

Final Conference Program

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



ITherm
LAS VEGAS, NV
2019

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



WELCOME LETTER

On behalf of the organizing committee, it is a great pleasure to welcome you to ITherm 2019, the leading international conference for scientific and engineering exploration of thermal, thermo-mechanical and emerging technology issues associated with electronic devices, packages, and systems. ITherm 2019 is being held along with the 69th Electronic Components and Technology Conference (ECTC), a premier electronic packaging conference.

ITherm 2019 is packed with many activities, including over 180 Technical Papers in 50 sessions and 4 Technical Tracks; 3 Keynote Talks addressing the heterogeneous integration, optimization and control of electronic systems, and future technologies for servers and advanced computing; 5 Technical Panel Sessions for a highly interactive engagement with experts; 5 Technology-Talk Sessions providing deep dive talks on high profile topics; over 70 Student Posters as a highly interactive forum on the latest research; 18 Professional Development Courses including two with heavy thermal content; and Vendor Exhibits and Presentations. For ITherm 2019, several sessions have identified outstanding papers that will be featured in the sessions with longer presentation times. Several exciting joint ECTC/ITherm events will be held on Tuesday evening including a Student Reception, Young Professionals Networking Reception, and the EPS President's Panel on future visions for electronic packaging. On Wednesday evening, there will be a new student additive manufacturing heat sink design competition session, as well as a joint ECTC/ITherm Women's Panel. Furthermore, a third annual Art-in-Science exhibition will be held during the conference with voting throughout the week using the conference app.

Many thanks go to everyone who has contributed to the success of ITherm 2019. 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 complete list of key contributors is listed 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 2019 conference and making it possible by your attendance. If this is not your first time attending ITherm, then welcome back and we hope you will establish new contacts and friends. Please welcome our first-time attendees, and help them to meet others. Regardless of whether this is your first time with us or not, we will endeavor to have you enjoy the conference and come back to attend again in the future. We hope that while you enjoy the wide variety of technical venues that ITherm 2019 offers, you can also take a little extra time to enjoy the various entertainment and dining options in the Las Vegas area. ITherm 2020 will be held in Orlando, FL on May 26-29, 2020, and we hope that you mark your calendars to be there as well.

Best wishes,



Jeffrey C. Suhling, Ph.D.
General Chair



Vadim Gektin, Ph.D.
Program Chair



Justin A. Weibel, Ph.D.
Vice Program Chair



Dustin W. Demetriou, Ph.D.
Communications Chair

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CONFERENCE DESCRIPTION

Sponsored by the IEEE's Electronics Packaging Society (EPS), ITherm 2019 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 2019 will be held along with the 69th Electronic Components and Technology Conference (ECTC 2019, <http://www.ectc.net>), a premier electronics packaging conference at The Cosmopolitan of Las Vegas, Las Vegas, NV USA. Dual-registration for ITherm and ECTC is offered at a substantial discount. In addition to paper presentations and vendor exhibits, ITherm 2019 will include panel discussions, keynote lectures by prominent speakers, invited Tech Talks, and professional short courses.



CONFERENCE SUMMARY

- **Over 180 Technical Papers in 50 Sessions** that are organized into **4 Technical Tracks**
- **3 Keynote Talks** covering the areas of heterogeneous packaging, assembly and test, thermal management in complex systems, and computing beyond Moore's Law
- **5 Technical Panel Sessions** for a highly interactive engagement with experts
- **5 Technology-Talk Sessions** providing deep dive talks on high profile topics
- **70 Student Posters** as a highly interactive forum on the latest research
- **18 Professional Development Courses** including 2 with heavy thermal content
- **Vendor Exhibits and Presentations**
- **38 Featured Presentations** with expanded presentation length
- **Art-in-Science Exhibition** and **Student Heat Sink Design Challenge**
- **ECTC/ITherm Joint Women’s Panel** and **Young Professional’s Networking Reception**
- **Heterogeneous Integration Roadmap (HIR) All-Day Workshop**
- **EPS President’s Panel Session**



Explore the Potential of AI with Boundless Computing

Huawei intelligent computing
leads the way to a fully connected, intelligent world.

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LEADING NEW ICT

GENERAL INFORMATION

REGISTRATION

Location: The Cosmopolitan of Las Vegas, Level 3, Gracia Commons

Opening Hours:

Tuesday, May 28	3:30 PM – 5:30 PM
Wednesday, May 29	6:30 AM – 5:30 PM
Thursday, May 30	7:00 AM – 5:30 PM
Friday, May 31	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)	IEEE Member Fee	Non-Member Fee	Student
Joint ITherm/ECTC Registration	1,160 USD	1,375 USD	
ITherm Registration	750 USD	900 USD	400 USD
One-Day Registration	400 USD	400 USD	

Speakers: On the day of your talk/session, please attend the Speakers' Breakfast in Gracia 4/8 from 7:00-7:45 AM to meet your session chairs and go over session procedures.

MISCELLANEOUS INFORMATION

HOTEL AMENITIES

The Cosmopolitan of Las Vegas features:

- Located in the heart of Las Vegas Boulevard
- 24-Hour Front Desk
- Complimentary Wireless in Lobby Area
- Several Restaurants
- Valet and Self Service Parking (Fee) for Guests
- Business Center, Gift Shop, Guest Launderette
- Fitness Center, Pools, Game Rooms, Spa

GENERAL EMERGENCY INFORMATION

Cosmopolitan Security Personnel respond to all emergencies 24 hours. House Phone "X55555" or Outside Line "702-698-1911". All Security Personnel are First Aid, CPR and AED Trained/Certified. Preparedness, Response, Evacuation and Emergency Plans are on file.

COMMITTEE MEETINGS

ITherm EXECUTIVE COMMITTEE

The ITherm Executive Committee meeting will take place in Condesa 4 (2nd Floor) on Wednesday May 29th, from 5:00 to 6:00 PM. *By invitation only.*

ASME K-16 COMMITTEE

The ASME K-16 Committee meeting will take place in Condesa 4 (2nd Floor) on Wednesday May 29th, from 7:30 to 8:30 PM. *Open to Committee Members and to all interested in becoming involved.*

ITherm 2020 PROGRAM PLANNING

The ITherm 2020 Program Planning meeting will take place in Gracia 3, on Thursday May 30th, from 7:00 to 8:00 PM. *Open to all current and future contributors.*

ASME JOURNAL OF ELECTRONIC PACKAGING

Journal of Electronic Packaging meeting hosted by Editor Y. C. Lee will be held in Condesa 4 (2nd Floor) on Wednesday May 29th, from 8:30 to 9:00 PM. *Open to all who are interested.*

ITherm 2019 ORGANIZERS DINNER

The ITherm 2019 Organizers Dinner will take place at Jaleo Restaurant (3rd Floor) on Thursday May 30th, from 8:00 to 10:00 PM. *By invitation only.*

EPS COMMITTEE MEETING

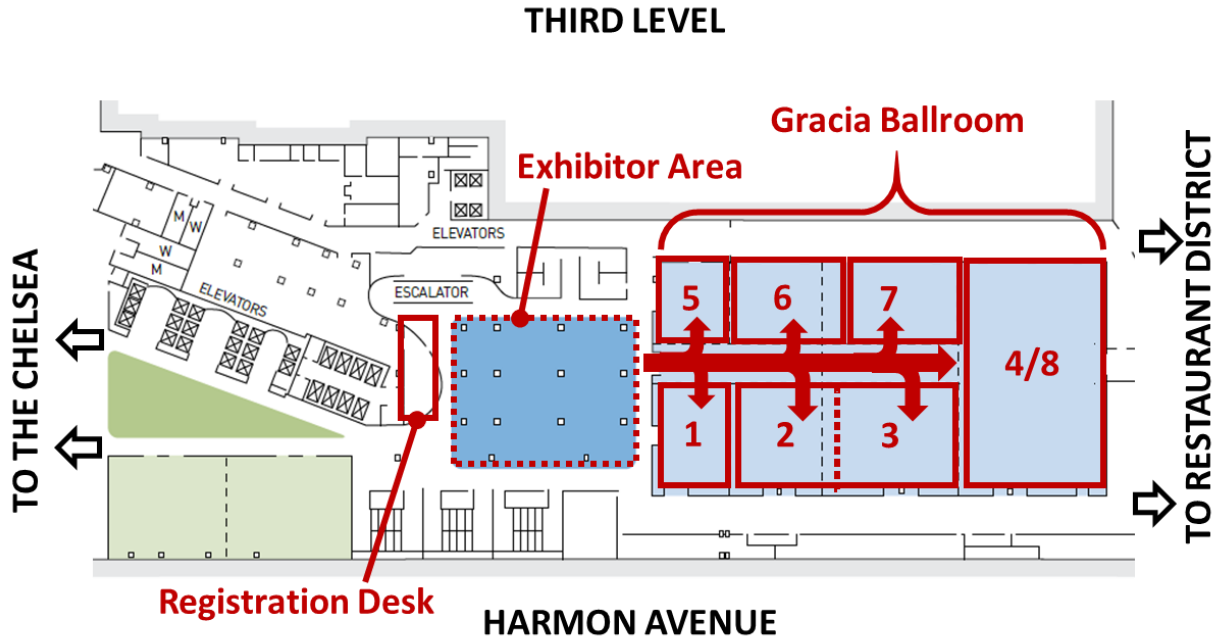
The IEEE EPS Thermal and Mechanical Technical Committee will meet in Condesa 5 (2nd Floor) on Thursday May 30th, from 7:00-8:00 AM.

CONFERENCE SITEMAP

COSMOPOLITAN (THIRD LEVEL MAP)



ITherm 2019 MEETING LOCATIONS



SPONSORS & VENDOR EXHIBITS

For more details on our ITherm 2019 Sponsors, Exhibitors, and Partners, please visit:
http://ieee-itherm.net/itherm/conference/sponsors_and_exhibitors

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SILVER SPONSOR



PROGRAM SPONSOR



EXHIBITORS



PARTNERS



Direct Contact Liquid Cooling (DCLC™)

Maximizing Data Center Performance



Performance

Facilitates peak performance for higher powered or overclocked processors



Efficiency

Significant reduction in data center energy consumption



Density

Enables 100% utilization of rack and data center spaces



Patented Split-Flow Coldplates

A key component of the Server Module, CoolIT Systems' patented Split-Flow Coldplates are solid copper components which deliver superior performance for today's high thermal density processors.

The Split-Flow design uses microchannel architecture to minimize pressure drop, maximize coolant flow, and direct the coolest liquid to the hottest area of the processor first.

At only 2.4mm in height, Coldplates are easily integrated into extremely compact, low-profile blade architectures, and allow for optimal performance.

Custom Coldplate designs are available.



Prepare to Liquid Cool your electronics.
Stop by the CoolIT booth or email our team at sales@coolitsystems.com to learn how



CONFERENCE ORGANIZATION COMMITTEE

ORGANIZATION COMMITTEE

General Chair	Jeffrey C. Suhling	Auburn University
Program Chair	Vadim Gektin	Futurewei Technologies
Vice Program Chair	Justin A. Weibel	Purdue University
Communications Chair	Dustin W. Demetriou	IBM Corporation

COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

Chair	Kamal Sikka	IBM Corporation
Co-Chair	Banafsheh Barabadi	Massachusetts Institute of Technology
Co-Chair	Lauren Boteler	US Army Research Laboratory
Co-Chair	Jin Yang	Intel Corporation

SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

Chair	Michael J Ellsworth Jr.	IBM Corporation
Chair	Ashish Gupta	Intel Corporation
Co-Chair	Chandra Mohan Jha	Intel Corporation
Co-Chair	Emil Rahim	Google

EMERGING TECHNOLOGIES & FUNDAMENTALS TRACK

Chair	Amir H. Shooshtari	University of Maryland
Co-Chair	Sukwon Choi	Penn State University
Co-Chair	Satish Kumar	Georgia Institute of Technology
Co-Chair	Amy Marconnet	Purdue University

MECHANICS & RELIABILITY TRACK

Chair	Abhijit Dasgupta	University of Maryland
Co-Chair	Przemyslaw Gromala	Bosch
Co-Chair	Pradeep Lall	Auburn University

SPECIAL TECHNICAL CONTRIBUTIONS

Keynotes Chair	John Thome	EPFL, JJ Cooling Innovation Sàrl
Keynotes Co-Chair	Amy Fleischer	Cal Poly
Keynotes Co-Chair	Satish Kumar	Georgia Institute of Technology
Technology-Talk Chair	Peter de Bock	GE Global Research
Technology-Talk Co-Chair	David H. Altman	Raytheon
Technology-Talk Co-Chair	Madhusudan Iyengar	Google
Panels Chair	Victor Chiriac	Futurewei Technologies
Panels Co-Chair	Baris Dogruoz	Cisco
Panels Co-Chair	Przemyslaw Gromala	Bosch
Poster Session & Art-in-Science Chair	Mahsa Ebrahim	Loyola Marymount University
Poster Session Co-Chair	Khosrow Ebrahimi	Minnesota State University, Mankato
Poster Session Co-Chair	Amir H. Shooshtari	University of Maryland
PDC Short Course Chair	Patrick McCluskey	University of Maryland
PDC Short Course Co-Chair	Jeffrey Suhling	Auburn University

Women's Panel Representative	Cristina Amon	University of Toronto
Women's Panel Representative	Amy Fleischer	Cal Poly

ADMINISTRATIVE

Administrative Assistant	Damaris David	ITherm
Sponsoring & Exhibitor Chair	Joshua Gess	Oregon State University
Sponsoring & Exhibitor Co-Chair	Gary B. Kromann	Consultant
Finance Chair	Milnes David	IBM Corporation
Operations Chair	Pritish Parida	IBM Research
NSF Interactions Chair	Yoonjin Won	University of California, Irvine
On-Site Registration	Susan Ansorge	

COMMUNICATION

Paper Management Database	Sandeep Tonapi	Anveshak
Conference Proceedings Manager	Paul Wesling	ITherm
Technical Program and Design	Vadim Gektin	Futurewei Technologies
Technical Program and Design	Justin Weibel	Purdue University
Webmaster	Shashank Thakur	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	Yogendra K. Joshi	Georgia Institute of Technology
Richard Chu ITherm Award Co-Chair	Koneru Ramakrishna	Thermal Consultant
Best Paper Award Chair	Yogendra K. Joshi	Georgia Institute of Technology
Best Paper Award Co-Chair	Koneru Ramakrishna	Thermal Consultant

INTERNATIONAL ITherm AMBASSADORS

Ambassador	Mehmet Arik	Ozyegin University, Turkey
Ambassador	Ryan Enright	Nokia Bell Labs, Ireland
Ambassador	Roger Kempers	York University, Canada
Ambassador	Poh Seng Lee	NUS, Singapore
Ambassador	Rishi Raj	IIT Patna, India

ITherm LINKEDIN GROUP

You can follow ITherm activities at LinkedIn: <https://www.linkedin.com/groups/8650280>

CONFERENCE EXECUTIVE COMMITTEE

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.

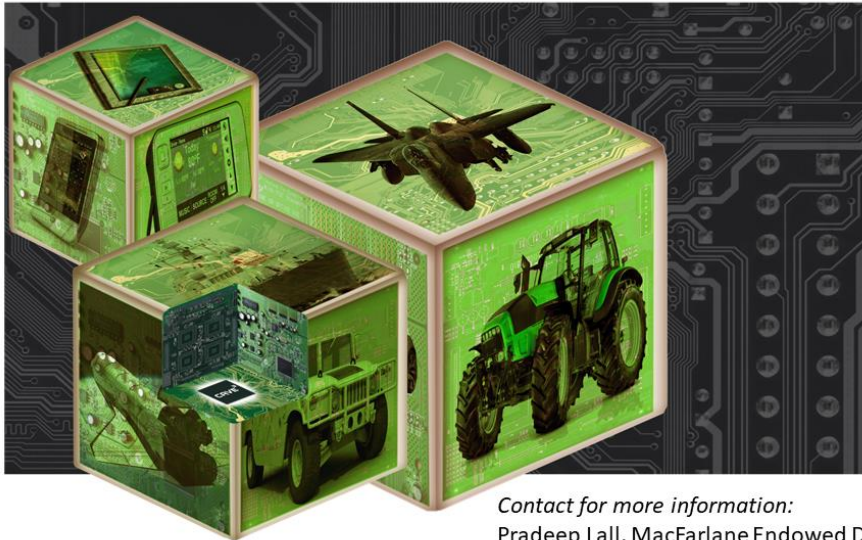
Dereje Agonafer	University of Texas at Arlington
Cristina H. Amon	University of Toronto
Mehdi Asheghi	Stanford University
Avram Bar-Cohen	University of Maryland
Sushil H. Bhavnani	Auburn University
Thomas Brunswiler	IBM Research – Zurich
Madhusudan Iyengar	Google
Yogendra K. Joshi	Georgia Institute of 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



NSF-CAVE3 Electronics Research Center Auburn University

Experts in Harsh Environment Electronics

cave³



Contact for more information:

Pradeep Lall, MacFarlane Endowed Distinguished Professor
and Director; Tele: (334)844-3424; lall@auburn.edu

10th ANNIVERSARY **6SigmaET**
by Future Facilities

Intelligent Thermal Simulation For Electronics

“As a user of multiple CFD packages, meshing imported geometry is always a challenge, in particular for complex geometry. However, for me, **the gold standard is 6SigmaET**. The process of importing CAD geometry is simple and the built-in meshing rules work beautifully.”

*-Michael Schroeder
Thermal Mechanical Engineer, Intel Corporation*

LAST YEAR'S BEST PAPERS (ITherm 2018)

COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

BEST PAPER

Nanoelectrosprayed Liquid Jets for Evaporative Heat Transfer Enhancement

Joel D. Chapman, Peter A. Kottke, Andrei G. Fedorov
(Georgia Institute of Technology)

OUTSTANDING PAPER

Measuring Heat Transfer Coefficients for Microchannel Jet Impingement Using Time-domain Thermoreflectance

Thomas Germain, Tanvir A. Chowdhury, Jake Carter,
and Shawn A. Putnam (University of Central Florida)

SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

BEST PAPER

Designing a Temperature Model to Understand the Thermal Challenges of Portable Computing Platforms

Ying-Ju Yu and Carole-Jean Wu (Arizona State
University)

OUTSTANDING PAPER

A Compact Cooling-System Model for Transient Data Center Simulations

James W. VanGilder, Christopher M. Healey, Michael
Condor, Wei Tian, and Quentin Menuisier (Schneider
Electric)

EMERGING TECHNOLOGIES AND FUNDAMENTALS TRACK

BEST PAPER

Boiling Heat Transfer Performance of Three-dimensionally Ordered Microporous Copper with Modulated Pore Diameters

Quang N. Pham, Shiwei Zhang, Lin Cheng-Hui, Shuai
Hao, and Yoonjin Won (University of California –
Irvine)

OUTSTANDING PAPER

Thermal Boundary Conductance Mapping at Metal-MoSe₂ Interface

David B. Brown (Georgia Institute of Technology);
Xufan Li, Kai Xiao, David B. Geohegan (Oak Ridge
National Laboratory); Satish Kumar (Georgia Institute
of Technology)

MECHANICS AND RELIABILITY TRACK

BEST PAPER

A Novel Concept for Accelerated Stress Testing of Thermal Greases and In-situ Observation of Thermal Contact Degradation

Bernhard Wunderle, Daniel May, Jens Heilmann, Joerg
Arnold, Josef Hirscheider, Y. Li (Chemnitz University of
Technology); Joerg Bauer (Fraunhofer IZM); Mohamad
Abo Ras (Berliner Nanotest and Design GmbH)

OUTSTANDING PAPER

A Novel Numerical Multiphysics Framework for the Modeling of Cu-Al Wire Bond Corrosion under HAST Conditions

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

KEYNOTES



Gaurang Choksi
Intel Corporation



Andrew Alleyne
University of Illinois,
Urbana-Champaign



Cullen Bash
Hewlett Packard Enterprise

K-1: COMPONENT INTEGRATION VS. PRODUCT DIFFERENTIATION: ELECTRONIC PACKAGING CHOICES FOR HETEROGENEOUS ASSEMBLY & TEST

Presenter: Gaurang Choksi, Intel Corporation

May 29, Wednesday, 9:00-10:00 AM, Gracia 2/3

Abstract: During the last few decades, advances in electronic packaging have supported and sustained significant growth across computing, networking and data management ecosystems. Emerging applications and increased competition will drive an extremely diverse set of 2D, 2.5, 3D packaging architectures and designs, requiring novel material technologies and manufacturing processes. The area of heterogeneous packaging, assembly and test will continue to require significant improvements in the collaterals required for time-sensitive, cost-effective, and ‘smart’ technologies. This drives the need to define, develop and deploy cost-effective solutions that balance the need for increased integration and enabling the right level of product differentiation. Rigorous assessments with the appropriate quantification and understanding of multiple trade-offs across performance, manufacturing complexity, yield and cost need to be comprehended for the right decisions to be made on different options and the degree of component integration vs. product differentiation.

Challenges need to be addressed for facilitating the effective analysis and characterization to facilitate efficient design, materials selection and associated assembly and test manufacturing processes. The role of inter-disciplinary solutions and the need for new competencies will be highlighted, including recent trends in technologies, advanced analysis / simulation tools and metrologies and their applications to electronic packaging. This includes the analysis, characterization, validation and optimization of the different steps of the design, assembly manufacturing and test equipment and processes, and the design / materials used to meet mechanical integrity, reliability, high speed signal integrity, power delivery and thermal dissipation requirements.

Gaurang Choksi joined Intel in 1988 after receiving his PhD degree and during his 30+ year tenure at Intel, he has contributed to various areas including mechanical analysis and testing, electrical and physical design and analysis of multi-chip modules, design/analysis tool development for packages/boards, and thermal technologies and solutions. The scope of his group currently includes materials selection and characterization, dimensional measurements, and modeling and validation related to structural integrity, power delivery, high speed signaling, thermals and heat dissipation, and fluid flow to support the design and development of electronic packaging, assembly and test technologies. The group has teams and labs in Chandler, Oregon and Malaysia. He is a recipient of the Intel Achievement Award and serves on national advisory / review boards.

