abstracts

All papers will be peer reviewed and published in the ITherm proceedings. Student first authors will have the opportunity to apply for ITherm travel grants in order to make an oral presentation and participate in a Student Poster and Networking Session. In addition to paper presentations and vendor exhibits, ITherm 2019 will have panel discussions, keynote lectures by prominent speakers, invited Tech Talks, and professional short courses. Original papers are solicited in the following general areas of interest (but not limited to):

Component-Level Thermal Management

- Single/Multi Chip Module & System in Package
- 3D Packaging & Embedded Cooling
- Hotspot & Impingement Cooling
- Passive Two-Phase Cooling: Heat Pipes, Vapor Chambers, & Thermosyphons
- Pulsating/Oscillating & Non-Conventional Heat Pipes
- Thermal Interface Materials and Heat Spreaders
- Thermoelectricity & Peltier Devices
- Novel Air Cooling Techniques & Heat Exchangers
- Pumps, Compressors, Fans & Blowers
- Single-Phase Liquid & Two-Phase Cold Plates
- Boiling/Evaporation/Condensation, Microgap Cooling

System-Level Thermal Management

- Data Center Energy Efficiency
- Thermal Storage
- Immersion Cooling, Refrigeration
- Mobile, Internet of Things, MEMS
- Telecommunication Systems
- Automotive; Space and Aerospace
- Power Electronics
- LEDs
- Photovoltaics
- RF Electronics
- Batteries

Mechanics & Reliability

- Thermo-Mechanical Modeling and Simulation of Devices, Components, Boards, and Systems
- Mechanics and Reliability of Solder Joints & Interconnects
- Materials Characterization, Processing, Constitutive Models
- Failure Mechanics, Fatigue, Damage Modeling
- Experimental Techniques for Packaging Deformations, Strains, and Stresses
- Shock, Drop, and Vibrational Analysis of Packages, Sub-Systems, and Systems
- TSV / 3D Reliability and Packaging Challenges
- Mechanics Issues in Assembly and Manufacturing
- Applied Reliability for Failure Detection and Characterization
- Process-Structure-Property Correlations / Multi-Scale Analyses for Degradation and Failure
- Accelerated Stress Testing and Modelling
- Lifetime Prognostics and Condition Monitoring

Emerging Technologies and Fundamentals

- Numerical Methods from Nano-to-Macro Scale
- Experimental Methods from Nano-to-Macro Scale
- Nanotechnology Including 1-D and 2-D Materials
- Thermal Interface Materials and Phase Change Materials
- Embedded Cooling
- Transistor Technology
- Novel Materials and Fabrication Techniques
- Measurement and Instrumentation Techniques
- Prognostic Health Management and Reliability Analysis
- Flexible Electronics

ITherm provides an opportunity for industrial and university participation in the form of financial support to ITherm 2019. All contributors will be given strong recognition both onsite and in the conference materials.

Prof. Jeffrey C. Suhling, General Chair, jsuhling@auburn.edu
ITherm Website: http://ieee-itterm.net/

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Dr. Vadim Gektin, Program Chair, Vadim.Gektin@huawei.com
Prof. Justin A. Weibel, Vice Program Chair, jaweibel@purdue.edu

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<td>8:00-9:00</td>
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<td>9:00-10:00</td>
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<td>10:00-10:30</td>
<td>Heterogeneous Integration Roadmap Workshop (8:00-5:00)</td>
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<td>Day-1: Wednesday, May 30, 2018</td>
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