K-2: A SYSTEMS APPROACH TO MANAGEMENT OF TRANSIENT THERMAL SYSTEMS FOR MOBILE ELECTRIFICATION

Presenter: Andrew Alleyne, University of Illinois, Urbana-Champaign

May 30, Thursday, 9:00-10:00 AM, Gracia 2/3

Abstract: Modern electrified mobility demands increased levels of electrical power, thereby putting mounting strains on the concomitant thermal management. These trends can be seen across a variety of mobility modalities. This talk will present results on the management of thermal loads from a systems perspective with a focus on complex systems having multiple interconnected subsystems; these subsystems include thermal sources, sinks, transport, heat exchange interfaces, and storage elements. The overall systems also include the interaction with the electrical components providing the source of the thermal loads. First, we introduce a graph-based framework that is useful for understanding the complex interconnections within these systems. Subsequently, we will present numerical design optimization approaches that exploit the mathematical formulation resulting from the graphs to select vehicle topology as well as component sizing while considering both static design and dynamic control. This optimization approach includes the co-design of the electrical and thermal, or electro-thermal, systems rather than the more typical sequential design of electrical systems dictating thermal requirements. Thirdly, a control approach for the complex electro-thermal class of systems using a hierarchical approach will be presented. The hierarchical framework allows for the simultaneous management of both the electrical and thermal power. The presentation will include design examples from the automotive and aerospace domains.

Andrew Alleyne received his B.S.E. from Princeton and his M.S./Ph.D. degrees, respectively, from UC Berkeley. He joined the University of Illinois, Urbana-Champaign in 1994 where he currently holds the Ralph and Catherine Fisher Professorship and is the Director for the NSF Engineering Research Center on Power Optimization for Electro-Thermal Systems (POETS). His research focuses on the modeling, simulation and control of nonlinear mechanical systems with a current focus on transient thermal system. His academic record includes supervision of over 80 M.S. and Ph.D. students and over 400 conference and journal publications. He has been a Distinguished Lecturer of the Institute for Electronic and Electrical Engineers (IEEE) and a National Research Council (NRC) Associate. He is a Fellow of IEEE and ASME and currently serves on the Scientific Advisory Board for the U.S. Air Force and the National Academies Board On Army Research and Development.

K-3: COMPUTING BEYOND MOORE'S LAW

Presenter: Cullen Bash, Hewlett Packard Enterprise

May 31, Friday, 9:00-10:00 AM, Gracia 2/3

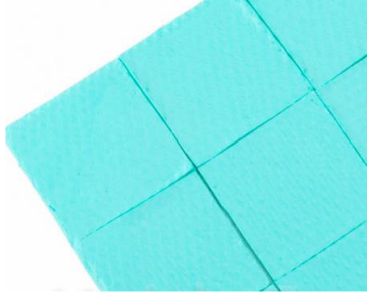
Abstract: The end of Moore's Law scaling coupled with the proliferation of data brought on by an increasing array of devices at the edge of the network is forcing a fundamental shift in computer architecture. For over 65 years classical Von Neumann architecture, where computational elements like CPUs make up the core of any system, are giving way to new architectures where memory is the dominant element surrounded by a heterogeneous mix of computational devices that are increasingly being constructed to serve specific, rather than general, workloads. These new architectures offer fewer constraints on design resulting in the creation of a number of unique devices that place new challenges on traditional architectural elements like communication fabrics, data storage and even the way in which computations are performed at the fundamental level. This talk will introduce some of these new elements and the workloads that drive their design. Particular emphasis will be placed on advances in photonics, computational accelerators and computer architecture.

Cullen Bash is a Vice President of R&D at Hewlett Packard Labs and currently serves as Director of the Systems Architecture Lab where he leads a multi-disciplinary team of researchers investigating computer architecture ranging from data centers to distributed systems. His team focuses on a wide range of inter-related topics including system and fabric architecture, system software, photonics, IC packaging, energy and thermal sciences, and software-hardware co-design. Cullen will also be serving as General Chair of IEEE's International Conference on Rebooting Computing in November of 2019.



Tflex HD80000 Series Thermal Gap Filler

PRODUCT DESCRIPTION



Laird Tflex™ HD80000 is the latest product in the High Deflection gap filler series. Tflex™ HD80000 combines 6 W/mK thermal conductivity with superior pressure versus deflection characteristics. The combination will allow minimal stress on components while also yielding low thermal resistance. As a result, less mechanical and thermal stresses will be experienced within your device.

The Tflex HD80000 material is extremely soft, but also can be handled and applied manually without the need to add a fiberglass or other reinforcement layer, maintaining the superior thermal performance of the product.

FEATURES AND BENEFITS

- 6 W/mK thermal conductivity
- Low pressure versus deflection
- Excellent surface wetting for low contact resistance
- No fiberglass reinforcement
- Minimizes board and component stress
- Environmentally friendly solution that meets regulatory requirements including RoHS and REACH

SPECIFICATIONS

TYPICAL PROPERTIES	VALUE	TEST METHOD
Construction & Composition	Ceramic filled silicone sheet	N/A
Color	Teal	Visual
Thickness Range	1 mm (0.040") - 5.0mm (0.20")	N/A
Thickness Tolerance	+/- 10%	N/A
Thermal Conductivity (W/mK)	6.0	Hot Disk
Density (g/cc)	3.3	Helium Pycnometer
Hardness (Shore 00, 3 sec)	40	ASTM D2240
Hardness (Shore 00, 30 sec)	32	ASTM D2240
Outgassing TML (weight %)	0.3	ASTM E595
Outgassing CVCM (weight %)	0.04	ASTM E595
Temperature Range	-40°C to 150°C	Laird Test Method
Rth@ 50 mils, 10 psi	0.330	ASTM D5470 (Modified)
Dielectric Constant @ 1 MHz	9	ASTM D150
UL Flammability Rating	V-0	UL 94
Volume Resistivity	1.06 x 10 ¹⁶	ASTM D257

Americas: +1.866.928.8181
Europe: +49.(0).8031.2460.0
Asia: +86.755.2714.1166

www.lairdtech.com

PROFESSIONAL DEVELOPMENT COURSES

A set of 18 Professional Development Courses (PDCs) are being offered as a collaboration between the co-located ITherm and ECTC Conferences. All PDC courses will be held on Tuesday, May 28, 2019, on the day before the start of the ITherm and ECTC conferences. A separate registration fee is required to attend these courses, and the PDC course registration can be performed at the ECTC registration desk located on 4th floor of the Cosmopolitan Hotel.

MORNING COURSES (8:00 AM – 12:00 PM)

PDC 01. Achieving High Reliability of Lead-Free Solder Joints – Materials Considerations

Ning-Cheng Lee – Indium Corporation

PDC 02. Introduction to Fan-Out Wafer Level Packaging

Beth Keser – Intel Corporation

PDC 03. Fundamentals of Glass Technology and Applications for Advanced Semiconductor Packaging

Dr. Indrajit Dutta – Corning, Inc.

PDC 04. New Era in Electronics: Moore's Law for ICs – Yesterday and Moore's Law for Packaging Tomorrow

Rao Tummala – Georgia Institute of Technology

PDC 05. Polymers and Nanocomposites for Electronic and Photonic Packaging

C. P. Wong – Georgia Institute of Technology; Daniel Lu – Henkel Corporation

PDC 06. Fundamentals of RF Design and Fabrication Processes of Fan-Out Wafer/Panel Level Packages and Interposers

Ivan Ndip and Markus Wöhrmann – Fraunhofer IZM

PDC 07. Solving Package Failure Mechanisms for Improved Reliability

Darvin Edwards – Edwards Enterprises

PDC 08. Characterization of Advanced EMCs For FO-WLP, Heterogeneous Integration, and Automotive Electronics

Przemyslaw Gromala – Bosch GmbH; Bongtan Han – University of Maryland

PDC 09. Integrated Thermal Packaging and Reliability of Power Electronics

Patrick McCluskey – University of Maryland

AFTERNOON COURSES (1:15 – 5:15 PM)

PDC 10. Flip Chip Technologies

Eric Perfecto – Independent Consultant; Shengmin Wen – Synaptics Inc.

PDC 11. Wafer-Level Chip-Scale Packaging (WCSP) Fundamentals

Patrick Thompson -- Texas Instruments, Inc.

PDC 12. Flexible Hybrid Technologies – Manufacturing and Reliability

Pradeep Lall – Auburn University

PDC 13. Fan-Out Wafer/Panel Level Packaging and 3D IC Heterogeneous Integration

John Lau – ASM Pacific Technology Ltd.

PDC 14. Polymers for Wafer Level Packaging

Jeffrey Gotro – InnoCentrix, LLC

PDC 15. Reliability Mechanics and Modeling for IC Packaging – Theory, Implementation and Practices

Ricky Lee -- HKUST and Xuejun Fan – Lamar University

PDC 16. Robust Electronics for Automotive Applications Including Autonomous Driving

Matthias Petzold – Fraunhofer IZM, Mervi Paulasto-Kröckel – Aalto University, and Klaus-Juergen Wolter – TU Dresden

PDC 17. From Wafer to Panel Level Packaging

Tanja Braun and Michael Töpfer – Fraunhofer IZM

PDC 18. Electronics Cooling Technologies for Handheld Devices, Computing, and High-Power Electronics

William Maltz and Guy Wagner – Electronic Cooling Solutions

HETEROGENEOUS INTEGRATION ROADMAP (HIR) WORKSHOP

MAY 28, TUES, 8:00 AM – 5:30 PM, CONDESA 3 (2ND FLOOR)

Coordinators: William Chen (ASE), Bill Bottoms (3MT Solutions) & Ravi Mahajan (Intel)

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 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. Our industry continues to change with the rapid migration of logic, memory, and applications to the cloud, the evolution of the Internet of Things (IoT) to the Internet of Everything (IoE), the proliferation of smart devices everywhere, the rise of 5G, the increasing presence of microelectronics in wearables & health application, and in autonomous automotive, and the rapid advancement of AI. The pace of innovation is simultaneously increasing to meet these challenges. The Heterogeneous Integration Roadmap will address the future directions of heterogeneous integration technologies and applications serving the future markets and applications.

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>



William Chen
(ASE)



Bill Bottoms
(3MT Solutions)



Ravi Mahajan
(Intel)



HETEROGENEOUS INTEGRATION ROADMAP

ECTC/ITherm STUDENT RECEPTION

MAY 28, TUES, 5:00-6:00 PM, MONT-ROYAL COMMONS (4TH FLOOR)

Hosted by Texas Instruments, Inc.

ITherm student attendees are invited to attend the ECTC/ITherm Student Reception, where you will have the opportunity to talk to industry professionals about what helped them succeed in their first job search and reach their current positions. During this reception, you can enjoy good food while networking with industry leaders and achievers. Don't miss your opportunity to interact with people who you might not have the chance to meet otherwise! You will also be able to submit your resumes to our sponsoring partners.

ECTC/ITherm YOUNG PROFESSIONAL'S NETWORKING RECEPTION

MAY 28, TUES, 7:00-7:45 PM, NOLITA 1 (4TH FLOOR)

Chair: Yan Liu (Medtronic)

ITherm young professionals and current graduate students – this event is designed just for you. In this active event, we will pair you with senior EPS members and professionals through a series of active and engaging activities. You will have opportunities to learn more about packaging-related topics, ask career questions, and meet some professional colleagues.

EPS Board of Governors members: Avi Bar-Cohen, Chris Bailey, Karlheinz Bock, Alan Huffman, Sam Karikalan, Beth Keser, Ravi Mahajan, Toni Mattila, David McCann, Kitty Pearsall, Eric Perfecto, Jeff Suhling, Andrew Tay, and Pat Thompson.

EPS PRESIDENT'S PANEL SESSION

MAY 28, TUES, 7:45-9:15 PM, MONT-ROYAL 1 & 2 (4TH FLOOR)

Chairs: Avi Bar-Cohen, EPS President (Raytheon); Karlheinz Bock (TU Dresden)

All ITherm attendees are invited to attend the EPS President's Panel, which explores the future path of packaging science and technology and proposes possible scenarios for 2025. Visions of future packaging technologies will be presented and discussed with invited experts in the field of electronics packaging. The authors of the best-selected submissions of the EPS packaging technology vision conquest will also join the discussion panel. The involvement of our young professionals will bring fresh perspectives and new ways of thinking. The intention of this panel is to identify significant future packaging technologies in order to best serve IEEE and the electronics community.



Avi Bar-Cohen



Karlheinz Bock

Liquid Cooling Test Solutions

Laboratory CDU

Liquid to Liquid



Liquid to Air



Components

**cold plate / radiator
 connector / piping**

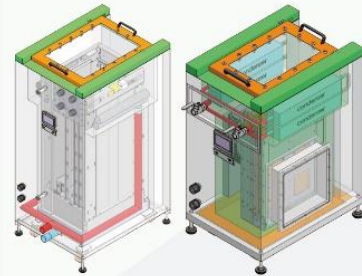
*Thermal resistance test
 Flow resistance: dP vs. Q
 Pump P - Q performance*



Immersion

**POC Single-Phase Tank
 POC Two-Phase Tank**

*Boiler tester
 Condenser coil tester*



Thermal Labs in TW & USA



1. 16 CH temperature & velocity measurement for small chassis
2. High frequency dynamic
16 CH pressure measurement
3. Vibration, accelerometer, spectrum analyzer
4. LDA 0.01~220 m/s
5. PIV
6. CTA anemometer
7. K / R / α measurement of materials
8. Airflow benches, wind tunnels and water tunnels >30 types
9. Fan torque measurement
10. Split Hopkinson Bar
11. Heat sink stiffness tester
12. CDU - 1 kW / 20 kW
13. Natural convection chamber >20 types
14. IR imaging camera
15. Software:
 - (a) SolidWorks 3D CAD,
 - (b) SolidWorks Flow Simulation,
 - (c) SolidWorks Simulation,
 - (d) NI LabVIEW & CVI,
 - (e) Matlab,
 - (f) DesignFOIL

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ECTC/ITherm JOINT WOMEN'S PANEL

MAY 29, WED, 6:30-7:30 PM, NOLITA 1 (4TH FLOOR)

Moderators: Cristina Amon (University of Toronto); Kristina Young-Fisher (Global Foundries)

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 panelists will speak on *Unleashing the Power of Diversity in the Workforce*. Discussions will include the power of diversity in high-performing workplaces, strategies to build a diverse workforce, and tools for inclusion and engagement. Panelists will also address the creation of policies and programs to increase inclusion along with metrics to assess progress, and share both successes and challenges to achieving these goals. A Q&A session and reception for panelists and attendees will follow.

Panelists: Rolf Aschenbrenner (Fraunhofer-Institut fuer Zuverlaessigkeit und Mikrointegration); Dereje Agonafer (University of Texas at Arlington); Monica Jackson (GE Aviation Business); Jean Trehwella (Global foundries)

RICHARD CHU ITherm AWARD FOR EXCELLENCE

MICRO-TWO-PHASE ELECTRONICS COOLING...FINALLY ON ITS WAY

AWARD LUNCHEON AND TALK, WEDNESDAY, MAY 29, 12:00 PM – 1:30 PM, GRACIA 4/8

Presented by 2019 Awardee Prof. John R. Thome (EPFL, JJ Cooling Innovation Sàrl)

Abstract: In this lecture, I will recount some of the initial history of micro channel two-phase flow and boiling work by others that enticed me to join into the development of this field and will then focus on my team's work at the EPFL in Lausanne during the last 20 years, covering work on micro channel flow boiling, new flow visualisation/image processing techniques, flow stabilisation, heat transfer models, flow pattern maps, micro-two-phase cooling systems, and numerical modeling of bubbly/slug flows.

John R. Thome is Professor-Emeritus of Heat and Mass Transfer at the Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland since 1998. He obtained his PhD at Oxford University in 1978. Having retired in July 2018 at the EPFL, he has now founded a consulting/thermal engineering software company, JJ Cooling Innovation Sàrl in Lausanne. He is also a Visiting professor at Brunel University in London and an Honorary professor at the University of Edinburgh...to keep his "feet" in research while still supervising MS student theses at the EPFL. He is the author of five books on two-phase heat transfer and flow and has over 245 journal papers on macroscale and microscale two-phase flow, flow visualisation, boiling/condensation heat transfer, flow pattern-based models, and micro-two-phase cooling systems for electronics cooling. He has done numerous sponsored projects with IBM, ABB, Nokia Bell Labs, Carl Zeiss, CERN, etc. He is editor-in-chief of the 16-volume series Encyclopedia of Two-Phase Heat Transfer and Flow (2016-2018). He founded the Virtual International Research Institute of Two-Phase Flow and Heat Transfer in 2014, now with 25 participating universities to promote research collaboration, sharing of experimental and numerical data, and education.



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

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TECHNOLOGY-TALK SESSIONS

TT-3: NEXT GENERATION THERMAL SYSTEM DESIGN (MAY 29, WED, 1:30 – 3:00 PM),
GRACIA 3

Session Chair: Timothy Fisher (UCLA)

THE NEED FOR NEXT GEN. THERMAL SYSTEM MODELING

Speaker: Peter de Bock (GE Research)



Abstract: Where in the past cooling of electronics consisted of a single heat source and a pumped loop cooled by a radiator, recent trends on electrification, WBG electronics, advanced thermodynamics and a drive for ever increasing efficiency is growing a need for more complex thermal systems. However, modeling capability of systems that have capability of advanced fluids, two-phase heat transfer, multiple coolant loops, novel 3D heat exchanger designs, transient simulation and optimization is limited. The GE team is exploring use of universal heat exchanger modeling concepts and surrogate modeling using digital thread for design (DT4D), to develop the thermal systems of the future.

Dr. Peter de Bock is Principal Thermal engineer at GE Research in Niskayuna, New York. In his role he has over 15 years' experience in developing innovative thermal management solutions for electronics and electrical machines. He holds a PhD in ME from the University of Cincinnati and a MSME from Twente Technical University, the Netherlands. His current work is focused on developing next generation technologies for Power and Aviation systems. Dr. de Bock is vice-chair of the ASME K-16 committee on Heat Transfer in Electronic Equipment, a member of the Heterogenous Integration Roadmap Thermal Work Group and holds over 25 patents in the areas of heat transfer and thermal management.

USING DATA IN FLOW PHYSICS MODELING

Speaker: Jeff D. Eldredge (UCLA)



Abstract: In fluid dynamics, low-order models have generally been regarded as computationally efficient but quantitatively poor predictors of flow physics. However, when combined with real sensor data, they create a potent framework for dynamic estimation: an accurate reconstruction of the flow state from limited measurements. In this work, I will present two applications in which we assimilate data, using an ensemble Kalman filter, into low-order dynamical models to greatly improve these models' predictive capabilities. In the first application, we use pressure measurements on the surface of a wing in conjunction with a low-order inviscid vortex model to predict the stalled flow about the wing, even when subjected to incident flow disturbances. In the second, we use ultrasound measurements of

blood velocity at three locations in the lower leg to discern the parameters of a low-order model of the lower leg's entire vascular flow.

Dr. Jeff Eldredge earned his B.S. from Cornell University and his Ph.D. from Caltech, all in Mechanical Engineering. He was a post-doctoral researcher at Cambridge University from 2001-03. Since then, he has been a Professor of Mechanical and Aerospace Engineering at UCLA, where his research focuses on fluid dynamics. He is a Fellow of the American Physical Society and an Associate Fellow of AIAA. He serves on the editorial board of the journal *Physical Review Fluids* and as an associate editor of *Theoretical & Computational Fluid Dynamics*. He is a past recipient of the NSF CAREER Award.

TECHNOLOGY-TALK SESSIONS (Continued)

HIGH-EFFICIENCY ELECTRIC AIRCRAFT THERMAL RESEARCH (HEATHER)

Speaker: Sydney Schnulo (NASA Glenn Research Center)



Abstract: Thermal management (TM) proves to be one of the largest challenges in electric aircraft propulsion concepts. Hybrid-electric, turboelectric, and electric aircraft require large amounts of heat to be rejected, and unlike traditional aircraft, this waste heat has low rejection temperatures (<200 C). To address this challenge, the HEATheR project takes the approach of minimizing this waste heat and using thermal management methods that are less penalizing to the aircraft performance as a whole. To minimize the heat load, we consider an optimal power system. The optimal power system consists of highly efficient motors and generators, as well as an advanced AC-AC converter. This hardware development is paired with new modeling methods to assess the impact of TM on the aircraft, with the goal to minimize weight, drag, and power. Thermal management system modeling has been developed to assess these systems and consider both a conventional thermal management system and advanced thermal management systems. This is integrated with the engine, electric system, and aircraft model to assess the fuel burn benefit of the optimal power system.

Sydney Schnulo is a Research Aerospace Engineer in the Propulsion System Analysis Branch at NASA Glenn in Cleveland, Ohio. She is currently the modeling lead for the HEATheR Project. She has been working on electrified aircraft propulsion at NASA since graduating from Purdue University with a Bachelor of Science in Mechanical Engineering in 2016. Other projects she is involved in include the thermal system design and development of a mission planning tool for the NASA experimental electric aircraft, X-57, and the conceptual design of an Urban Air Mobility vehicle through trajectory optimization.

TECHNOLOGY-TALK SESSIONS (Continued)

TT-5: HETEROGENEOUS INTEGRATION (MAY 30, THU, 8:00 – 9:00 AM), GRACIA 2/3

Session Chair: Madhusudan Iyengar (Google)

EMERGING CHALLENGES AND MATERIALS FOR THERMAL MANAGEMENT OF ELECTRONICS

Speaker: Arden L. Moore (Louisiana Tech University)



Abstract: The rapid development of faster, cheaper, and more powerful computing has led to some of the most important technological and societal advances in modern history. However, the physical means associated with enhancing computing capabilities at the device and die levels have also created a very challenging set of circumstances for keeping electronic devices cool, a critical factor in determining their speed, efficiency, and reliability. With advances in nanoelectronics and the emergence of new application areas such as three-dimensional chip stack architectures and flexible electronics, now more than ever there are both needs and opportunities for novel materials to help address some of these pressing thermal management challenges. Here, a number of cubic crystals, two-dimensional layered materials, nanostructure networks and composites, molecular layers and surface functionalization, and aligned polymer structures are examined for potential applications as heat spreading layers and substrates, thermal interface materials, and backfill materials in future-generation electronics.

Arden Moore is an Assistant Professor of Mechanical Engineering at Louisiana Tech University and holds a joint appointment with the Institute for Micromanufacturing (IfM) where he works on advanced materials and devices for multi-scale energy applications. Prior to joining the faculty at Louisiana Tech, Dr. Moore was a Thermal Advisory Engineer for IBM's Systems & Technology Group from 2011 to 2013. In addition to academic publications, Dr. Moore is inventor or co-inventor on over a dozen patents or patent applications related to thermal management. He is a 2019 National Science Foundation CAREER Awardee. Dr. Moore graduated with his Ph. D. degree in mechanical engineering from the University of Texas at Austin in 2010.

DIRECT LASER METAL PRINTING OF HEAT REMOVAL DEVICES ONTO SILICON

Speaker: Scott Schiffres (SUNY Binghamton)



Abstract: We will present on the first demonstration of direct 3D metal printing of heat removal devices onto silicon. We will elucidate the material science behind the Sn₃Ag₄Ti alloy laser printing onto silicon via silicide bonding. We will also discuss how the printed material can transition from Sn₃Ag₄Ti to copper via intermetallic formation. By this technology, direct cooling devices can be fabricated onto the backside of a silicon wafer. Fine pitch and high-aspect ratio fins can be made to increase surface area. It is also possible to directly place evaporators in contact with the chip using this manufacturing technique. Based on our current printing capabilities (100 μm resolution), a chip dissipating 100 W/cm² is ~20 °C cooler with fins directly printed onto the silicon than a conventional flip-chip with indirect cooling (two thermal interface materials, lid, and heat sink). Regarding survivability of the manufacturing process, the maximum temperature of the transistor due to this process is modeled and experimentally measured to be less than 250 °C. Reliability and thermal cycling will also be discussed.

Scott Schiffres is an Assistant Professor of Mechanical Engineering at SUNY Binghamton. Scott is a recent recipient of a 2019 NSF CAREER award. Prior to joining Binghamton, Scott was a Postdoctoral Associate in the groups of Dr. Evelyn Wang and Dr. John Hart at MIT. Scott received his PhD from Carnegie Mellon University, where he was advised by Dr. Jonathan Malen. Scott worked at Boeing's Satellite Development Center for two years prior to going back to school for a PhD. Scott received a BSE from Princeton University, and MEng from Cornell University.

TECHNOLOGY-TALK SESSIONS (Continued)

TT-7: AEROSPACE/AUTOMOTIVE/TELECOM (MAY 30, THU, 1:30 – 3:00 PM), GRACIA 3

Session Chair: Mark North (Boyd)

BUILDING THE FUTURE OF THERMAL MANAGEMENT WITH ADDITIVE MANUFACTURING

Speaker: Michael Stoia (Boeing Research & Technology)



Abstract: This presentation will describe recent advances and trends in additive manufacturing (AM) processes and their application in the development of next generation thermal management devices. Topical areas will include fabrication of thin-wall features, design for additive manufacturing principles, selection of AM process parameters, post-processing, and the benefits and challenges of using AM for thermal management components. Recent comparisons of thermal test results for AM and traditionally manufactured heat exchangers will also be discussed. The ability to reliably produce thin-walled features with complex geometries is a prerequisite to delivering the next generation of compact, lightweight, conformal, topologically optimized and cost-effective heat transfer devices that can meet projected growth in power and thermal demands.

Michael Stoia is a Principal Engineer at Boeing Research & Technology with over 20 years of industry experience. His current responsibilities include leading the development of power and thermal subsystems for advanced platforms, including a hypersonic passenger airplane, unmanned air vehicles and hybrid electric aircraft. He also supports several R&D projects focused on next generation thermal devices produced using advanced materials and manufacturing processes, including additive manufacturing. His prior responsibilities include development of heat exchangers, thin film solar arrays, solid oxide fuel cells and propulsion systems for space vehicles. BSME (1994) and MBA (1995) Rutgers University, MSME (1997) University of Wisconsin.

INDUSTRY TRENDS AND THERMAL CHALLENGES IN TELECOMMUNICATIONS NETWORKS

Speaker: Todd Salamon (Nokia Bell Labs)



Abstract: Network operators are beginning the buildout of next-generation 5G wireless infrastructure, with the enhanced bandwidth and extremely low latency of 5G networks anticipated to enable a range of applications, including industrial automation, self-driving cars and digital health, to name a few. The increased bandwidth demands that 5G will place on network infrastructure will require innovations in wireless and wireline technologies. However, this represents a significant technical challenge as the transport of information via electromagnetic signals over air, optical fiber and copper wire are within a factor of 2 of theoretical limits with respect to spectrum usage [Hz] and spectral efficiency [bits/sec/Hz], with the remaining dimension left to exploit being spatial parallelism, which has profound implications on future hardware designs. In this talk, I will discuss anticipated telecom industry trends brought on by 5G, how such trends will impact the design of networks and devices, and the associated implications for thermal management in telecommunications networks.

Todd R. Salamon received the Ph.D. degree in chemical engineering from the Massachusetts Institute of Technology (MIT), Cambridge, MA, USA. He is currently a Member of Technical Staff in the Efficient Energy Transfer Research Department, Nokia Bell Labs, Murray Hill, NJ, USA, where he has worked on thermal management, microfluidics, transport phenomena in optical fiber manufacturing, design of photonic crystal fibers, and Raman and erbium amplifier dynamics and control in transparent optical networks. He has authored over 60 publications and conference presentations and holds 36 issued or pending patents. He was the Principal Investigator on a U.S. Department of Energy project titled “Advanced Refrigerant-based Cooling Technologies for the Information and Communications infrastructure” to develop and commercialize refrigerant-based cooling technology targeting the Information and Communications Technology (ICT) sector, and a Team Member of the MIT-lead DARPA ICECool Fundamentals Program.

TECHNOLOGY-TALK SESSIONS (Continued)

JET IMPINGEMENT COOLING OF ELECTRIC MACHINES WITH DRIVELINE FLUIDS

Speaker: Bidzina Kekelia (NREL)



Abstract: With increasing power density of electric traction drives, the challenges associated with thermal management for electric machines increase. One promising cooling technique for electric traction drives in a vehicle is impinging (or spraying) automatic transmission fluid (ATF) jets onto the machine's copper windings. This cooling method is advantageous as windings are typically the most temperature-sensitive component in the machine and, as in many cases, the electric machines are housed within the vehicle's transmission or transaxle, where ATF is readily available, no additional cooling fluid is required. Besides, ATF is a dielectric fluid and can be in direct contact with electrically-active machine components. Dielectric driveline fluids could potentially be used for motor-integrated power electronics cooling as well. In this presentation, some interesting findings of NREL's continued work on experimental characterization of thermal performance of free ATF circular jets - impinged on a heated target surface - are presented. Measured heat transfer coefficients are useful for understanding factors influencing performance of driveline fluid-based cooling systems and help designers in developing high-performance, power-dense and reliable machines.

Dr. Bidzina Kekelia earned his Bachelor's (Hons) in Mechanical Engineering from Georgian Technical University, Georgia (1992), M.Sc. in Renewable Energy (Solar Thermal & PV) from the University of Oldenburg, Germany (1999) and Ph.D. in Mechanical Engineering from the University of Utah, USA (2012). After receiving his Ph.D., he worked as a postdoctoral research associate at the University of Utah, developing thermal battery prototypes for electric vehicles and long-haul trucks. Since joining NREL in 2015, Bidzina Kekelia's research in Advanced Power Electronics and Electric Machines group has focused on developing a hydrogen pre-cooling system for fueling stations based on high heat transfer rates of phase change, exploring novel cooling methods for power electronics and electric drives, and characterizing heat transfer coefficients of jet impingement cooling of electric machines with driveline fluids..

TECHNOLOGY-TALK SESSIONS (Continued)

TT-9: HEAT EXCHANGERS (MAY 31, FRI, 8:00 – 9:00 AM), GRACIA 2/3

Session Chair: Michael Ohadi (University of Maryland)

NEXT GEN HXS UTILIZING NOVEL DESIGN TOPOLOGIES, MATERIALS, AND MANUFACTURING TECHNIQUES

Speaker: Michael Ohadi (ARPA-E)



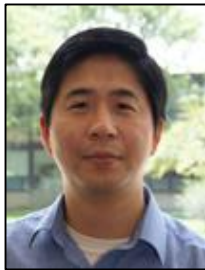
Abstract: Heat exchangers increasingly play a critical and controlling role in high efficiency power generation cycles, as well as diverse waste heat recovery applications. In this presentation, I will briefly review case examples where heat exchangers play a substantial role in energy conversion, followed by reviewing the highlights of the recent \$36M funding invested by the U.S. Dept. of Energy/ARPAE division utilizing innovative design topologies, materials, and manufacturing techniques for development of next generation heat exchangers.

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 Minta Martin Professor of Engineering. He is a Fellow of ASME and ASHRAE and Past Conference General Chair of ITherm. He is a recent recipient of the University of Maryland System Board of Regents Excellence in Innovation Award.

COMPUTATIONAL DESIGN OF CONJUGATE HEAT TRANSFER SYSTEMS

Speaker: Xiaoping Qian (University of Wisconsin-Madison)

Abstract: In this talk, I will present recent progress in computational design of conjugate heat transfer systems. Examples of parameter-free shape optimization and multi-physics topology optimization will be described. Challenges and opportunities of using machine learning in computational design will be discussed.



Xiaoping Qian is a professor in the Department of Mechanical Engineering at the University of Wisconsin-Madison. His research focuses on computational design of multi-physics systems, topology optimization, shape optimization, and design for additive manufacturing. He has served as an associate editor for ASME Journal of Mechanical Design, ASME Journal of Manufacturing Science and Engineering and journal Computer-Aided Design. He is an ASME fellow.

TECHNOLOGY-TALK SESSIONS (Continued)

TT-11: TRANSIENT THERMAL MANAGEMENT (MAY 31, FRI, 1:30 – 3:00 PM), GRACIA 3

Session Chair: Patrick Shamberger (Texas A&M)

DESIGN CHALLENGES AND OPPORTUNITIES IN PACKAGE-INTEGRATED TRANSIENT THERMAL MITIGATION

Speaker: Michael Fish (U.S. Army Research Laboratory)



Abstract: Phase change materials (PCMs) have attracted the attention of researchers for their promise to buffer or mitigate the effects of transient thermal pulses within electronic systems. While widespread adoption has historically been held back by the by the low thermal conductivity of otherwise attractive materials with relevant transition temperatures, advancements in PCM enhanced composite materials, additive manufacturing, and more recent interest in low melting point metals has tipped the balance towards feasibility in highly transient systems. One impediment to deploying PCM-enhanced packaging is a lack of package-level design tools that can illustrate the tradeoffs between performance, size/weight, and cost that results from integrating phase-change materials and/or their composites. This

talk exhibits the extensions made to the Army Research Laboratory's thermal-mechanical co-design tool, ARL ParaPower, to enable both phase change transient modeling and integration into system-level design tools. By providing rapid surveying capability within any particular design space, detailed simulation burden is reduced and the most promising demonstrators are prioritized.

Dr. Michael Fish leads the transient thermal program as part of the Advanced Power Packaging group at the U.S. Army Research Laboratory. He has expertise in embedded thermal management, simulation, and thermal test bed development. His current effort is in the packaging and management of highly transient electronic systems, with particular focus on directed energy weapons and vehicle electrification and power conversion. He holds a doctorate in Mechanical Engineering from the University of Maryland, College Park where he studied thermal phenomena in heterogeneously integrated electronic systems. He received his BS and MS from the University of Virginia, studying micro/nanoscale heat transport and thermal metrology.

DESIGN AND MANUFACTURE OF COMPOSITES FOR THERMAL ENERGY STORAGE

Speaker: Jonathan R. Felts (Texas A&M University)



Abstract: As electronics get ever smaller and more powerful, thermal management becomes increasingly more challenging. Specifically, heat fluxes in excess of 100 W/cm² must be dissipated over a small temperature range, often in spaces too small to incorporate forced liquid cooling systems. When the thermal load generated by a heat source is intermittent, solid-liquid phase change materials (PCMs) such as paraffin wax or hydrated salts become attractive materials for “smoothing out” the transient heat load. The effectiveness of these systems to store heat depends on both the capacity to store heat (very high for PCMs) and the rate of heat transport (very low for PCMs). Composites incorporating high thermal conductivity elements with PCMs is a rapidly growing area of research, with a quickly expanding list of composite systems, yet very little work has gone into the rational design of

such composites. This talk highlights our recent theoretical and experimental work on PCM composite systems, as we transition this field from the question “what can we make?” to “what should we make?”

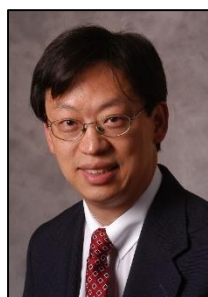
Biography on the following page.

TECHNOLOGY-TALK SESSIONS (Continued)

Dr. Jonathan R. Felts earned a BS degree in mechanical engineering from Georgia Institute of Technology in 2008. He received his MS from Illinois in 2009, and was awarded his PhD under the advisement of MechSE professor William P. King for work on tip-based nanomanufacturing and nanometrology of chemical nanostructures. He was the recipient of the Eugene and Lina Abraham Endowed PhD Fellowship and the Department of Energy Office of Science Graduate Fellowship during his PhD studies, and he was awarded a National Academy of Science National Research Council Postdoctoral Fellowship at the Naval Research Laboratory for 2013-2014. He joined the faculty at Texas A&M in 2014. Felts is the recipient of a 2019 NSF CAREER award, is a member of Pi Tau Sigma and Tau Beta Pi honor societies, and he has authored or co-authored 27 peer-reviewed journal articles and one patent. His current research interests lie at the intersection of chemistry, mechanics, and physics to alter transport and reactivity.

ACTIVE TRANSIENT CONTROL OF TWO-PHASE COOLING SYSTEMS

Speaker: John Wen (Rensselaer Polytechnic Institute)



Abstract: Cooling systems are traditionally designed based on steady state operating conditions. In applications involving high power electronic and photonic devices, components may be subject to high transient heat flux. Two-phase cooling through boiling heat transfer offers an appealing solution due to the potentially high heat transfer efficiency. However, the control system design requires greater care to address possibly dangerous temperature rise due to the incursion of the critical heat flux (CHF). For microchannel heat exchangers, there are additional instability phenomena that will need to be considered including Ledinegg instability, pressure drop oscillation, and flow maldistribution, in the case of multiple parallel channels. This talk will discuss a hierarchical control design approach for two-phase cooling systems subject to high transient heat flux. The approach involves 1) selection of the operating condition to balance between efficiency and CHF avoidance, 2) feedback control to avoid instability, and 3) predictive control to safely switch between operation points in anticipation of high transient heat flux events. Simulation and experimental results will be presented to illustrate the performance of the thermal control system.

John T. Wen has been with Rensselaer Polytechnic Institute since 1988 where he is currently the Head of the Department of Electrical, Computer, and Systems Engineering. From 2013-2018, he was the Head of the Department of Industrial and Systems Engineering. From 2005-2013, he served as the Director of the Center for Automation Technologies and Systems (CATS), a New York State designated Center for Advanced Technology. He led the New York State participation in the Advanced Robotics for Manufacturing (ARM) Institute and serves on the ARM Technical Advisory Council. He received B.Eng. from McGill University, M.S. from University of Illinois, and Ph.D. from RPI, all in Electrical Engineering. His research is in the area of control theory and applications, particularly for challenging problems that lie at the intersection of multiple disciplines, including robotics, material processing, thermal management, biochronicity, and optomechanronics systems.



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PANEL SESSIONS

P-2 (MAY 29, WED, 10:30 AM – 12:00 PM), GRACIA 3

Moderator: Victor Chiriac (Futurewei Technologies)

Thermal/Mechanical Management of Mobile/Computing 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. This is associated with increasingly demanding thermal management and other packaging issues ranging from low to high form factors. 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) YC Lee (UC Boulder)
Gaurang Choksi (Intel Corporation) Hiroyuki Ryoson (Dexerials)
Ken Goodson (Stanford University) John Thome (EPFL, JJ Cooling Innovation Sàrl)
Mark Hartman (Outlast Technologies)



P-4 (MAY 29, WED, 3:30 – 5:00 PM), GRACIA 3

Moderator: John R. Thome (EPFL, JJ Cooling Innovation)

Micro-Two-Phase Liquid Cooling Systems for Electronics

Abstract: Two-phase cooling continues to gain traction in the cooling of electronics. 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: Luca Amalfi (Nokia Bell Labs) Robert Christensen (CeramTEC GmbH)
Filippo Cataldo (Provides MetalMeccanica) Ahmed Zaghlool (Mersen)



PANEL SESSIONS (Continued)

P-6 (MAY 30, THU, 10:30 AM – 12:00 PM), GRACIA 3

Moderators: Yogendra Joshi (Georgia Tech), Lauren Boteler (US Army)

TRENDS TOWARDS MULTI-DISCIPLINARY CO-DESIGN FOR NEXT GENERATION ELECTRONICS SYSTEMS

Abstract: As technology transitions into more electrified systems, the electrical, thermal, and reliability needs of these systems must be simultaneously accounted for due to the need for more power in smaller units with no loss in reliability. Unfortunately, most research has focused on solving only one technical challenge: a better heat sink, a better circuit design or a more reliable material. When thermal design is treated as a discrete step and not addressed until the end of development, systems become large, overly complex, and inefficient. This panel discusses the trend towards multi-disciplinary co-design for next generation electronics systems.

Panelists: Andrew Alleyne (UIUC) Bill Gerstler (GE)
Avi Bar-Cohen (Raytheon) Satish Kumar (Georgia Tech)
Lauren Boteler (US Army) Ankur Srivastava (Univ of Maryland)



P-8 (MAY 30, THU, 3:30 – 5:00 PM), GRACIA 3

Moderator: Przemyslaw Gromala (Bosch), Karsten Meier (TU Dresden)

RELIABILITY CHALLENGES IN ELECTRONIC PACKAGING FOR HARSH ENVIRONMENT

Abstract: Panel will try to answer what are the emerging reliability challenges in electronic packaging for harsh environment due to three major trends in automotive: electrification, autonomous driving and connectivity. As a consequence, we need a new approach for powertrain solution (change of the type from combustion engine to electric engine) and introduction of electronic components (e.g. high performance microprocessor with 1000+ solder joints and with technological node size below 20 nm) from consumer segment to harsh environment, such as automotive, but as well as avionics, etc.

Panelists: Reza Ghaffarian (NASA JPL) Gary Morrison (Texas instruments)
David Huitink (Uni Arkansas) Richard Rao (MicroChip)
Yong Liu (ON Semi) Vanesa Smet (Georgia Tech)



PANEL SESSIONS (Continued)

P-10 (MAY 31, FRI, 10:30 AM – 12:00 PM), GRACIA 3

Moderators: Baris Dogruoz (Cisco), Victor Chiriac (Futurewei Technologies)

THERMAL MANAGEMENT IN THE WORLD OF IOT, POE, AND BLOCKCHAIN — WHERE ARE WE HEADING?

Abstract: This panel will focus on the thermal and mechanical design aspects of the Internet of Things (IoT) related hardware and structures, Power over Ethernet (PoE) devices and systems, and cryptocurrency mining farms/facilities. State-of-the-art thermal management technologies in these applications will be explored, where the related devices and structures vary greatly in size, i.e. from micro sensors / small hand-held devices to data centers. Therefore, each application has to deal with multi scale thermal issues, namely: (i) IoT makes connection to applications, which enhance efficiency, and create new and unique services; (ii) PoE reduces the volume of power cords, leading to a lower cost and less complicated infrastructure for data centers, facilities and smart structures, nevertheless with the penalty of increased power and heat density; (iii) ever increasing energy usage of the cryptocurrency mining will increase the heat density on the data center/cryptocurrency mining farm significantly, requiring innovative thermal designs.

Panelists: Angel Han (Huawei) Rockwell Hsu (Cisco) Madhu Iyengar (Google)



SHT Smart High Tech AB offers a unique product on combined graphene based thermal interface material (TIM)

and heat spreader

FEATURES AND BENEFITS

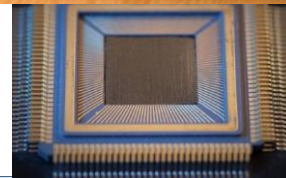
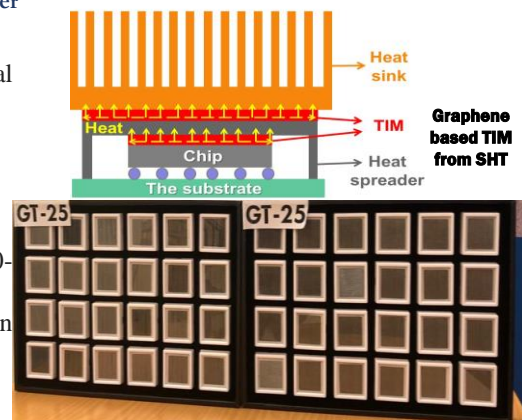
GT-Series is our new invention for Thermal Interface Material with multiple beneficial features.

- Two-axis thermal conducting path
- Hybrid TIM and heatspreader
- Easy-to-use
- “Instant Attach”, “Reflow” or “Curable” versions available
- Extremely high through-plane thermal conductivity (350-1000W/mK), 10-100 times higher than competitors
- Also electrically insulating and thermally conducting version available

APPLICATIONS

Our product application spans from mobile communication, AI, CPU/GPU, LED, IGBT, RF, optoelectronics, automotive electronics and other applications.

For more information visit : sht-tek.com



 **SHT** Address: Kemivägen 6, SE-412 58 Gothenburg Sweden, Email: info@sht-tek.com, Tel : +46 769 489 996

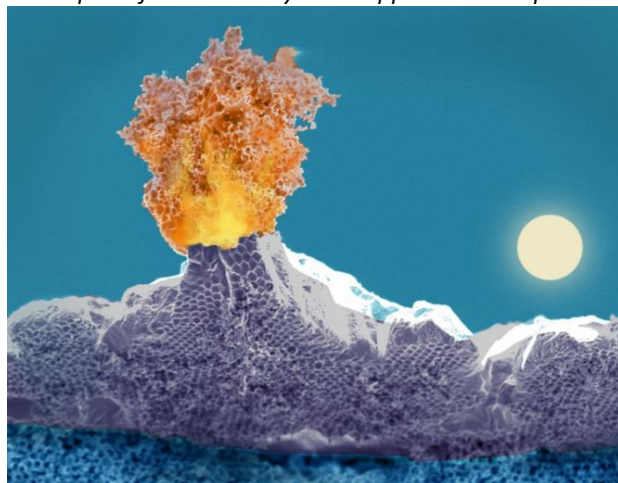
ART-IN-SCIENCE EXHIBITION

MAY 29-30 (VOTING THROUGH THE ITherm MOBILE APP)

This event provides a fun opportunity for the ITherm community to showcase the artistic side of their scientific discovery and technical applications through images displaying heat and mass transfer, as well as thermo-mechanical investigations. The exhibition will run through the conference with the artwork displayed prominently in the common spaces. Attendees will be able to vote for their favorite artwork and the winners of the Exhibition will be announced at the Friday Awards Luncheon.

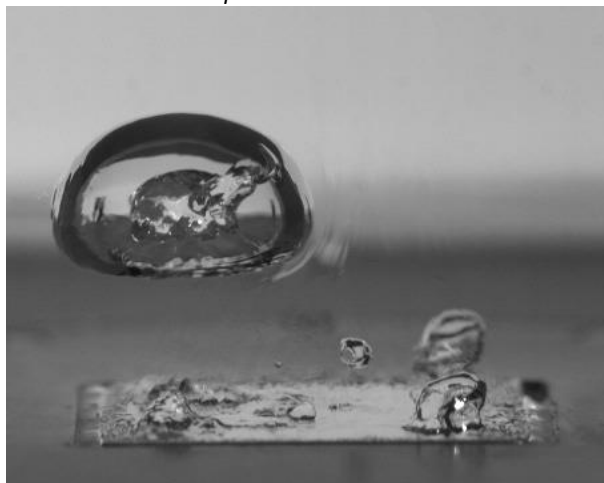
ITherm 2018 Art-in-Science Winners

"Eruption from Multi-layered Copper Inverse Opal"



Quang Pham, University of California, Irvine

"Elephant in a Bubble"



Matthew Clark, Purdue University

ITherm MOBILE APP

The ITherm 2019 mobile app (iOS & Android) has been developed to assist you in scheduling your time at ITherm in Las Vegas as well as connecting with other ITherm attendees. To download the ITherm 2019 Mobile App either search "Whova" in the App Store on your iPhone or in Google Play on your Android phone or scan the QR code below:



After downloading the Whova app, you will be asked for an invitation code

THE INVITATION CODE IS: iicqk

STUDENT HEAT SINK DESIGN CHALLENGE

MAY 29, WED, 5:00-6:30 PM, GRACIA 2

The ITherm organizing committee is delighted to announce the inaugural Student Heat Sink Design Challenge that will be held during ITherm 2019.

The Student Heat Sink Design Challenge is a team competition in which students will design, analyze and optimize an aluminum additively manufactured heat sink to cool a constant heat flux power electronics module subject to forced convection. The design from each student team is then evaluated based on a series of design and manufacturing criteria. The teams having the most effective and creative designs will have an opportunity to test their design using the additive manufacturing facilities at GE and using state-of-the-art test equipment at Oregon State University. Travel grants will be available to provide support for at least one member of each of the top teams to travel and present the team's work at the 2019 ITherm Conference in front of industry leaders.

STUDENT POSTER SESSION

MAY 30, THUR, 5:00-7:00 PM, GRACIA 4/8

Students get the opportunity to present their research and interact with other conference attendees from industry and academia during the Student Poster and Networking Session. They can also distribute resumes and get connected to industrial representatives. Outstanding posters will be selected for awards and will be judged based on technical merit, clarity and self-sufficiency of the content, novelty and originality of the work, overall impact of the poster display, and oral presentation at the poster session.

Student Poster Presenters from ITherm 2018

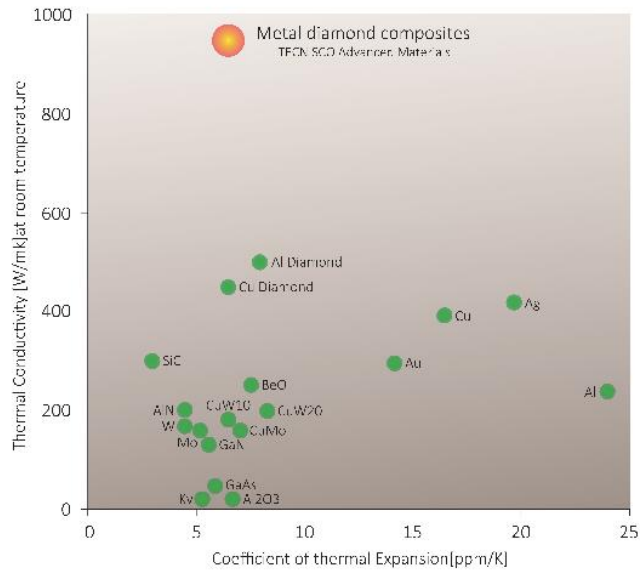




Metal diamond composites

Make a significant contribution to improving product performance and reliability as well as extending the lifetime by offering:

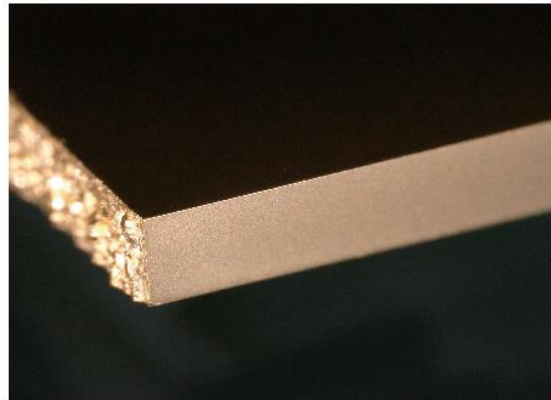
- ♥ Excellent thermal conductivity
- ♥ CTE well adapted to packaging materials
- ♥ Easy integration of components



Material Properties

Thermal conductivity	900	W/mK
CTE	6.5~8.0	ppm/K
Density	5.5	g/cm ³
Specific Heat	0.39	J/gK
Specific Electrical Resistivity	8.75	μΩcm
Young's Modulus	275	GPa
Flexural Strength	350	MPa

*At room temp



tecnisco diamond



LIST OF STUDENT POSTERS

Track	Poster #	Student Name	School	ITherm Paper #	Paper Title
Thermal-1: Component Level-	1	Venu Madhav H	Indian Institute of Science, Bangalore	P120	Analytical model for a cylindrical heat pipe
	2	Kalind Baraya	Purdue University	P128	Experimental demonstration of heat pipe operation beyond the capillary limit during brief transient heat loads
	3	Laia Ferrer Argemi	University of California, Irvine	P138	Effects of silicide inclusion shape on thermal transport of silicon-based nanowires and nanocomposites for thermoelectrical applications
	4	Tianqing Wu	National University of Singapore	P163	Pool Boiling Heat Transfer Enhancement with Porous Fin Arrays Manufactured by Selective Laser Melting
	5	Tiwei Wei	KU Leuven & imec	P170	Thermal analysis of polymer 3D printed jet impingement coolers for high performance 2.5D Si interposer packages
	6	Zongqing Ren	University of California, Irvine	P184	Hotspot Management by Holey Silicon-Metal Composites for 1kW/cm ² and Beyond
	7	Sevket Umut Yuruker	University of Maryland	P195	A Metamodeling Approach for Optimization of Manifold Microchannel Systems for High Flux Cooling Applications
	8	Navid Dehdari Ebrahimi	University of California - Los Angeles	P204	Heat Transfer Augmentation Using Scale-roughened Surfaces for Low-Reynolds Number Flows Generated by Piezoelectric Fans
	9	Ahmet Mete Muslu	Ozyegin University	P215	Impact of Electronics over Localized Hot Spots over Multi-Chip White LED Light Engines
	10	Cheng-Hui Lin	University of California, Irvine	P223	Pressure-dependent thermal characterization of bi-porous copper structures
	11	Debraliz Isaac Aragonés	Purdue University	P265	Effect of Filler Configuration on the Effective Thermal Conductivity of Polymer Composites
	12	Nitish Kumar	Georgia Tech	P295	Electrothermal Simulation of β -Ga2O3 based Field Effect Transistors
	13	Yuanhan Chen	University of California, Irvine	P300	Phosphor-Silicone Coating Thickness Dependence of the WLED Junction Temperature
	14	Timothy Polom	University of Wisconsin-Madison	P341	Spatially-Varying Electrothermal Impedance Analysis for Designing Power Semiconductor Converter Systems
	15	Mitchell Baxendale	Georgia Institute of Technology	P397	Data Center Temperature Control using PI System and MATLAB
	16	Ujash Shah	University of California - Los Angeles	P413	Dynamic Thermal Management for Silicon Interconnect Fabric using Flash Cooling
	17	Feng Liang	X'ian Jiaotong University	P424	A Central Cooling Structure for Motorized Spindles: Principle and Application
Thermal-2: System Level	18	Li Chen	Villanova University	P107	Economic and Environmental Analysis of U.S.-Based Data Centers Containing Photovoltaic Power Generation
	19	Jaakko McEvoy	Trinity College Dublin	P119	Experimental Investigation of Resonant Flow Pulsation in Mesochannels Embedded with Wavy Fins
	20	Sanskar Panse	North Carolina State University	P146	Air-based Cooling in High Porosity, Thin Aluminum Foams for Compact Electronics Cooling
	21	Jeho kim	georgia institute of technology	P158	Thermal Modeling of Air Cooled Outdoor Digital Displays
	22	Jooyoung Lee	Kyung Hee University / Korea	P161	Compact Liquid Cooling System Incorporating Fin and Metal Foam Hybrid Structures for High Power IGBTs
	23	Anirudh Krishna	University of California, Irvine	P190	Dynamic Radiative Thermal Management by Crumpled Graphene
	24	Reece Whitt	University of Arkansas	P216	Heat Transfer And Pressure Drop Performance Of Additively Manufactured Plastic Heat Sinks For Low-Weight Directed Cooling Integration For Power Electronics
	25	Zihao Yuan	Boston University	P231	Two-Phase Cooling with Micropillar Evaporators: A New Approach to Remove Heat from Future High-Performance Chips
	26	Sadegh Khalili	Binghamton University	P253	Impact of Fans Location on the Cooling Efficiency of IT Servers
	27	Rehan Khalid	Villanova University	P267	Waste Heat Recovery Using Coupled 2-Phase Cooling & Heat Pump Driven Absorption Refrigeration
	28	Mohammad Tradat	SUNY Binghamton	P355	Numerical Investigation of Novel Underfloor Air-Directors Effect on Data Center Performance

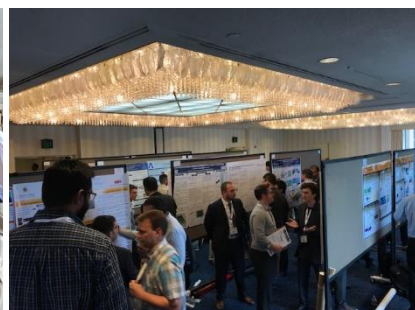
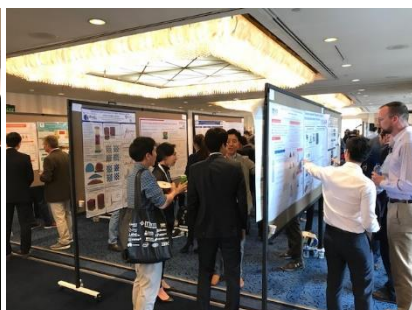
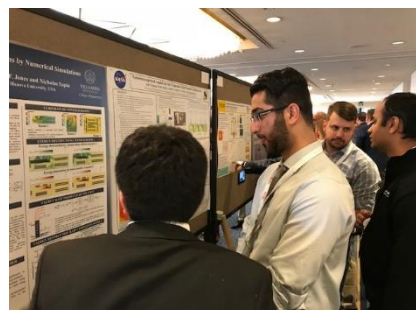
LIST OF STUDENT POSTERS (CONTINUED)

Track	Poster #	Student Name	School	ITherm Paper #	Paper Title
Mechanics & Reliability	29	Jonathan Kordell	University of Maryland	P268	Fiber Optic Conjugate-Stress Sensor for Local Stiffness Changes under Quasistatic Loads
	30	Raed Al Athamneh	Auburn University	P287	Effect of Aging on the Fatigue Life and Shear Strength of SAC305 Solder Joints in Actual Setting Conditions
	31	Jun Chen	Auburn University	P298	Evaluation of the Impact of Four-Degree Off-Axis Wafers on Silicon and 4H Silicon Carbide Stress Sensors
	32	Sinan Su	Auburn University	P313	Effect of Surface Finish on The Fatigue Behavior of Bi-based Solder Joints
	33	Francy John Akkara	Auburn University	P320	Effect of Aging on Component Reliability in Harsh Thermal Cycling
	34	Hyesoo Jang	Auburn university	P377	Method for Assessment of Folding-Reliability of Flexible Electronics in Wearable Applications
	35	Vishal Mehta	Auburn University	P383	Effect of Storage Temperature on the High Strain Rate Mechanical Properties of SAC305 Solder
	36	Nakul Kothari	Auburn university	P385	Study of the effect of Solder-Joint voiding using X-ray MicroCT data-based FE Models with Experimental Validation
	37	Jinesh Narangaparambil	Auburn University	P386	Effect of Sintering temperature on the Fatigue life of Additively Printed Electronics during cyclic bending
	38	Aathi Raja Ram Pandurangan	Auburn University	P388	Effect of Shock Pulse Variation and Restraint Mechanisms on Surface Mount Electronics under High G Shock
	39	Ved Soni	Auburn University	P389	Effect of Shallow Charging on Flexible Power Source Capacity Subjected to Varying C-Rates and Extreme Temperatures
	40	Vikas Yadav	Auburn University	P392	Evolution of Anand Parameters for SAC-Q Solder Alloy after prolonged storage up to 1 Year at High Strain Rate at Very High Operating Temperature
	41	Yunli Zhang	Auburn University	P393	3-D Numerical Multiphysics Model for Cu-Al Wire Bond Corrosion
	42	Jacek Nazdrowicz	Lodz University of Technology	P398	Temperature change leverage on performance of MEMS rotational motion sensors
	43	Madhu Kasturi	Auburn University	P408	Stress Strain Analysis on Stitch Bond of Copper Wirebonds Using X-ray Micro CT Technique
	44	Mohammad Alam	Auburn University	P417	Mechanical Characterization and Microstructural Evolution of SAC and SAC+X Lead Free Solders Subjected to High Temperature Aging
	45	Md Mahmudur Chowdhury	Auburn University	P418	Effects of Aging on the Damage Accumulation in SAC305 Lead Free Solders Subjected to Cyclic Loading
	46	Mohd Aminul Hoque	Auburn University	P419	Evolution of the Mechanical Properties of Lead Free Solder Joints Subjected to Mechanical Cycling
	47	Jing Wu	Auburn University	P420	Investigation of Aging Induced Microstructural Changes in Doped SAC+X Solders
	48	KM Rafidh Hassan	Auburn University	P421	Experimental Characterization of the Dependence of the Poisson's Ratio of Lead Free Solder on Temperature, Strain Rate, Solidification Profile, and Isothermal Aging
	49	Promod Chowdhury	Auburn University	P422	Characterization of Viscoelastic Response of Underfill Materials
50	Abdullah Fahim	Auburn University	P425	Mechanical Behavior Evolution of SAC305 and SAC+Bi Lead Free Solder Joints under Thermal Cycling	
51	S M Hasan	Auburn University	P426	Evolution of the Mechanical Behavior of Lead Free Solders Exposed to Thermal Cycling	



LIST OF STUDENT POSTERS (CONTINUED)

Track	Poster #	Student Name	School	ITherm Paper #	Paper Title
Emerging Technologies & Fundamentals	52	Nicholas Vu	United States Naval Academy	P113	Effect of Grain Size on the Thermal Properties of Nickel-Titanium Shape Memory Alloys Across the Martensite-Austenite Phase Transition
	53	Serdar Ozguc	Purdue University	P127	Experimental Demonstration of an Additively Manufactured Vapor Chamber Heat Spreader
	54	Aaditya Candadai	Purdue University	P130	A Measurement Technique for Thermal Conductivity Characterization of Ultra-High Molecular Weight Polyethylene Yarns Using High-Resolution Infrared Microscopy
	55	Sicheng Sun	University of Wisconsin-Madison	P145	Large scale 3D topology optimization of conjugate heat transfer
	56	Wen-Sheng Lo	National Chiao Tung University	P177	Learning Based Mesh Generation for Thermal Simulation in Handheld Devices with Variable Power Consumption
	57	Ziqi Yu	University of California, Irvine	P200	Investigation of Thermal Metamaterials based on Nanoporous Silicon using Ray Tracing and Finite Element Simulations
	58	Patrick Krane	Purdue University	P207	Identifying Hot Spots in Electronics Packages with a Sensitivity-Coefficient Based Inverse Heat Conduction Method
	59	Parham Jafari	University of Houston	P209	A Predictive Model For Evaporation Mass Flux
	60	Masoumeh Nazari	University of Houston	P210	Unprecedented Capillary Evaporative Heat Fluxes in Nanochannels
	61	Xiao Nie	University of California, Irvine	P212	Stretchable Selective Emitters based on Carbon Nanotube Films for Adaptive Thermal Control
	62	Alison Hoe	Texas A&M University	P224	A Numerical Analysis of Conductive Heat Transfer in Cylindrical and Spherical Thermal Energy Storage Composites
	63	Shiva Farzinazar	University of California, Irvine	P228	Thermal Conductivity Measurement of Mesoscale Lattices Using Steady-State Infrared Thermography
	64	William Yameen	Western New England University	P230	Experimental Characterization of a Manifold-Microchannel Heat Exchanger Fabricated Based on Additive Manufacturing
	65	Jonathan Sullivan	University of California, Irvine	P249	Wafer-scale Hierarchically Textured Silicon for Surface Cooling
	66	Meisam Habibimatin	University of Florida	P262	Prediction of Regime Transition in Two Phase Flow Microchannels Based on Ultrathin Liquid Film Interfacial Instability
	67	Vaidehi Oruganti	Villanova University	P280	An Experimental Study of a Single Droplet Impacting onto a Heated Surface at High Impact Weber Numbers
	68	Tony Thomas	Auburn University	P359	Failure Mode of Flexible Electronics Under Mechanical Vibration
	69	Amrit Abrol	Auburn University	P367	Capacity Degradation of Flexible Li-Ion Power Sources Subjected to Shallow Discharging
70	Kartik Goyal	Auburn University	P373	Reliability of Additively Printed Traces on a Polymer Substrate Subjected to Mechanical Stretching	



LAST YEAR'S BEST POSTERS (ITherm 2018)

COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

BEST POSTER

Identification of the Dominant Heat Transfer Mechanisms During Confined Two-Phase Jet Impingement

Matthew Clark (Purdue University)

OUTSTANDING POSTER

High Heat Flux Boiling Heat Transfer Through Nanoporous Membranes

Qingyang Wang (University of California, San Diego)

SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

BEST POSTER

Electrical and Thermal Analysis of Vertical GaN-on-GaN P-N Diodes

Luke Yates (Georgia Institute of Technology)

OUTSTANDING POSTER

Artificial Neural Network Based Prediction of Temperature and Flow Profile in Data Centers

Jayati Athavale (Georgia Institute of Technology)

EMERGING TECHNOLOGIES AND FUNDAMENTALS TRACK

BEST POSTER

Experimental Characterization of Microchannel Heat Sinks Made by Additive Manufacturing

Ivel Collins (Purdue University)

OUTSTANDING POSTER

Improving the Transient Thermal Characterization of GaN HEMTs"

Georges Pavlidis (Georgia Institute of Technology)

MECHANICS AND RELIABILITY TRACK

BEST POSTER

"Mechanical Characterization of Intermetallic Compounds in SAC Solder Joints at Elevated Temperatures"

Abdullah Fahim (Auburn University)

OUTSTANDING POSTER

Flexible Power-Source Survivability Assurance under Bending Loads and Operating Temperatures Representative of Stresses of Daily Motion

Amrit Abrol (Auburn University)

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Bijendra Singh	G Moreno	Liang Gong	P Chowdhury	S Allard	
Bijoyraj Sahu	Giti Karimi	L Bharatham	P Sathyamurthy	S Langanke	

CONFERENCE TECHNICAL PROGRAM

TRACKS & SESSIONS

COMPONENT-LEVEL THERMAL MANAGEMENT

- TI-1A: LED and Power Devices I
- TI-1B: TIMs and Hotspot Cooling I
- TI-2: LED and Power Devices II
- TI-3: Heat Pipes and Vapor Chambers I
- TI-4: Device and Transistor Cooling I
- TI-5: Heat Spreaders
- TI-6: Package Cooling I
- TI-7: Heat Pipes and Vapor Chambers II
- TI-8: Device and Transistor Cooling II
- TI-9: TIMs and Hotspot Cooling II
- TI-10: Single-Phase Micro channels & Cold Plates
- TI-11: Two-Phase Cooling Techniques
- TI-12A: Cooling of Complex Packaging Systems
- TI-12B: Package Cooling II

SYSTEM-LEVEL THERMAL MANAGEMENT

- TII-1: Liquid Cooling I
- TII-2: Data Center I
- TII-3: Data Center II
- TII-4: Air Cooling I
- TII-5: Liquid Cooling II
- TII-6: Liquid Cooling III
- TII-7: Data Center III
- TII-8A: Air Cooling II
- TII-8B: Thermal Systems I
- TII-9: Data Center IV
- TII-10: Thermal Systems II
- TII-11: Thermal Systems III
- TII-12A: Data Center V
- TII-12B: Liquid Cooling IV

EMERGING TECHNOLOGIES & FUNDAMENTALS


- E-1: Numerical Methods, Nano-To-Macro Scale I
- E-2: Numerical Methods, Nano-To-Macro Scale II
- E-3: Thermal Transport in Nanotechnology
- E-4: Fundamentals of Boiling and Condensation
- E-5: Additive Manufacturing I
- E-6: Novel Measurement, Instrumentation and Experimental Techniques
- E-7: Additive Manufacturing II
- E-9: Emerging Materials and Fabrication Techniques
- E-10: Additive Manufacturing III
- E-11: Flexible Electronics
- E-12: Single-phase/Two-phase Convection in Channels and Jets

MECHANICS & RELIABILITY

- M-1: Multiphysics and Co-Design
- M-2: Emerging Technologies: Wearable, Flexible, Printed Electronics
- M-3: Materials Characterization I
- M-4: Materials Characterization II
- M-5: Reliability of HI Packages and Single Chip Packages
- M-6: Response and Reliability at High Strain I
- M-7: Reliability and Accelerated Testing of Solder Interconnects I
- M-8: Reliability and PHM I
- M-9: Reliability and PHM II
- M-10: Response and Reliability at High Strain II
- M-11: Reliability and Accelerated Testing of Solder Interconnects II



DAY 1 SESSIONS: WEDNESDAY, MAY 29, 7:00 - 10:30 AM

7:00 AM	Speakers' Breakfast, Gracia 4/8	
	E-1: Numerical Methods, Nano-To-Macro Scale I Gracia 1	TI-1A: LED and Power Devices I Gracia 7
	Session Chairs: <i>Harish Ganapathy (Intel), Raphael Mandel (University of Maryland)</i>	Session Chairs: <i>Craig Green (Carbice), Ajit Vallabhaneni (Georgia Tech)</i>
8:00 AM	Large Scale 3D Topology Optimization of Conjugate Heat Transfer (p145) Sicheng Sun, Piotr Liebersbach, Xiaoping Qian (University of Wisconsin-Madison)	Measurement-Based Multi-Domain Modelling of LEDs for Industry 4.0 (p124) Marton Bein, Robin Bornoff, Gabor Farkas, Lajos Gaal (Mentor A Siemens Business Budapest), Andras Poppe, Marta Rencz (Mentor A Siemens Business Budapest, Budapest University of Technology and Economics)
8:20 AM	Learning Based Mesh Generation for Thermal Simulation in Handheld Devices with Variable Power Consumption (p177) Wen-Sheng Lo, Hong-Wen Chiou, Shih-Chieh Hsu, Yu-Min Lee (National Chiao Tung University), Liang-Chia Cheng (Industrial Technology Research Institute)	Impact of Electronics over Localized Hot Spots in Multi-Chip White LED Light Engines (p215) Ahmet Mete Muslu, Mehmet Arik (Ozyegin University)
8:40 AM	Investigation of Thermal Metamaterials based on Nanoporous Silicon using Ray Tracing and Finite Element Simulations (p200) Ziqi Yu, Zongqing Ren, Jaeho Lee (University of California Irvine)	Phosphor-Silicone Coating Thickness Dependence of the WLED Junction Temperature (p300) Yuanhan Chen, Frank Shi (UCI)
9:00 AM	<p align="center">K-1 Keynote: Component Integration vs. Product Differentiation: Electronic Packaging Choices for Heterogeneous Assembly & Test</p> <p align="center">Gracia 2/3 Gaurang Choksi, Intel</p> <div style="display: flex; align-items: flex-start;">  <div> <p>Gaurang joined Intel in 1988 after receiving his PhD degree and during his 30+ year tenure at Intel, he has contributed to various areas including mechanical analysis and testing, electrical and physical design and analysis of multi-chip modules, design/analysis tool development for packages/boards, and thermal technologies and solutions.</p> <p>The scope of his group currently includes materials selection and characterization, dimensional measurements, and modeling and validation related to structural integrity, power delivery, high speed signaling, thermals and heat dissipation, and fluid flow to support the design and development of electronic packaging, assembly and test technologies. The group has teams and labs in Chandler, Oregon and Malaysia. He is a recipient of the Intel Achievement Award and serves on national advisory / review boards.</p> </div> </div>	
10:00 AM	Refreshment Break, Gracia Commons	

DAY 1 SESSIONS: WEDNESDAY, MAY 29, 7:00 - 10:30 AM

Speakers' Breakfast, Gracia 4/8

TII-1: Liquid Cooling I Gracia 6	M-1: Multiphysics and Co-Design Gracia 5	TI-1B: TIMs and Hotspot Cooling I Gracia 2/3
Session Chairs: <i>Akhilesh Rallabandi (Intel), Sankarananda Basak (Intel)</i>	Session Chairs: <i>Patrick McCluskey (University of Maryland), Abhijit Dasgupta (University of Maryland)</i>	Session Chairs: <i>Lauren Boteler (US Army Research Laboratory), Franklin Robinson (NASA GSFC), Piyas Chowdhury (IBM)</i>
Measuring Water Permeation Through EDPM Rubber Hoses (p101) Prabjit Singh, Larry Palmer (IBM Corp)	Benchmark Study on Cooling and Reliability Performance Due to Difference in Structure of Power Modules (p285) Yuta Ito, Koichi Ishiyama, Qiang Yu (Yokohama National University)	Pressure-Dependent Thermal Characterization of Bi-porous Copper Structures (p223) Cheng-Hui Lin, Yoonjin Won (University Of California Irvine)
Duo-CPU Liquid Cooling Loop Configuration: Parallel or Series? (p114) Haoran Chen, Yong Han, Gongyue Tang, Xiaowu Zhang (Agency for Science Technology and Research)	3-D Numerical Multiphysics Model for Cu-Al Wire Bond Corrosion (p393) Pradeep Lall, Yunli Zhang (Auburn University), Luu Nguyen (Texas Instruments)	Optimal Filler Sizes for Thermal Interface Materials (p234) Piyas Chowdhury, Kamal Sikka, Alfred Grill, Dishit Parekh (IBM)
	Temperature Change Leverage on Performance of MEMS Rotational Motion Sensors (p398) Jacek Nazdrowicz, Jacek Nazdrowicz, Andrzej Napieralski (Lodz University of Technology)	Effect of Filler Configuration on the Effective Thermal Conductivity of Polymer Composites (p265) Debraliz Isaac Aragonés (University of Central Florida & Purdue University), Aaditya Candadai, Rajath Kantharaj, Amy Marconnet (Purdue University)

K-1 Keynote: Component Integration vs. Product Differentiation: Electronic Packaging Choices for Heterogeneous Assembly & Test

Gracia 2/3
Gaurang Choksi, Intel

Abstract: During the last few decades, advances in electronic packaging have supported and sustained significant growth across computing, networking and data management ecosystems. Emerging applications and increased competition will drive an extremely diverse set of 2D, 2.5, 3D packaging architectures and designs, requiring novel material technologies and manufacturing processes. The area of heterogeneous packaging, assembly and test will continue to require significant improvements in the collaterals required for time-sensitive, cost-effective, and 'smart' technologies. This drives the need to define, develop and deploy cost-effective solutions that balance the need for increased integration and enabling the right level of product differentiation. Rigorous assessments with the appropriate quantification and understanding of multiple trade-offs across performance, manufacturing complexity, yield and cost need to be comprehended for the right decisions to be made on different options and the degree of component integration vs. product differentiation.

Challenges need to be addressed for facilitating the effective analysis and characterization to facilitate efficient design, materials selection and associated assembly and test manufacturing processes. The role of inter-disciplinary solutions and the need for new competencies will be highlighted, including recent trends in technologies, advanced analysis / simulation tools and metrologies and their applications to electronic packaging. This includes the analysis, characterization, validation and optimization of the different steps of the design, assembly manufacturing and test equipment and processes, and the design / materials used to meet mechanical integrity, reliability, high speed signal integrity, power delivery and thermal dissipation requirements.

Refreshment Break, Gracia Commons

DAY 1 SESSIONS: WEDNESDAY, MAY 29, 10:30 – 1:30 PM		
	E-2: Numerical Methods, Nano-To-Macro Scale II Gracia 1 Session Chairs: <i>Harish Ganapathy (Intel), Raphael Mandel (University of Maryland)</i>	TI-2: LED and Power Devices II Gracia 7 Session Chairs: <i>Firooz Faili (Element Six), Nazli Donmezer (METU)</i>
10:30 AM	Featured Paper Presentation A Numerical Analysis of Conductive Heat Transfer in Cylindrical Thermal Energy Storage Composites (p224) Alison Hoe, Michael Deckard, Jonathan Felts, Patrick Shamberger (Texas A&M University)	Featured Paper Presentation Spatially-Varying Electrothermal Impedance Analysis for Designing Power Semiconductor Converter Systems (p341) Timothy Polom (University of Wisconsin-Madison), Christoph Van Der Broeck, Rik De Doncker (RWTH Aachen University), Robert Lorenz (University of Wisconsin-Madison)
11:00 AM	Modeling Performance and Thermal Induced Reliability Issues of a 3nm FinFET Logic Chip Operation in a Fan-Out and a Flip-Chip Packages (p239) Munkang Choi, Xiaopeng Xu, Victor Moroz (Synopsys)	Phonon Mean Free Path - Thermal Conductivity Relation in AlN (p197) Ilke Albar, Fatma Nazli Donmezer Akgun (Bogazici University)
11:20 AM	Transient Thermal Compact Models Time Integration with Python (p440) Torsten Hauck, Vibhash Jha (NXP Semiconductors)	Parametric Compact Thermal Modeling of Power LEDs (p246) Tomasz Torzewicz (Lodz University of Technology), Przemyslaw Ptak (Gdynia Maritime University), A. Samson, T. Raszkowski, Marcin Janicki (Lodz University of Technology), Krzysztof Gorecki (Gdynia Maritime University)
11:40 AM	Exhibitor Presentation ECXML: An Open Standard for Model Sharing in the Electronics Cooling Supply Chain Joe Dorsey (Future Facilities, Inc.)	Diamond Resistives - The Passive Way to Manage the Heat and Keep the VSWR Low at High Frequencies (p334) Firooz Faili, Gruffudd Williams, Thomas Obeloer, Daniel Twitchen (Element Six Technologies)
12:00 PM	Luncheon & Richard Chu ITherm Award for Excellence Presentation, Gracia 4/8 Prof. John R. Thome, EPFL, JJ Cooling Innovation Sàrl <div style="display: flex; align-items: flex-start;">  <div> <p>Abstract: In this lecture, I will recount some of the initial history of micro channel two-phase flow and boiling work by others that enticed me to join into the development of this field and will then focus on my team's work at the EPFL in Lausanne during the last 20 years, covering work on micro channel flow boiling, new flow visualisation/image processing techniques, flow stabilisation, heat transfer models, flow pattern maps, micro-two-phase cooling systems, and numerical modeling of bubbly/slug flows.</p> </div> </div>	

DAY 1 SESSIONS: WEDNESDAY, MAY 29, 10:30 – 1:30 PM		
TII-2: Data Center I Gracia 6	M-2: Emerging Technologies: Wearable, Flexible, Printed Electronics Gracia 5	P-2: Thermal/Mechanical Management of Mobile/Computing Devices Gracia 3
Session Chairs: <i>Mehmet Arik (Ozyegin University), Arun Raghupathy (Google)</i>	Session Chairs: <i>Pradeep Lall (Auburn University), Abhijit Dasgupta (University of Maryland)</i>	Moderator: <i>Victor Chiriac (Futurewei Technologies)</i>
Featured Paper Presentation Economic and Environmental Analysis of U.S.-Based Data Centers Containing Photovoltaic Power Generation (p107) Li Chen, Aaron Wemhoff (Villanova University)	Featured Paper Presentation Method for Assessment of Folding-Reliability of Flexible Electronics in Wearable Applications (p377) Pradeep Lall, Hyesoo Jang (Auburn), Ben Leever (US AFRL), Scott Miller (Nextflex Manufacturing Institute)	Thermal/Mechanical Management of Mobile/Computing 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. This is associated with increasingly demanding thermal management and other packaging issues ranging from low to high form factors. 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.
Design Optimization and Characterization of a Mini Heat Exchanger for Data Centre Cooling Application (p108) Gongyue Tang, Yong Han, Haoran Chen, Xiaowu Zhang (Institute of Microelectronics)	Package Design for Multiphysics MEMS Sensor (p133) Nicolo Manca, Marco Del Sarto, Alex Gritti, Roseanne Duca, Vince Mangion (STMicroelectronics)	Panelists: Rick Beyerle (NeoGraf Solutions) Gaurang Choksi (Intel) Ken Goodson (Stanford University) Mark Hartman (Outlast Technologies) YC Lee (UC Boulder) Hiroyuki Ryoson (Dexerials) John Thome (JJ Cooling Innovation)
An Optimization Algorithm to Design Compact Plate Heat Exchangers for Waste Heat Recovery Applications in High Power Datacenter Racks (p121) Raffaele Luca Amalfi, Filippo Cataldo, John Richard Thome (Ecole Polytechnique Federale De Lausanne)	Effect of Sintering Temperature on the Fatigue Life of Additively Printed Electronics during Cyclic Bending (p386) Pradeep Lall, Jinesh Narangaparambil (Auburn University), Ben Leever (USAF Research Labs), Scott Miller (NextFlex Manufacturing Institute)	
Trends in High Performance Computing: Exascale Systems and Facilities Beyond the First Wave (p122) Dustin Demetriou (IBM), Lynn Parnell (Consulting Engineer), Vinod Kamath (Lenovo DataCenter Group), Eric Zhang (IBM)	Effect of Shallow Charging on Flexible Power Source Capacity Subjected to Varying Charge Protocols and C-Rates (p389) Pradeep Lall, Ved Soni, Amrit Abrol (Auburn University), Ben Leever (USAF Research Labs), Scott Miller (NextFlex Manufacturing Institute)	
Luncheon & Richard Chu ITherm Award for Excellence Presentation Gracia 4/8 Prof. John R. Thome, EPFL, JJ Cooling Innovation Sàrl		
<p>John R. Thome is Professor-Emeritus of Heat and Mass Transfer at the Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland since 1998. He obtained his PhD at Oxford University in 1978. Having retired in July 2018 at the EPFL, he has now founded a consulting/thermal engineering software company, JJ Cooling Innovation Sàrl in Lausanne. He is also a Visiting professor at Brunel University in London and an Honorary professor at the University of Edinburgh. He is the author of five books on two-phase heat transfer and flow and has over 245 journal papers on macroscale and microscale two-phase flow, flow visualisation, boiling/condensation heat transfer, flow pattern-based models, and micro-two-phase cooling systems for electronics cooling. He has done numerous sponsored projects with IBM, ABB, Nokia Bell Labs, Carl Zeiss, CERN, etc. He is editor-in-chief of the 16-volume series Encyclopedia of Two-Phase Heat Transfer and Flow (2016-2018). He founded the Virtual International Research Institute of Two-Phase Flow and Heat Transfer in 2014, now with 25 participating universities to promote research collaboration, sharing of experimental and numerical data, and education.</p>		

DAY 1 SESSIONS: WEDNESDAY, MAY 29, 1:30 – 3:30 PM		
	E-3: Thermal Transport in Nanotechnology Gracia 1 Session Chairs: <i>Jaeho Lee (UC-Irvine), Ronald Warzoha (United States Naval Academy)</i>	TI-3: Heat Pipes and Vapor Chambers I Gracia 7 Session Chairs: <i>Bidzina Kekelia (National Renewable Energy Laboratory), Mohammed Ababneh (ACT)</i>
1:30 PM	Featured Paper Presentation Stretchable Selective Emitters based on Carbon Nanotube Films for Adaptive Thermal Control (p212) Xiao Nie, Anirudh Krishna (University of California Irvine), Myunghwan Jeong, Peng Wu, Choongho Yu (Texas A&M University), Jaeho Lee (University of California Irvine)	Featured Paper Presentation Numerical Simulations of Pulsating Heat Pipes, Part 1: Modelling (p102) Philippe Aubin, Brian Dentremont, Filippo Cataldo (Ecole Polytechnique Federale De Lausanne), Jackson Braz Marcinichen (JJ Cooling Innovation Sarl), Raffaele Luca Amalfi (EPFL, Nokia Bell Laboratories), John Richard Thome (EPFL, JJ Cooling Innovation Sarl)
2:00 PM	Near Field Radiative Emissivity Enhancement with Application in Electronics Cooling (p264) Mine Kaya, Shima Hajimirza (Texas A&M University), Aliakbar Merrikh (Advanced Micro Devices), Mehdi Saeidi (Qualcomm)	Numerical Simulations of Pulsating Heat Pipes, Part 2: Comparison to Experimental Data (p103) Philippe Aubin, Filippo Cataldo, Jackson Braz Marcinichen (Ecole Polytechnique Federale De Lausanne), Raffaele Luca Amalfi (EPFL, Nokia Bell Laboratories), Sung Jin Kim (Korea Advanced Institute of Science and Technology), John Richard Thome (EPFL, JJ Cooling Innovation Sarl)
2:20 PM	Computational Investigation of Nanoscale Memristor Devices for Neuromorphic Computing (p314) Darshan Pahinkar, Pradip Basnet, Bill Zivasatienraj, Alex Weidenbach, Matthew West, William Alan Doolittle, Eric Vogel, Samuel Graham (Georgia Institute of Technology)	Analytical Model for a Cylindrical Heat Pipe (p120) Venu Madhav H (Indian Institute of Science Bangalore), Venkata Raghavendra (Indian Space Research Organisation Bangalore), Pramod Kumar (Indian Institute of Science Bangalore), Amrit Ambirajan (Indian Space Research Organisation Bangalore)
2:40 PM	Molecular Dynamic Simulation of the Effect of Nanocoating on Two-Phase Evaporative Heat and Mass Transfer (p437) Binjian Ma, Shan Li, Junhui Li (Washington University in Saint Louis), Baris Dogruoz (Cisco System), Damena Agonafer (Washington University in Saint Louis)	Three Dimensional Heat Pipe Vapor Chamber Design and Performance (p137) Nelson Gernert, Mark North (Aavid, Thermal Division of Boyd Corp.)
3:00 PM	Refreshment Break, Gracia Commons	

DAY 1 SESSIONS: WEDNESDAY, MAY 29, 1:30 – 3:30 PM

<p>TII-3: Data Center II</p> <p>Gracia 6</p>	<p>M-3: Materials Characterization I</p> <p>Gracia 5</p>	<p>TT-3: Next Generation Thermal System Design</p> <p>Gracia 3</p>
<p>Session Chairs: <i>Vibhash Jha (Intel), Sachin Deshmukh (Intel)</i></p>	<p>Session Chairs: <i>SB Park (Binghamton University SUNY), Abhijit Dasgupta (University of Maryland), Sandeep Tonapi (Anveshak)</i></p>	<p>Session Chairs: <i>Timothy Fisher (UCLA)</i></p>
<p>Featured Paper Presentation Investigation on Performance Difference on Air and Liquid Close Loop Heatsink in 1U Server (p227) Feng Qi, Wenbin Tian, Shaorong Zhou, Yuehong Fan, Casey Winkle (Intel)</p>	<p>Featured Paper Presentation Uniaxial Creep Response of Double-Layered Pressure Sensitive Adhesive (PSA) (p339) Hao Huang, Abhijit Dasgupta (University of Maryland), Ehsan Mirbagheri, Krishna Darbha (Microsoft Corporation)</p>	<p>The Need for Next Gen. Thermal System Modeling Peter deBock (GE)</p>
<p>Advanced Thermal Solution for High Performance Server System Energy Efficiency (p173) Xianguang Tan, Jie Zhao, Hongmei Liu, Jiajun Zhang (Baidu), Jun Zhang, Jialiang Xu, Sandeep Ahuja, Dayi Zhi, Ken Zhang (Intel)</p>	<p>Evolution of the Mechanical Properties of Lead Free Solder Joints Subjected to Mechanical Cycling (p419) Mohd Aminul Hoque, Md Mahmudur Chowdhury, Sad Hamasha, Jeffrey Suhling, Pradeep Lall (Auburn University)</p>	<p>Using Data in Flow Physics Modeling Jeff Eldridge (UCLA)</p>
<p>Numerical Convective Heat Transfer Analysis of a Hybrid-Cooled Data Center Blade Server (p181) Sara Battaglioli, Assel Sakanova, Tim Persoons (Trinity College Dublin)</p>	<p>Effect of Prolonged Storage up to 1-year on Anand Parameters for SAC105 Leadfree Alloys (p391) Pradeep Lall, Vikas Yadav, Jeff Suhling (Auburn University), David Locker (US ARMY AMRDEC)</p>	<p>High-Efficiency Electric Aircraft Thermal Research (HEAThER) Sydney Schnulo (NASA Glenn)</p>
<p>Use of Direct Airside Economizers in Thermal Management of Data Centers: Opportunities and Challenges (p203) Huseyin Bostanci, Seifollah Nasrazadani (University of North Texas)</p>	<p>Mechanical Characterization and Microstructural Evolution of SAC and SAC+X Lead Free Solders Subjected to High Temperature Aging (p417) Mohammad Alam, KM Rafidh Hassan, Jeffrey Suhling, Pradeep Lall (Auburn University)</p>	
<p>Refreshment Break, Gracia Commons</p>		

DAY 1 SESSIONS: WEDNESDAY, MAY 29, 3:30 – 7:30 PM		
	E-4: Fundamentals of Boiling and Condensation Gracia 1 Session Chairs: <i>Farah Singer (University of Maryland), Harish Ganapathy (Intel), Vibhash Jha (Intel), Satish Kumar (Georgia Institute of Technology)</i>	TI-4: Device and Transistor Cooling I Gracia 7 Session Chairs: <i>Emad Poshtan (Bosch Germany), Mahsa Ebrahim (Loyola Marymount University)</i>
3:30 PM	Featured Paper Presentation Unprecedented Capillary Evaporative Heat Flux in Nanochannels (p210) Masoumeh Nazari, Hadi Ghasemi (University of Houston)	Featured Paper Presentation Effects of Silicide Inclusion Shape on Thermal Transport of Silicon-Based Nanowires and Nanocomposites for Thermoelectrical Applications (p138) Laia Ferrer-Argemi, Jonathan Sullivan, Jaeho Lee (University of California Irvine)
4:00 PM	An Experimental Study of a Single Droplet Impacting onto a Heated Surface at High Impact Weber Numbers (p280) Vaidehi Oruganti (Villanova University), Joshua Amurao, Mahsa Ebrahim (Loyola Marymount University), Alfonso Ortega (Villanova University)	Leakage-Aware Dynamic Compact Thermal Model for CMOS Technology (p171) Chi-Wen Pan, Pei-Yu Huang, Chia-Hao Hsu, Sheng-Liang Kuo, Tai-Yu Chen (MediaTek Inc)
4:20 PM	Reduction of Flow Boiling Instabilities in Microchannels by Periodic Variation of the Channel Cross-Sectional Geometry (p269) Le Gao (Qualcomm), Sushil Bhavnani (Auburn University)	Enhancement of the Electrical and Thermal Performance of AlGaN/GaN HEMTs Using a Novel Resistive Field Plate Structure (p238) Bikramjit Chatterjee ¹ , Tae Kyoung Kim ² , Yiwen Song ¹ , James Spencer Lundh ¹ , Sang-Woo Han ¹ , Daniel Shoemaker ¹ , Jae Min Lee ² , Moon Uk Cho ² , Rongming Chu ¹ , Joon Seop Kwak ² , Sukwon Choi ¹ , ¹ Penn State, ² Sunchon National University
4:40 PM	A Predictive Model for Evaporation Mass Flux (p209) Parham Jafari, Hadi Ghasemi (University of Houston)	Electrothermal Simulation of Delta-Doped β-Ga₂O₃ Based Field Effect Transistors (p295) Nitish Kumar (Georgia Institute of Technology), Chandan Joishi, Zhanbo Xia, Siddharth Rajan (The Ohio State University), Satish Kumar (Georgia Institute of Technology)
5:00 PM	Student Heat Sink Design Challenge Gracia 2 The ITherm organizing committee is delighted to announce the inaugural Student Heat Sink Design Challenge that is being held during ITherm 2019.	
6:30 PM	ECTC/ITherm Joint Women's Panel & Reception Nolita 1 (4 th Floor) Moderators: Cristina Amon (University of Toronto); Kristina Young-Fisher (Global Foundries) Panelists: <i>Rolf Aschenbrenner (Fraunhofer-Institut fuer Zuverlaessigkeit und Mikrointegration); Dereje Agonafer (University of Texas at Arlington); Monica Jackson (GE Aviation Business); Jean Trehwella (Global foundries)</i>	

DAY 1 SESSIONS: WEDNESDAY, MAY 29, 3:30 – 7:30 PM

<p>TII-4: Air Cooling I</p> <p>Gracia 6</p>	<p>M-4: Materials Characterization II</p> <p>Gracia 5</p>	<p>P-4: Micro-Two-Phase Liquid Cooling Systems for Electronics</p> <p>Gracia 3</p>
<p>Session Chairs: <i>Joshua Gess (Oregon State University), Xiaojin Wei (Google)</i></p>	<p>Session Chairs: <i>Abhijit Dasgupta (University of Maryland), SB Park (Binghamton University SUNY)</i></p>	<p>Moderators: <i>John R. Thome (EPFL, JJ Cooling Innovation Sàrl)</i></p>
<p>Featured Paper Presentation Air-based Cooling in High Porosity, Aluminum Foams for Compact Electronics Cooling (p146) Sanskar Panse, Prashant Singh, Srinath Ekkad (North Carolina State University)</p>	<p>3:30 PM: Investigation of Aging Induced Microstructural Changes in Doped SAC+X Solders (p420) Jing Wu, Sudan Ahmed, Jeffrey Suhling, Pradeep Lall (Auburn University)</p>	<p>Micro-Two-Phase Liquid Cooling Systems for Electronics</p> <p>Abstract: Two-phase cooling continues to gain traction in the cooling of electronics. 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.</p> <p>Panelists: Luca Amalfi (Nokia Bell Labs) Filippo Cataldo (Provides MetalMeccanica) Robert Christensen (CeramTEC GmbH) Ahmed Zaghlol (Mersen)</p>
<p>Impact of Solar Radiation on the Thermal Design of Outdoor Enclosures for 5G Devices in the Automotive Transmission Platform with Thermal Risk Analysis (p140) Bhagyashree Ganore, Daniel Cox, Richard Perry, Mengkun Ke (Intel)</p>	<p>3:50 PM: Evolution of the Mechanical Behavior of Lead Free Solders Exposed to Thermal Cycling (p426) Kamrul Hasan, Abdullah Fahim, Jeffrey Suhling, Sad Hamasha, Pradeep Lall (Auburn University)</p>	
<p>Thermal Modeling of Air Cooled Outdoor Digital Displays (p158) Jeho Kim (Georgia Institute of Technology), Mike Brown (LG-MRI), Yogendra Joshi (Georgia Institute of Technology), Kevin OConnor, Marcos Diaz (LG-MRI)</p>	<p>4:10 PM: Experimental Characterization of the Dependence of the Poisson’s Ratio of Lead Free Solder on Temperature, Strain Rate, Solidification Profile, and Isothermal Aging (p421) KM Rafidh Hassan, Mohammad Alam, Jeffrey Suhling, Pradeep Lall (Auburn)</p>	
<p>Numerical Study of a New Rack Layout for Better Cold Air Distribution and Reduced Fan Power (p273) Xin Xiong, Yogesh Fulpagare, Chuan Sun, Poh Seng Lee (National University of Singapore)</p>	<p>4:30 PM: A Study on the Elastic Constants of 4H Silicon Carbide (4H-SiC) (p297) Jun Chen, Jeffrey Suhling, Richard Jaeger (Auburn University)</p>	
	<p>4:50 PM: Characterization of Viscoelastic Response of Underfill Materials (p422) Promod Chowdhury, Jeffrey Suhling, Pradeep Lall (Auburn University)</p>	

Student Heat Sink Design Challenge

Gracia 2


The Student Heat Sink Design Challenge is a team competition in which students design, analyze and optimize an aluminum additively manufactured heat sink to cool a constant heat flux power electronics module subject to forced convection. The design from each student team is then evaluated based on a series of design and manufacturing criteria.

ECTC/ITherm Joint Women’s Panel & Reception

Nolita 1 (4th Floor)

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 panelists will speak on *Unleashing the Power of Diversity in the Workforce*. Discussions will include the power of diversity in high-performing workplaces, strategies to build a diverse workforce, and tools for inclusion and engagement. Panelists will also address the creation of policies and programs to increase inclusion along with metrics to assess progress, and share both successes and challenges to achieving these goals. A Q&A session and reception for panelists and attendees will follow.

DAY 2 SESSIONS: THURSDAY, MAY 30, 7:00 - 10:30 AM

7:00 AM	Speakers' Breakfast, Gracia 4/8	
	<p>E-5: Additive Manufacturing I</p> <p>Gracia 1</p> <p>Session Chairs: <i>Farah Singer (University of Maryland), Martinus Arie (University of Maryland)</i></p>	<p>TI-5: Heat Spreaders</p> <p>Gracia 7</p> <p>Session Chairs: <i>Yingying Wang (Google), Jin Yang (Intel)</i></p>
8:00 AM	<p>Experimental Demonstration of an Additively Manufactured Vapor Chamber Heat Spreader (p127)</p> <p>Serdar Ozguc, Saeel Pai, Liang Pan (Purdue University), Patrick Geoghegan (Oak Ridge National Laboratory), Justin Weibel (Purdue University),</p>	<p>Spreading Resistance in Flux Channels with Nonuniform Properties and Complex Structures (p214)</p> <p>Belal Al-Khamaiseh (American University Of Sharjah), Yuri Muzychka, Serpil Kocabiyik (Memorial University Of Newfoundland)</p>
8:20 AM	<p>Additive Manufacturing of Compact Manifold-Microchannel Heat Exchangers utilizing Direct Metal Laser Sintering (p156)</p> <p>Hadi Keramati, Fabio Battaglia, Martinus Arie, Farah Singer, Michael Ohadi (University of Maryland)</p>	<p>Analysis of Heat Transfer from a Heat Dissipating Device on a Substrate (p400)</p> <p>Joao Vitor Thomsen Silveira, Zidi Li, Bolun Yang (Tokyo Institute of Technology), Ryuta Yasui (MEITEC Corporation), Takuya Shinoda (DENSO Corporation), Kazuyoshi Fushinobu (Tokyo Institute of Technology)</p>
8:40 AM	<p>Thermal Conductivity Measurement of Mesoscale Lattices Using Steady-State Infrared Thermography (p228)</p> <p>Shiva Farzinazar, Lorenzo Valdevit, Jaeho Lee (University of California Irvine)</p>	
9:00 AM	<p align="center">K-2 Keynote: A Systems Approach to Management of Transient Thermal Systems for Mobile Electrification</p> <p align="center">Gracia 2/3</p> <p align="center">Andrew Alleyne, University of Illinois, Urbana-Champaign</p> <div style="display: flex; align-items: flex-start;">  <div> <p>Andrew Alleyne received his B.S.E. from Princeton and his M.S./Ph.D. degrees, respectively, from UC Berkeley. He joined the University of Illinois, Urbana-Champaign in 1994 where he currently holds the Ralph and Catherine Fisher Professorship and is the Director for the NSF Engineering Research Center on Power Optimization for Electro-Thermal Systems (POETS). His research focuses on the modeling, simulation and control of nonlinear mechanical systems with a current focus on transient thermal system. His academic record includes supervision of over 80 M.S. and Ph.D. students and over 400 conference and journal publications. He has been a Distinguished Lecturer of the Institute for Electronic and Electrical Engineers (IEEE) and a National Research Council (NRC) Associate. He is a Fellow of IEEE and ASME and currently serves on the Scientific Advisory Board for the U.S. Air Force and the National Academies Board On Army Research and Development.</p> </div> </div>	
10:00 AM	Refreshment Break, Gracia Commons	

DAY 2 SESSIONS: THURSDAY, MAY 30, 7:00 - 10:30 AM

Speakers' Breakfast, Gracia 4/8

<p>TII-5: Liquid Cooling II</p> <p>Gracia 6</p>	<p>M-5: Reliability of HI Packages and Single Chip Packages</p> <p>Gracia 5</p>	<p>TT-5: Heterogeneous Integration</p> <p>Gracia 2/3</p>
<p>Session Chairs: <i>Columbia Mishra (Intel), Ajay Vadakkepatt (Qualcomm)</i></p>	<p>Session Chairs: <i>Przemyslaw Gromala (Robert Bosch GmbH), Tian Zhao (Robert Bosch GmbH)</i></p>	<p>Session Chairs: <i>Madhusudan Iyengar (Google)</i></p>
<p>Heat Transfer and Pressure Drop Performance of Additively Manufactured Polymer Heat Spreaders for Low-Weight Directed Cooling Integration in Power Electronics (p216) Reece Whitt, Bakhtiyar Mohammad Nafis, David Huitink, Zhao Yuan, Amol Deshpande, Balaji Narayanasamy, Fang Luo (University of Arkansas)</p>	<p>Reliability of Package on Package (PoP) Assembly under Thermal Cycles (p135) Reza Ghaffarian (JPL)</p>	<p>Emerging Challenges and Materials for Thermal Management of Electronics Arden L. Moore (Louisiana Tech University)</p> <p>Direct Laser Metal Printing of Heat Removal Devices onto Silicon Scott Schiffres (SUNY Binghamton)</p>
<p>Two-Phase Vapor Chambers with Micropillar Evaporators: A New Approach to Remove Heat from Future High-Performance Chips (p231) Zihao Yuan (Boston University), Geoffrey Vaartstra (MIT), Prachi Shukla (Boston University), Mostafa Said, Sherief Reda (Brown University), Evelyn Wang (MIT), Ayse Coskun (Boston University)</p>	<p>System in Package (SiP) Assembly and Reliability (p136) Reza Ghaffarian (JPL)</p>	
<p>An Experimental Study of Single-phase Heat Transfer inside an Additively Fabricated Microchannel Heat Exchanger (p112) Jiajun Xu, Jaime Rios (University of the District of Columbia)</p>	<p>Design Study to Prevent Mold Delamination for Overmolded Lead Frame Package (p326) Yeonsung Kim, Carl Raleigh, Shafi Saiyed (Analog Devices Inc)</p>	

K-2 Keynote: A Systems Approach to Management of Transient Thermal Systems for Mobile Electrification

Gracia 2/3

Andrew Alleyne, University of Illinois, Urbana-Champaign

Abstract: Modern electrified mobility demands increased levels of electrical power, thereby putting mounting strains on the concomitant thermal management. These trends can be seen across a variety of mobility modalities. This talk will present results on the management of thermal loads from a systems perspective with a focus on complex systems having multiple interconnected subsystems; these subsystems include thermal sources, sinks, transport, heat exchange interfaces, and storage elements. The overall systems also include the interaction with the electrical components providing the source of the thermal loads. First, we introduce a graph-based framework that is useful for understanding the complex interconnections within these systems. Subsequently, we will present numerical design optimization approaches that exploit the mathematical formulation resulting from the graphs to select vehicle topology as well as component sizing while considering both static design and dynamic control. This optimization approach includes the co-design of the electrical and thermal, or electro-thermal, systems rather than the more typical sequential design of electrical systems dictating thermal requirements. Thirdly, a control approach for the complex electro-thermal class of systems using a hierarchical approach will be presented. The hierarchical framework allows for the simultaneous management of both the electrical and thermal power. The presentation will include design examples from the automotive and aerospace domains.

Refreshment Break, Gracia Commons

DAY 2 SESSIONS: THURSDAY, MAY 30, 10:30 – 1:30 PM

	<p>E-6: Novel Measurement, Instrumentation and Experimental Techniques</p> <p>Gracia 1</p> <p>Session Chairs: <i>Patrick Shamberger (Texas A&M), Dion Antao (Texas A&M), Amy Marconnet (Purdue University)</i></p>	<p>TI-6: Package Cooling I</p> <p>Gracia 7</p> <p>Session Chairs: <i>Yingying Wang (Google), Husam Alissa (Microsoft)</i></p>
<p>10:30 AM</p>	<p>Featured Paper Presentation A Measurement Technique for Thermal Conductivity Characterization of Ultra-High Molecular Weight Polyethylene Yarns Using High-Resolution Infrared Microscopy (p130) Aaditya Anand Candadai, Justin Weibel, Amy Marconnet (Purdue University)</p>	<p>Featured Paper Presentation Integrating Heat Sinks into a 3D Co-Design Network Model for Quick Parametric Analysis (p338) Lauren Boteler (US Army Research Laboratory), Steven Miner (US Naval Academy), Michael Fish, Morris Berman (US Army Research Laboratory)</p>
<p>11:00 AM</p>	<p>Two-Color Laser Induced Fluorescence Measurements of Natural Convection in a Dielectric Fluid (p162) Rachel McAfee, Bryce Cox, Joshua Gess (Oregon State University)</p>	<p>Accurate Modeling of Forced Convection Cooling for Microelectronic Packages: Numerical and Experimental Thermal Studies (p126) Mamadou Kabirou Toure, Papa Momar Souare (University of Sherbrooke), Benoit Foisy, Eric Duchesne (IBM Bromont), Julien Sylvestre (University of Sherbrooke)</p>
<p>11:20 AM</p>	<p>Identifying Hot Spots in Electronics Packages with a Sensitivity-Coefficient Based Inverse Heat Conduction Method (p207) Patrick Krane, David Gonzalez Cuadrado, Francisco Lozano, Guillermo Paniagua, Amy Marconnet (Purdue University)</p>	<p>Multi-port Dynamic Compact Thermal Models of BGA package using Model Order Reduction and Metaheuristic Optimization (p306) Valentin Bissuel, Vincent Fox, Eric Monier-Vinard (Thales Global Services), Alain Neveu, Frederic Joly (Paris Saclay University), Olivier Daniel (Thales Global Services)</p>
<p>11:40 AM</p>	<p>Step-by-Step Guide to Determining Experimental Uncertainty in Thin-Film Resistance (p316) Michael Fish, Lauren Boteler, Morris Berman (US Army Research Laboratory)</p>	<p>Exhibitor Presentation Thermal Management Solutions for High Performance Microprocessor Manufacturing Dr.-Ing. Sven Knippscheer (TECNISCO EUROPE GmbH)</p>
<p>12:00 PM</p>	<p>Luncheon: ITherm Sponsors, Exhibitors, and Partners Gracia 4/8</p>	

DAY 2 SESSIONS: THURSDAY, MAY 30, 10:30 – 1:30 PM

<p>TII-6: Liquid Cooling III</p> <p>Gracia 6</p>	<p>M-6: Response and Reliability at High Strain I</p> <p>Gracia 5</p>	<p>P-6: Trends Towards Multi-Disciplinary Co-Design for Next Generation Electronics Systems</p> <p>Gracia 3</p>
<p>Session Chairs: <i>Sankarananda Basak (Intel), Columbia Mishra (Intel)</i></p>	<p>Session Chairs: <i>Abhijit Dasgupta (University of Maryland)</i></p>	<p>Moderator: <i>Yogendra Joshi (Georgia Tech), Lauren Boteler (US Army)</i></p>
<p>Featured Paper Presentation Pool Boiling Experiment of Dielectric Liquids and Numerical Study for Cooling a Microprocessor (p308) Omidreza Ghaffari (University Of Sherbrooke), Francis Grenier (Systemex Energies Inc), Jean Francois Morissette (University Of Sherbrooke), Martin Bolduc (Varitron Technologie Inc), Simon Jasmin (Systemex Energies Inc), Julien Sylvestre (University Of Sherbrooke)</p>	<p>Featured Paper Presentation Reliability of Leadfree Solders in High Temperature Vibration in Automotive Environments (p390) Pradeep Lall, Vikas Yadav, Jeff Suhling (Auburn University), David Locker (US ARMY AMRDEC)</p>	<p>Trends Towards Multi-Disciplinary Co-Design for Next Generation Electronics Systems</p> <p>Abstract: As technology transitions into more electrified systems, the electrical, thermal, and reliability needs of these systems must be simultaneously accounted for due to the need for more power in smaller units with no loss in reliability. Unfortunately, most research has focused on solving only one technical challenge: a better heat sink, a better circuit design or a more reliable material. When thermal design is treated as a discrete step and not addressed until the end of development, systems become large, overly complex, and inefficient. This panel discusses the trend towards multi-disciplinary co-design for next generation electronics systems.</p> <p>Panelists: Andrew Alleyne (UIUC) Avi Bar-Cohen (Raytheon) Lauren Boteler (US Army) Bill Gerstler (GE) Satish Kumar (Georgia Tech) Ankur Srivastava (Univ of Maryland)</p>
<p>Experimental Investigation of Resonant Flow Pulsation in Mesochannels Embedded with Wavy Fins (p119) Jaakko McEvoy, Tim Persoons (Trinity College Dublin)</p>	<p>Effect of Shock Pulse Variation on Surface Mount Electronics under High G Shock (p388) Pradeep Lall, Aathi Raja Ram Pandurangan, Kalyan Dornala, Jeff Suhling, (Auburn University) John Deep (US Air Force Research Laboratories), Ryan Lowe (ARA Associates, Inc.)</p>	
<p>Particulate Functionalized Nanodiamond as a Low Concentration Additive to Liquid Systems to Enhance their Thermal Extraction Capability (p144) Farzin Mashali¹, Ethan M. Languri¹, Jim Davidson^{2,3}, David Kerns^{2,3}, Blake Branson², Wayne Johnson¹, Lino Costa⁴, Kathleen Lansford⁴, ¹Tennessee Technological University, ²International Femtoscience Inc, ³Vanderbilt University, ⁴University of Tennessee Space Institute</p>	<p>Effect of Elevated Storage Temperature on the High Strain Rate Mechanical Properties of SAC305 Solder (p383) Pradeep Lall, Vishal Mehta, Jeff Suhling (Auburn University), Ken Blecker (US Army Combat Capabilities Development Command - Armament Center)</p>	
<p>Compact Liquid Cooling System Incorporating Metal Foam and Fin Hybrid Structures for High Power IGBTs (p161) Jooyoung Lee, Seokkan Ki, Youngsuk Nam (Kyung Hee University)</p>	<p>Evolution of Anand Parameters for SAC-Q Solder Alloy After Prolonged Storage up to 1-Year at High Strain Rate at Very High Operating Temperature (p392) Pradeep Lall, Vikas Yadav, Jeff Suhling (Auburn University), David Locker (US ARMY AMRDEC)</p>	
<p align="center">Luncheon: ITherm Sponsors, Exhibitors, and Partners Gracia 4/8</p>		

DAY 2 SESSIONS: THURSDAY, MAY 30, 1:30 – 3:30 PM		
	E-7: Additive Manufacturing II Gracia 1 Session Chairs: <i>Farah Singer (University of Maryland), Martinus Arie (University of Maryland)</i>	TI-7: Heat Pipes and Vapor Chambers II Gracia 7 Session Chairs: <i>Bidzina Kekelia (National Renewable Energy Laboratory), Sami Alkharabsheh (Binghamton University)</i>
1:30 PM	Featured Paper Presentation Experimental Characterization of a Manifold-Microchannel Heat Exchanger Fabricated Based on Additive Manufacturing (p230) William Yameen, Nathan Piascik, Riccardo Clemente, Andrew Miller, Seyed Niknam, Jingru Benner, Anthony Santamaria, Mehdi Mortazavi (Western New England University)	Featured Paper Presentation Experimental Demonstration of Heat Pipe Operation Beyond the Capillary Limit During Brief Transient Heat Loads (p128) Kalind Baraya, Justin Weibel, Suresh Garimella (Purdue University)
2:00 PM	Maximizing the Performance of a 3D Printed Heat Sink by Accounting for Anisotropic Thermal Conductivity During Filament Deposition (p353) Matthew Smith (TCPoly), Seokpum Kim, Alexander Lambert (ORNL), Maxwell Walde (Georgia Institute of Technology), John Lindahl (ORNL), Kaustubh Mugale (University of Tennessee), Thomas Bougher (Georgia Institute of Technology), Ahmed Arabi Hassen (ORNL), Vlastimil Kunc (ORNL)	High Temperature Lightweight Heat Pipes for Solid-State Power Amplifier (SSPA) Thermal Management (p205) Mohammed Ababneh, Calin Tarau, William Anderson (Advanced Cooling Technologies)
2:20 PM	Effect of Print Parameters on Print Consistency of Aerosol Jet Printed Electronics (p364) Pradeep Lall, Amrit Abrol, Nakul Kothari (Auburn University), Ben Leever (US AFRL), Scott Miller (NextFlex Manufacturing Institute)	Development and Application of a Thin Flat Heat Pipe Design Optimization Tool for Small Satellite Systems (p318) Steven Isaacs, Peter Hamlington (University of Colorado at Boulder)
2:40 PM	Reliability of Additively Printed Traces on Polymer Substrates Subjected to Mechanical Stretching (p373) Pradeep Lall, Kartik Goyal (Auburn University), Ben Leever (US AFRL), Scott Miller (NextFlex Manufacturing Institute)	Characterization of an Embedded Heat Pipe Heat Sink for Multiple Heat Sources for Power Electronics Applications (p439) Neda Mansouri, Ahmed Zaghlol, Cliff Weasner (Mersen Canada Toronto Inc)
3:00 PM	Refreshment Break, Gracia Commons	

DAY 2 SESSIONS: THURSDAY, MAY 30, 1:30 – 3:30 PM

<p>TII-7: Data Center III</p> <p>Gracia 6</p>	<p>M-7: Reliability and Accelerated Testing of Solder Interconnects I</p> <p>Gracia 5</p>	<p>TT-7: Aerospace / Automotive / Telecom</p> <p>Gracia 3</p>
<p>Session Chairs: <i>Erich Ewy (Intel), Anil Yuksel (IBM)</i></p>	<p>Session Chairs: <i>Eric Wong (Raytheon), Abhijit Dasgupta (University of Maryland), A R Nazmus Sakib (NXP Semiconductors)</i></p>	<p>Session Chair: <i>Mark North (Boyd)</i></p>
<p>Featured Paper Presentation Waste Heat Recovery Using Coupled 2-Phase Cooling & Heat-Pump Driven Absorption Refrigeration (p267) Rehan Khalid (Villanova University), Steven Schon (QuantaCool), Alfonso Ortega, Aaron Wemhoff (Villanova University)</p>	<p>Featured Paper Presentation Comparisons of Solder Joints Fatigue Life Predictions and Several Long-Term Testing Results (p302) Rainer Dudek, Kerstin Kreyssig, Sven Rzepka (Fraunhofer ENAS Micro Materials Center Chemnitz), Michael Novak, Wolfgang Gruebl (Continental), Peter Fruehauf, Andreas Weigert (Siemens)</p>	<p>Building the Future of Thermal Management with Additive Manufacturing Michael Stoia (Boeing Research & Technology)</p>
<p>Rack Thermal Model Prediction Accuracy Improvement by Utilizing Rack Power Consumption as Modelling Feature (p299) Nirmal Singh Rajput, Yoshinori Miyamoto, Takafumi Natsumeda, Minoru Yoshikawa (NEC Corporation)</p>	<p>Effect of Aging on Component Reliability in Harsh Thermal Cycling (p320) Francy Akkara, Cong Zhao, Seth Gordon, Sinan Su, Mohammed Abueed, Sa'D Hamasha, Jeffery Suhling, Pradeep Lall (Auburn University)</p>	<p>Industry Trends and Thermal Challenges in Telecommunications Networks Todd Salamon (Nokia Bell Labs)</p>
<p>Experimental Demonstration of Local Air Conditioning System Utilizing Low Pressure Refrigerant at Data Center (p301) Yoshinori Miyamoto, Koichi Todoroki, Takafumi Natsumeda, Nirmal Rajput, Masaki Chiba, Minoru Yoshikawa (NEC Corporation)</p>	<p>Effects of Aging on the Damage Accumulation in SAC305 Lead Free Solders Subjected to Cyclic Loading (p418) Md Mahmudur Chowdhury, Mohd Aminul Hoque, Sad Hamasha, Jeffrey Suhling, Pradeep Lall (Auburn University)</p>	<p>Jet Impingement Cooling of Electric Machines with Driveline Fluids Bidzina Kekelia (NREL)</p>
<p>Full-Scale Two-Phase Liquid Immersion Cooling Data Center System in Tropical Environment (p303) Chenlong Wu, Wei Tong, Baris Burak Kanbur, Fei Duan (Nanyang Technological University)</p>	<p>Mechanical Behavior Evolution of SAC305 Lead Free Solder Joints under Thermal Cycling (p425) Abdullah Fahim, Kamrul Hasan, Sudan Ahmed, Jeffrey Suhling, Pradeep Lall (Auburn University)</p>	
<p>Refreshment Break, Gracia Commons</p>		

DAY 2 SESSIONS: THURSDAY, MAY 30, 3:30 – 7:00 PM

	<p>TII-8A: Air Cooling II</p> <p>Gracia 1</p> <p>Session Chairs: Bahman Abasi (Oregon State University), Juan Cevallos (Intel)</p>	<p>TI-8: Device and Transistor Cooling II</p> <p>Gracia 7</p> <p>Session Chairs: Lauren Boteler (US Army Research Laboratory), Michael Fish (US Army Research Laboratory), Anil Yuksel (IBM)</p>
<p>3:30 PM</p>	<p>Featured Paper Presentation Thermal Management of Outdoor Digital Displays – A Review (p290) Yogendra Joshi (Georgia Tech), Mike Brown (LG-MRI)</p>	<p>Featured Paper Presentation Practical Thermal Modeling of Planar Magnetic Component Devices (p180) Valentin Bissuel, Eric Monier-Vinard (Thales Global Services), Lorenzo Codecasa (Politecnico Di Milano), Nhat-Minh Nguyen (Paris Nanterre University), Arnaud Mahe (Thales Avionics Electrical Systems), Olivier Daniel (Thales Global Services), Najib Laraqi (Paris Nanterre University), Vincenzo D Alessandro (Politecnico Di Milano)</p>
<p>4:00 PM</p>	<p>Effect of Design Variables and System-Level Constraints on Heat Pipes Heatsink Performance: Part I Component Materials and Heat Pipe Design Features (p329) Felipe Valenzuela Gaete (Villanova University), Milnes David, Michael J Ellsworth, Brian Werneke (IBM)</p>	<p>Thermal Characterization of Field-Plated AlGaIn/GaN HEMTs (p202) Canberk Dundar, Fatma Nazli Donmezer Akgun (Bogazici University)</p>
<p>4:20 PM</p>	<p>Effect of Design Variables and System-Level Constraints on Heat Pipes Heatsink Performance: Part II Heat Pipes Staggering and Non-Uniform In-Server Conditions (p336) Felipe Valenzuela Gaete (Villanova University), Milnes David, Michael J Ellsworth, Brian Werneke (IBM)</p>	<p>Thermal-Electric Transient Analysis for Metal Line under High Frequency Pulse Direct Current (p281) Haojun Zhang, Tian Shen, Sing Hui Yap, Kristina Young-Fisher, Patrick Justison (GlobalFoundries)</p>
<p>4:40 PM</p>	<p>A Novel Biomimetic Flapping Fan for Electronics Cooling (p381) Jingru Benner, Mehdi Mortazavi, Anthony Santamaria (Western New England University), Shun Su, Tony Nguyen (Bimitech)</p>	<p>Kapitza Resistance at the Two-Dimensional Electron Gas Interface (p315) Adam Wilson (US Army Research Laboratory, NRC), Nicholas Jankowski (US Army Research Laboratory), Franklin Nouketcha (US Army Research Laboratory, Oak Ridge Associated Universities), Randy Tompkins (US Army Research Laboratory)</p>
<p>5:00 PM</p>	<p>Student Poster Networking Session and Reception Gracia 4/8</p>	

DAY 2 SESSIONS: THURSDAY, MAY 30, 3:30 – 7:00 PM

<p>TII-8B: Thermal Systems I</p> <p>Gracia 6</p>	<p>M-8: Reliability and PHM I</p> <p>Gracia 5</p>	<p>P-8: Reliability Challenges in Electronic Packaging for Harsh Environment</p> <p>Gracia 3</p>
<p>Session Chairs: <i>Qian Han (Huawei Device USA), Bijendra Singh (Intel)</i></p>	<p>Session Chairs: <i>Pradeep Lall (Auburn University), Abhijit Dasgupta (University of Maryland)</i></p>	<p>Moderator: <i>Przemyslaw Gromala (Bosch), Karsten Meier (TU Dresden)</i></p>
<p>Featured Paper Presentation Dynamic Radiative Thermal Management by Crumpled Graphene (p190) Anirudh Krishna (University of California Irvine), Jin Myung Kim, Juyoung Leem, Michael Cai Wang, SungWoo Nam (University of Illinois at Urbana Champaign), Jaeho Lee (University of California Irvine)</p>	<p>Featured Paper Presentation Evaluation of the Impact of Four-Degree Off-Axis Wafers on Silicon Sensors (p298) Jun Chen, Richard Jaeger, Jeffrey Suhling (Auburn University)</p>	<p>Reliability Challenges in Electronic Packaging for Harsh Environment</p> <p>Abstract: Panel will try to answer what are the emerging reliability challenges in electronic packaging for harsh environment due to three major trends in automotive: electrification, autonomous driving and connectivity. As a consequence, we need a new approach for powertrain solution (change of the type from combustion engine to electric engine) and introduction of electronic components (e.g. high performance microprocessor with 1000+ solder joints and with technological node size below 20 nm) from consumer segment to harsh environment, such as automotive, but as well as avionics, etc.</p> <p>Panelists: Reza Ghaffarian (NASA JPL) David Huitink (Uni Arkansas) Yong Liu (ON Semi) Gary Morrison (Texas instruments) Richard Rao (MicroChip) Vanessa Smet (Georgia Tech)</p>
<p>A Novel Fanless Energy Efficient Edge Computing System Architecture and Engineering Practice for Baidu PCDN Application (p174) Dechao Kong, Zhenghui Wu, Qikang Fu, Huajian Zhang, Ning Liu (Baidu), Jun Zhang, Yuyang Xia, Jing Liu, Nishi Ahuja, Carrie Chen, Ken Zhang (Intel)</p>	<p>Fiber Optic Conjugate-Stress Sensor for Local Stiffness Changes under Quasistatic Loads (p268) Jonathan Kordell, Abhijit Dasgupta, Miao Yu (University of Maryland)</p>	
<p>Experimental Investigation of Ionic Wind Cooling in Plate Fin Heatsinks and Needle Electrode Arrangements (p183) Nicolas Baudin, Jaakko McEvoy, Maxime Rouzes, Tim Persoons, Anthony Robinson (Trinity College Dublin)</p>	<p>Stress Strain Analysis on Stitch Bond of Cu-Al Wirebonds Using X-ray Micro CT Technique (p408) Pradeep Lall, Madhu Kasturi, Jeff Suhling (Auburn University), David Locker (US ARMY AMRDEC)</p>	
<p>A Multiphysics Simulation of the Thermal Runaway in Large-Format Lithium-Ion Batteries (p225) Jiajun Xu (University of the District of Columbia), Christopher Hendricks (Naval Surface Warfare Center Carderock Division)</p>	<p>Delamination and Cracking Effects in Quad Flat Package (p251) Jia-Shen Lan, Mei-Ling Wu (National Sun Yat-Sen University)</p>	

Student Poster Networking Session and Reception

Gracia 4/8

Students get the opportunity to present their research and interact with other conference attendees from industry and academia during the Student Poster and Networking Session. They can also distribute resumes and get connected to industrial representatives. Outstanding posters will be selected for awards and will be judged based on technical merit, clarity and self-sufficiency of the content, novelty and originality of the work, overall impact of the poster display, and oral presentation at the poster session.

DAY 3 SESSIONS: FRIDAY, MAY 31, 7:00 - 10:30 AM

7:00 AM	Speakers' Breakfast, Gracia 4/8	
	<p>E-9: Emerging Materials and Fabrication Techniques</p> <p>Gracia 1</p> <p>Session Chairs: <i>Le Gao (Qualcomm), Georges Pavlidis (NIST)</i></p>	<p>TI-9: TIMs and Hotspot Cooling II</p> <p>Gracia 7</p> <p>Session Chairs: <i>Lauren Boteler (US Army Research Laboratory), Dishit Parekh (IBM), Poh-Seng Lee (National University of Singapore)</i></p>
8:00 AM	<p>Effect of Grain Size on the Thermal Properties of Nickel-Titanium Shape Memory Alloys Across the Martensite-Austenite Phase Transition (p113)</p> <p>Nicholas Vu¹, Ronald Warzoha¹, Brian Donovan¹, Darin Sharar², Asher Leff², Adam Wilson³, Andrew Smith¹, ¹United States Naval Academy, ²US Army Research Laboratory, ³National Research Council</p>	<p>Understanding Trade-offs of Phase Change Materials for Transient Thermal Mitigation (p337)</p> <p>Lauren Boteler, Michael Fish, Morris Berman, Justin Wang (US Army Research Laboratory)</p>
8:20 AM	<p>Wafer-scale Hierarchically Textured Silicon for Surface Cooling (p249)</p> <p>Jonathan Sullivan, Laia Ferrer-Argemi, Ziqi Yu, Jaeho Lee (University of California Irvine)</p>	<p>Convergence and Validation in Parapower: A Design Tool for Phase Change Materials in Electronics Packaging (p358)</p> <p>Michael Deckard (Texas A&M), Michael Fish, Morris Berman, Justin Wang, Lauren Boteler (US Army Research Lab), Patrick Shamberger (Texas A&M)</p>
8:40 AM	<p>Factors Influencing the Line Consistency of Commonly Used Geometries for Additively Printed Electronics (p374)</p> <p>Pradeep Lall, Kartik Goyal (Auburn University), Ben Leever (US AFRL), Scott Miller (Nextflex Manufacturing Institute)</p>	
9:00 AM	<p style="text-align: center;">K-3 Keynote: Computing Beyond Moore's Law</p> <p style="text-align: center;">Gracia 2/3</p> <p style="text-align: center;">Cullen Bash, Hewlett Packard Enterprise</p> <div style="display: flex; align-items: center;">  <div> <p>Cullen is a Vice President of R&D at Hewlett Packard Labs and currently serves as Director of the Systems Architecture Lab where he leads a multi-disciplinary team of researchers investigating computer architecture ranging from data centers to distributed systems. His team focuses on a wide range of inter-related topics including system and fabric architecture, system software, photonics, IC packaging, energy and thermal sciences, and software-hardware co-design. Cullen will also be serving as General Chair of IEEE's International Conference on Rebooting Computing in November of 2019.</p> </div> </div>	
10:00 AM	Refreshment Break, Gracia Commons	

DAY 3 SESSIONS: FRIDAY, MAY 31, 7:00 - 10:30 AM

Speakers' Breakfast, Gracia 4/8

<p>TII-9: Data Center IV</p> <p>Gracia 6</p>	<p>M-9: Reliability and PHM II</p> <p>Gracia 5</p>	<p>TT-9: Heat Exchangers</p> <p>Gracia 2/3</p>
<p>Session Chairs: <i>Prabhakar Subrahmanyam (Intel), Gavin Stanley (Microsoft)</i></p>	<p>Session Chairs: <i>Abhijit Dasgupta (University of Maryland), Pradeep Lall (Auburn University)</i></p>	<p>Session Chair: <i>Michael Ohadi (University of Maryland)</i></p>
<p>Numerical Investigation of Novel Underfloor Air-Directors Effect on Data Center Performance (p355) Mohammad Tradat, Sadegh Khalili, Malek Khatabi, Bahgat Sammakia (SUNY Binghamton), Mark Seymour (Future Facilities), Russell Tipton (Vertiv), Husam A Alissa (Microsoft)</p>	<p>In Situ Resistance Monitoring and Fatigue Life Prediction for Flip-Chip Solder Interconnects using RAPID Mechanical Cycling Method (p199) Cody Marbut, Mahsa Montazeri, David Huitink (University of Arkansas)</p>	<p>Next Gen HXs Utilizing Novel Design Topologies, Materials, and Manufacturing Techniques Michael Ohadi (University of Maryland)</p>
<p>Data Center Temperature Control Using PI System and MATLAB (p397) Mitchell Baxendale, Jayati Athavale, Scott Robertson, Yogendra Joshi (Georgia Institute of Technology)</p>	<p>Concept of the 3rd Generation of Reliability for Electronic Smart Systems (p427) Przemyslaw Gromala, Franz Dietz (Robert Bosch GmbH), Sven Rzepka (Fraunhofer ENAS), Bongtae Han (University of Maryland)</p>	<p>Computational Design of Conjugate Heat Transfer Systems Xiaoping Qian (University of Wisconsin-Madison)</p>
<p>A Design Methodology for Controlling Local Airflow Delivery in Data Centers Using Air Dampers (p431) Ghazal Mohsenian, Sadegh Khalili, Bahgat Sammakia (SUNY Binghamton)</p>	<p>Sensitivity of Sensor Location and Use Conditions on the Detectability of Accrued Damage for PHM under Combined Temperature Vibration (p362) Pradeep Lall, Tony Thomas (Auburn University)</p>	

K-3 Keynote: Computing Beyond Moore's Law

Gracia 2/3

Cullen Bash, Hewlett Packard Enterprise

Abstract: The end of Moore's Law scaling coupled with the proliferation of data brought on by an increasing array of devices at the edge of the network is forcing a fundamental shift in computer architecture. For over 65 years classical Von Neumann architecture, where computational elements like CPUs make up the core of any system, are giving way to new architectures where memory is the dominant element surrounded by a heterogeneous mix of computational devices that are increasingly being constructed to serve specific, rather than general, workloads. These new architectures offer fewer constraints on design resulting in the creation of a number of unique devices that place new challenges on traditional architectural elements like communication fabrics, data storage and even the way in which computations are performed at the fundamental level. This talk will introduce some of these new elements and the workloads that drive their design. Particular emphasis will be placed on advances in photonics, computational accelerators and computer architecture.

Refreshment Break, Gracia Commons

DAY 3 SESSIONS: FRIDAY, MAY 31, 10:30 – 1:30 PM

	<p>E-10: Additive Manufacturing III</p> <p>Gracia 1</p> <p>Session Chairs: <i>Pablo Hidalgo (Aavid Thermacore), Sudan Ahmed (Auburn University)</i></p>	<p>TI-10: Single-Phase Microchannels & Cold Plates</p> <p>Gracia 7</p> <p>Session Chairs: <i>Devdatta Kulkarni (Intel), Piyas Chowdhury (IBM)</i></p>
10:30 AM	<p>Featured Paper Presentation Performance Characterization of a Novel Cross-Media Composite Heat Exchanger for Air-to-Liquid Applications (p222) Martinus Arie, David Hymas, Farah Singer, Amir Shooshtari, Michael Ohadi (University of Maryland)</p>	<p>Featured Paper Presentation Design and Testing of Liquid Cooled Thermal Solution for High Loading Processors (p243) Veronica Torreblanca, Anali Soto, Devdatta Kulkarni (Intel)</p>
11:00 AM	<p>Additively Manufactured Impinging Air Jet Coolers for High-Power Electronic Devices (p208) Beomjin Kwon (Arizona State University), Thomas Foulkes, Tianyu Yang, Nenad Miljkovic, William King (University of Illinois at Urbana-Champaign)</p>	<p>Development of Si-Based Micro-fluidic Cooler for Thermal Management of Server Processor in Data Center (p117) Yong Han, Boon Long Lau, Gongyue Tang, Sharon Seow Huang Lim, Haoran Chen, Xiaowu Zhang (Institute Of Microelectronics)</p>
11:20 AM	<p>Viscous Effects in Collision Outcomes of a Falling Drop Impinging on a Sessile Drop (p275) David Deisenroth (University of Maryland), Jeffrey Allen (Michigan Technological University), Seong Hyuk Lee (Chung-Ang University)</p>	<p>A Metamodeling Approach for Optimization of Manifold Microchannel Systems for High Heat Flux Cooling Applications (p195) Sevket Umut Yuruker, Raphael Kahat Mandel, Amir Shooshtari, Michael Ohadi (University of Maryland)</p>
11:40 AM	<p>Effect of Sintering Time and Sintering Temperature on the Mechanical and Electrical Properties of Aerosol-Jet Additively Printed Electronics (p384) Pradeep Lall, Nakul Kothari, Amrit Abrol, Sudan Ahmed, Jeff Suhling (Auburn University), Ben Leever (US AFRL), Scott Miller (Nextflex Manufacturing Institute)</p>	<p>Cold Plate Pin-Fin Optimization for Multi-Die Systems Using Design of Experiment (p220) Yuanchen Hu, Yogendra Joshi (Georgia Institute of Technology)</p>
12:00 PM	<p>Luncheon: ITherm Awards & Organizer Recognitions Gracia 4/8</p>	

DAY 3 SESSIONS: FRIDAY, MAY 31, 10:30 – 1:30 PM

<p>TII-10: Thermal Systems II</p> <p>Gracia 6</p>	<p>M-10: Response and Reliability at High Strain II</p> <p>Gracia 5</p>	<p>P-10: Thermal Management in the World of IoT, PoE, and Blockchain — Where Are We Heading?</p> <p>Gracia 3</p>
<p>Session Chairs: <i>Mercy Dicuangco (Intel), Susmita Dash (Indian Institute of Science)</i></p>	<p>Session Chairs: <i>Pradeep Lall (Auburn University), Abhijit Dasgupta (University of Maryland)</i></p>	<p>Moderator: <i>Baris Dogruoz (Cisco), Victor Chiriac (Futurewei Technologies)</i></p>
<p>Featured Paper Presentation Coupled Thermal-Electrical Simulation and Validation Test for Novel High Power Delivery Design in CPU Socket Area (p272) Yuehong Fan, Hongfei Yan, Yipeng Zhong, Wei Shen (Intel)</p>	<p>Featured Paper Presentation Impact Test Simulation and Validation for Fiber Reinforced Plastics in Automotive Electronic Control Units (p270) Tian Zhao (Robert Bosch GmbH)</p>	<p>Thermal Management in the World of IoT, PoE, and Blockchain — Where Are We Heading?</p> <p>Abstract: This panel will focus on the thermal and mechanical design aspects of the Internet of Things (IoT) related hardware and structures, Power over Ethernet (PoE) devices and systems, and cryptocurrency mining farms/facilities.</p>
<p>Topology Optimized Fins for a PCM-Based Thermal Management System (p213) Ange-Christian Iradukunda, David Huitink (University of Arkansas)</p>	<p>Fatigue Life of Joint-Scale SAC305 Solder Specimens in Tensile and Shear Mode (p263) Abhishek Deshpande, Qian Jiang, Abhijit Dasgupta (University of Maryland), Ulrich Becker (Robert Bosch GmbH)</p>	<p>State-of-the-art thermal management technologies in these applications will be explored, where the related devices and structures vary greatly in size, i.e. from micro sensors / small hand-held devices to data centers. Therefore, each application has to deal with multi scale thermal issues, namely: (i) IoT makes connection to applications, which enhance efficiency, and create new and unique services; (ii) PoE reduces the volume of power cords, leading to a lower cost and less complicated infrastructure for data centers, facilities and smart structures, nevertheless with the penalty of increased power and heat density; (iii) ever increasing energy usage of the cryptocurrency mining will increase the heat density on the data center/cryptocurrency mining farm significantly, requiring innovative thermal designs.</p>
<p>Numerical Investigation of the Thermal and Hydrodynamic Behaviors of a Channel with Rectangular Pin Fins in Aligned and Staggered Configurations (p110) Johnny Issa (University of Balamand), Amina El Cheikh (Lebanese American University)</p>	<p>Cohesive Zone Modeling and Damage Prediction of Interfacial Delamination in Potted Electronics Subjected to High-G Mechanical Shock (p368) Pradeep Lall, Kalyan Dornala (Auburn University), John Deep (US AFRL), Ryan Lowe, Jeff Suhling (Auburn University)</p>	<p>Panelists: Angel Han (Huawei) Rockwell Hsu (Cisco) Madhu Iyengar (Google)</p>
<p>SSD Thermal Throttling Prediction Using Improved Fast Prediction Model (p279) Hedan Zhang, Ernold Thompson, Ning Ye, Dror Nissim, Steve Chi, Hem Takiar (Western Digital)</p>	<p>Effect of Dielectric Material on the Reliability of 3640 MLCC Capacitors under High-G Shock Loads (p371) Pradeep Lall, Kalyan Dornala, Aathi Pandurangan (Auburn University), John Deep (US AFRL), Ryan Lowe (ARA Associates), Jeff Suhling (Auburn University)</p>	

Luncheon: ITherm Awards & Organizer Recognitions

Gracia 4/8

DAY 3 SESSIONS: FRIDAY, MAY 31, 1:30 – 3:30 PM

	<p>E-11: Flexible Electronics</p> <p>Gracia 1</p> <p>Session Chairs: <i>Anil Yuksel (IBM), Xiaopeng Qu (Micron Technology)</i></p>	<p>TI-11: Two-Phase Cooling Techniques</p> <p>Gracia 7</p> <p>Session Chairs: <i>Timothy Chainer (IBM Research), Prabhakar Subrahmanyam (Intel)</i></p>
<p>1:30 PM</p>	<p>Featured Paper Presentation Capacity Degradation of Flexible Li-Ion Power Sources Subjected to Shallow Discharging (p367) Pradeep Lall, Amrit Abrol, Ved Soni (Auburn University), Ben Leever (US AFRL), Scott Miller (Nextflex Manufacturing Institute)</p>	<p>Featured Paper Presentation Micro-Scale Nozzled Jet Heat Transfer Distributions and Flow Field Entrainment Effects Directly on Die (p201) Prabhakar Subrahmanyam, Arun Krishnamoorthy (Intel)</p>
<p>2:00 PM</p>	<p>Failure Modes of Flexible Electronics under Mechanical Vibration (p359) Pradeep Lall, Tony Thomas (Auburn University)</p>	<p>Numerical Investigation of Spray Cooling-Based Thermal Management of Extreme Power Densities Using Anisotropic Composite Heat Spreaders (p206) Huseyin Bostanci, Sai Sujith Obuladinne (University of North Texas)</p>
<p>2:20 PM</p>	<p>PHM of Flexible Li-ion Batteries Subjected to Sustained Elevated-Temperature Storage and Thermal Cycling (p365) Pradeep Lall, Amrit Abrol (Auburn University)</p>	
<p>2:40 PM</p>	<p>Effect of Use Parameters on Fatigue-Life of Flexible Substrates under Bending Loads (p387) Pradeep Lall, Jinesh Narangaparambil (Auburn University)</p>	
<p>3:00 PM</p>	<p>Refreshment Break, Gracia Commons</p>	


DAY 3 SESSIONS: FRIDAY, MAY 31, 1:30 – 3:30 PM

<p>TII-11: Thermal Systems III</p> <p>Gracia 6</p>	<p>M-11: Reliability and Accelerated Testing of Solder Interconnects II</p> <p>Gracia 5</p>	<p>TT-11: Transient Thermal Management</p> <p>Gracia 3</p>
<p>Session Chairs: <i>Qian Han (Huawei Device USA), Mercy Dicuungco (Intel)</i></p>	<p>Session Chairs: <i>A R Nazmus Sakib (NXP Semiconductors), Eric Wong (Raytheon)</i></p>	<p>Session Chairs: <i>Patrick Shamberger (Texas A&M)</i></p>
<p>Featured Paper Presentation Impact of Board Placement on Thermal Performance of Handheld Devices (Tablets) (p429) Sankarananda Basak (Intel)</p>	<p>Featured Paper Presentation Effects of Solder Mask Application Method on the Reliability of an Automotive Flip Chip PBGA Microcontroller (p232) A R Nazmus Sakib, Richard Lai, Sandeep Shantaram (NXP Semiconductors)</p>	<p>Design Challenges and Opportunities in Package-Integrated Transient Thermal Mitigation Michael Fish (U.S. Army Research Laboratory)</p>
<p>Cell Tab Cooling System for Battery Life Extension (p284) Heiner Hans Heimes, Achim Kampker, Ahmad Mohsseni, Francesco Maltoni, Jan Biederbeck (RWTH Aachen University)</p>	<p>Effect of Aging on the Fatigue Life and Shear Strength of SAC305 Solder Joints in Actual Setting Conditions (p287) Raed Al Athamneh, Mohammed Abueed, Dania Bani Hani, Sinan Su, Sad Hamasha, Jeffery Suhling, Pradeep Lall (Auburn University)</p>	<p>Design and Manufacture of Composites for Thermal Energy Storage Jonathan R. Felts (Texas A&M University)</p>
<p>Cooling for Electric Aircraft Motors (p335) Patrick McCluskey, Yonatan Saadon, Zhaoxi Yao, Alexander Camacho (University of Maryland)</p>	<p>Effect of Surface Finish on the Fatigue Behavior of Bi-based Solder Joints (p313) Sinan Su, Minghong Jian, Xin Wei, Francy John Akkara, Sa'd Hamasha, Jeffrey Suhling, Pradeep Lall (Auburn University)</p>	<p>Active Transient Control of Two-Phase Cooling Systems John Wen (Rensselaer Polytechnic Institute)</p>
	<p>Study of the Effect of Solder-Joint Voiding Using X-ray MicroCT Data-based FE Models with Experimental Validation (p385) Pradeep Lall, Nakul Kothari, Shantanu Deshpande (Auburn University), Luu Nguyen (Texas Instruments)</p>	

Refreshment Break, Gracia Commons

DAY 3 SESSIONS: FRIDAY, MAY 31, 3:30 – 5:00 PM		
	E-12: Single-phase/Two-phase Convection in Channels and Jets Gracia 1 Session Chairs: <i>Shadi Mahjoob (California State University Northridge), Columbia Mishra (Intel)</i>	TI-12A: Cooling of Complex Packaging Systems Gracia 7 Session Chairs: <i>Sukhvinder Kang (Boyd Corporation), Benoit Foisy (IBM)</i>
3:30 PM	Featured Paper Presentation Heat Transfer and Two-Phase Flow Regimes in Manifolded Microgaps--R245fa Empirical Results (p256) David Deisenroth, Avram Bar-Cohen, Michael Ohadi (University of Maryland)	Featured Paper Presentation A Central Cooling Structure for Motorized Spindles: Principle and Application (p424) Feng Liang, Jianmin Gao, Fajing Li, Liang Xu, Zhao Wang, Hongquan Jiang (State Key Laboratory for Manufacturing Systems Engineering)
4:00 PM	Experimental Performance of Completely Passive Single and Recirculating Loop Thermosyphon Cooling Systems Using Low GWP R1234ze and R1234yf (p106) Filippo Cataldo (Provides Metalmeccanica), John Thome (EPFL)	Heat Transfer Augmentation Using Scale-roughened Surfaces for Low-Reynolds Number Flows Generated by Piezoelectric Fans (p204) Navid Dehdari Ebrahimi, Y Sungtaek Ju (University of California Los Angeles)
4:20 PM	Prediction of Regime Transition in Two Phase Flow Microchannels Based on Ultrathin Liquid Film Interfacial Instability (p262) Meisam Habibi Matin, Saeed Moghaddam (University of Florida)	Experimental Investigation of Direct Contact Baseplate Cooling for Electric Vehicle Power Electronics (p323) Jasper Nonneman (Ghent University), Stephan Schlimpert (Flanders Make), Ilya T Jollyn, Michel De Paepe (Ghent University)
4:40 PM	Optimization of Liquid Cooling Microchannel in 3D IC Using Complete Converging and Diverging Channel Models (p402) Leslie Hwang (University of Illinois at Urbana-Champaign), Beomjin Kwon (Arizona State University), Martin Wong (University of Illinois at Urbana-Champaign)	Dynamic Thermal Management for Silicon Interconnect Fabric Using Flash Cooling (p413) Ujash Shah, Umesha Mogera, Pranav Ambhore, Boris Vaisband, Subramanian Iyer, Timothy Fisher (University of California - Los Angeles)

DAY 3 SESSIONS: FRIDAY, MAY 31, 3:30 – 5:00 PM		
TII-12A: Data Center V	TI-12B: Package Cooling II	TII-12B: Liquid Cooling IV
Gracia 6	Gracia 5	Gracia 3
Session Chairs: <i>Sachin Deshmukh (Intel), Vibhash Jha (Intel)</i>	Session Chairs: <i>Xiangfei Yu (IBM), Sami Alkharabsheh (Binghamton University)</i>	Session Chairs: <i>Ajay Vadakkepatt (Qualcomm Technologies Inc), Sankarananda Basak (Intel)</i>
Featured Paper Presentation Impact of Fans Location on the Cooling Efficiency of IT Servers (p253) Sadegh Khalili, Mohammad Tradat (SUNY Binghamton), Husam Alissa (Microsoft), Cheng Chen (Facebook), Bahgat Sammakia (SUNY Binghamton)	Featured Paper Presentation Thermal Analysis of a 3D Flip-Chip Fan-Out Wafer Level Package (FcFOWL) for High Bandwidth 3D Integration (p166) Herman Oprins, Eric Beyne (Imec)	Featured Paper Presentation Experimental Characterization of Different Condenser Technologies in a Passive Two-Phase Cooling System for Thermal Management of Electronics (p294) Chiara Falsetti, Luca Amalfi (Ecole Polytechnique Federale De Lausanne), Todd Salamon (Nokia Bell Labs), Jackson Marcinichen (JJ Cooling Innovation Sarl), John Thome (Ecole Polytechnique Federale De Lausanne)
An Accurate Fast Fluid Dynamics Model for Data Center Applications (p141) Wei Tian, James VanGilder, Michael Condor (Schneider Electric), Xu Han, Wangda Zuo (University of Colorado Boulder)	Thermal Analysis of Polymer 3D Printed Jet Impingement Coolers for High Performance 2.5D Si Interposer Packages (p170) Tiwei Wei (Imec, KU Leuven), Herman Oprins, Vladimir Cherman (Imec), I. De Wolf (Imec, KU Leuven), Geert Van Der Plas, Eric Beyne (Imec), Martine Baelmans (Ku Leuven)	Combined Conduction and Natural Convection Cooling of Offshore Power Cables in Porous Sea Soil (p311) Ilya T Jollyn (Ghent University, Flanders Make), Manly Callewaert (Marlinks), Jasper Nonneman (Ghent University, Flanders Make), Johan Van de Wauw (Marlinks), Bernd Ameel (Ghent University)
Balancing Cooling and IT Airflow with Dampers in Ceiling-Ducted Hot-Aisle Containment in Data Centers (p142) James VanGilder, Yan Zhang, Stephen Linder, Michael Condor (Schneider Electric)	Hotspot Management by Holey Silicon-Metal Composites for 1kW/cm² and Beyond (p184) Zongqing Ren, Ziqi Yu (University of California Irvine), Jae Choon Kim (Samsung Electronics), Jaeho Lee (University of California Irvine)	A Single Flexible Cold Plate Cools Multiple Devices (p394) Shurong Tian, Todd Takken, Mark Shultz (IBM Research), Chris Marroquin (IBM Rochester), Vic Mahaney (IBM Austin), Yuan Yao (IBM Research), Michael J Ellsworth Jr (IBM), Anil Yuksel (IBM Austin), Paul Coteus (IBM Research)
Energy Audit of Data Centers and Server Rooms on an Academic Campus – A Case Study (p147) Mehulbhai Patel, Ameya Upadhyay, Fabio Battaglia, Farah Singer, Michael Ohadi (University of Maryland College Park)	Performance Evaluation of Chip Liquid 3D Cooling Systems under Non-Uniform Power Density: Effects of the Inlet and Plenum Configurations (p258) Soheil Soleimanikutanaei, Cheng-Xian Lin, Nezhil Pala, Gang Quan (Florida International University)	



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 SCHOOL OF ENGINEERING

CALCE CENTER FOR ADVANCED LIFE CYCLE ENGINEERING

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Physics of Failure, Failure Mechanisms, and Material Behavior

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Advanced Heat Exchangers and Process Intensification (AHXPI) Laboratory

Smart and Small Thermal Systems

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

A Novel Cross-Media Polymer-Metal Heat Exchangers (CHXs) for Dry Cooling Applications and Beyond

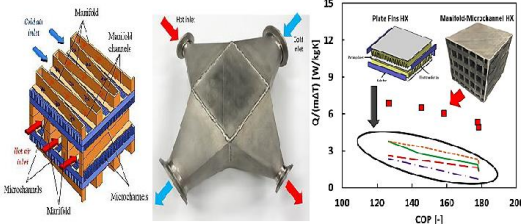
Next generation low weight, low cost, high performance HX (equivalent Thermal conductivity of: 115 W/m-K) composed of polymer channels and metallic wires, and fabricated using novel 3D printing method.



- 1st Market: Desktop Cooling
 26% Higher Q
 52% Reduced \$
- 2nd Market: ARID/HVAC
 186% Higher Q/m
 48% Reduced \$
- 3rd Market: Aerospace
 29% Reduced m
 TBD

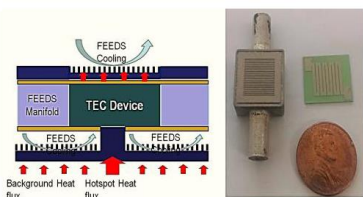
Additively Manufactured High Performance Gas-to-Gas HXs for High Temperature Energy Harvesting Applications

Inconel HX fabricated with fin thickness 0.15mm and manifold-microchannel geometry. Successful high T testing at 600C.



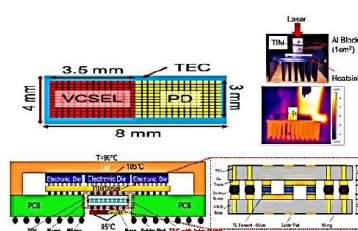
Embedded Cooling of High Flux Electronics via Micro-Enabled Surfaces and Fluid Delivery System

Film-Evaporation and Enhanced fluid Delivery: A heat flux of 1 kW/cm² was achieved at 90% and vapor quality and a COP of ~1000.



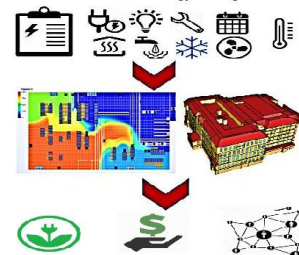
Packaging and Thermal Decoupling of Optical Array using a Thermoelectric Cooler

Thermoelectric cooler (TEC) to thermally-decouple and cool an optical array (85°C) from an electronic die (105°C).



Energy Audit of UMD Buildings and Data Centers

More than \$3 million Energy Savings so far!



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

NOTES

ITherm 2019, May 28 – May 31, 2019
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NOTES

Abstracts Due: September 2, 2019



19th Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems

ITherm 2020 is the leading international conference for scientific and engineering exploration of thermal, thermomechanical and emerging technology issues associated with electronic devices, packages, and systems. ITherm 2020 will be held along with ECTC 2020, at Walt Disney World Swan and Dolphin Resort in Orlando. Joint registrations will be available at a discounted rate.



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 2020 will have panel discussions, keynote lectures by prominent speakers, invited Tech Talks, and professional short courses. ITherm does not accept presentation-only submissions; only full paper submission will be accepted. Original papers are solicited in the following general areas of interest (but not limited to):

Component-Level Thermal Management

- Transistor Technology
- 2.5D / 3D Packaging
- Embedded Cooling
- Hotspot and Impingement Cooling
- Thermal Interface Materials and Heat Spreaders
- Thermoelectric and Peltier Devices
- Heat Pipes, Vapor Chambers and Thermosyphons
- Single / Two-phase Cold Plates and Heat Sinks
- RF and Power Electronics
- LEDs and Photovoltaics
- Pulsed Power Dissipation

System-Level Thermal Management

- Air Cooling Techniques and Heat Exchangers
- Liquid Cooling Solutions
- Immersion Cooling and Refrigeration
- Pumps, Compressors, Fans and Blowers
- Phase Change Materials
- Automotive, Batteries and Thermal Storage
- Mobile and Internet of Things
- Telecommunication Systems
- Space and Aerospace
- Data Center Thermal Management

Mechanics & Reliability

- Thermo-Mechanical Modeling and Simulation
- Mechanics and Reliability of Solder Joints and Interconnects
- Materials Characterization, Processing, and Constitutive Models
- Failure Mechanics, Fatigue, and Damage Modeling
- Measurement of Deformations, Strains and Stresses
- Shock, Drop and Vibrational Analysis
- TSV / 3D Reliability and Packaging
- Mechanics in Assembly and Manufacturing
- Applied Reliability and Failure Analysis
- Process-Structure-Property Relations / Multi-Scale Analyses
- Accelerated Stress Testing and Modeling
- Lifetime Prognostics and Condition Monitoring

Emerging Technologies and Fundamentals

- Boiling / Evaporation / Condensation
- Convection in Microchannels, Microgaps & Jets
- Pulsating / Oscillating and Non-Conventional Heat Pipes
- Thermal Transport in Nanotechnologies
- Novel Materials and Fabrication Techniques
- Measurement and Instrumentation Techniques
- Numerical Methods, Nano-to-Macro Scale
- Experimental Methods, Nano-to-Macro Scale
- Prognostic Health Management and Reliability Analysis
- Flexible Electronics
- Additive Manufacturing

ITherm provides an opportunity for industrial and university participation in the form of financial support to ITherm 2020. All contributors will be given strong recognition both onsite and in the conference materials.



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CONFERENCE SCHEDULE

ITherm 2019: Program Overview												
Emerging	Thermal I	Thermal II	Mechanics	Keynote	Tech-Talk	Panel	Meetings	Meals	Special Event	PDC		
7:00 - 8:00	8:00 - 9:00	9:00 - 10:00	10:00 - 10:30	10:30 - 12:00	12:00 - 1:30	1:30 - 3:00	3:00 - 3:30	3:30 - 5:00	5:00 - 6:00	6:00 - 7:00	7:00 - 8:00	8:00 - 9:00
Day-0: Tuesday, May 28, 2019												
ECTC/ITherm Joint Professional Development Courses (PDC), Courses 1-8												
Luncheon for PDC Courses' Attendees, till 1:15 pm												
ECTC/ITherm Joint Professional Development Courses (PDC), Courses 9-18 (1:15-5:15pm)												
ECTC/ITherm Student Reception (New Joint Event this Year)												
ECTC/ITherm Joint Young Professionals Panel and Reception, till 7:45 pm												
EPS President's Panel Session (Packaging Vision Competition Presentations) (New Joint Event this Year), 7:45 - 9:15 pm												
Day-1: Wednesday, May 29, 2019												
Heterogeneous Intergration Roadmap Workshop												
ITherm Sponsors & Exhibits												
Speakers' Breakfast	E-1 TI-1A TI-1B TI-1 M-1	K-1 Keynote	Coffee Break	E-2 TI-2 TI-2 M-2 P-2	Luncheon Richard Chu ITherm Award Presentation	E-3 TI-3 TI-3 M-3 TI-3	Coffee Break	E-4 TI-4 TI-4 M-4 P-4	ITherm Executive Committee	ECTC/ITherm Women's Panel and Reception, 6:30 - 7:30 pm	ASME K-16 and Journal of Electronic Packaging, 7:30 - 9:00 pm	
Day-2: Thursday, May 30, 2019												
ITherm Sponsors & Exhibits												
Speakers' Breakfast	E-5 TI-5 TI-5 M-5 TI-5	K-2 Keynote	Coffee Break	E-6 TI-6 TI-6 M-6 P-6	Luncheon ITherm Sponsors and Partners	E-7 TI-7 TI-7 M-7 TI-7	Coffee Break	TI-8 TI-8A TI-8B M-8 P-8	Student Poster Networking Session and Reception	ITherm 2020 Program Planning	ITherm Organizers Dinner (by Invitation)	
Day-3: Friday, May 31, 2019												
ITherm Sponsors & Exhibits												
Speakers' Breakfast	E-9 TI-9 TI-9 M-9 TI-9	K-3 Keynote	Coffee Break	E-10 TI-10 TI-10 M-10 P-10	Luncheon ITherm Best Paper Awards & Organizer Recognitions	E-11 TI-11 TI-11 M-11 TI-11	Coffee Break	E-12 TI-12A TI-12A TI-12B TI-12B				

