The 21st Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems

ITherm

SAN DIEGO, CA 2022

Sheraton Hotel & Marina
San Diego, CA
May 31 – June 3, 2022

IEEE
Advancing Technology for Humanity

IEEE ELECTRONICS PACKAGING SOCIETY

WELCOME LETTER

On behalf of the organizing committee, it is a great pleasure to welcome you to ITherm 2022, the leading international conference for the scientific and engineering exploration of thermal, thermo-mechanical, and emerging technology issues associated with electronic devices, packages, and systems. It is particularly exciting to be able to welcome everyone back for an in-person event. Many thanks go to the entire ITherm community as we all navigated the challenges of the last two years together. ITherm 2022 is once again being held along with the 72nd Electronic Components and Technology Conference (ECTC), a premier electronic packaging conference.

ITherm 2022 is packed with many activities, including over 170 Technical Papers across 4 Technical Tracks, 3 Keynote Talks addressing the topics of deep learning with analog in-memory compute, thermal challenges of battery electric vehicles, and hyperdimensional computing system design and thermal management; an Invited Presentation by the recipient of the Richard Chu ITherm Award for Excellence; 5 Technical Panel Sessions for a highly interactive engagement with experts; 5 Technology Talk Sessions providing deep dive talks on high profile topics; over 45 Student Posters with an engaging networking session; presentations from the finalist of the 2022 ASME/K-16 and IEEE/EPS Student Heat Sink Design Competition; 16 Professional Development Course; and Vendor Exhibits. ITherm 2022 attendees are also highly encouraged to take advantage of networking opportunities with our ECTC colleagues. Several exciting joint ITherm and ECTC events will be held on Tuesday evening including a Young Professionals Networking Reception and the EPS President's Panel on Heterogeneous Integrated Packaging. On Wednesday evening, ITherm and ECTC will jointly host the 2022 Diversity Panel and Reception, where distinguished panelists will speak on solving diversification challenges and workforce retention issues in the microelectronics industry. 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.

Many thanks go to everyone who has contributed to the success of ITherm 2022. We recognize the uncertainty that was navigated and appreciate your flexibility and willingness to iterate quickly during the planning. We know all this organization is above your regular everyday responsibilities and it is highly appreciated. We would like to thank our track chairs and co-chairs, session chairs/co-chairs, panel/technology talk 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.

Thank you for participating in the ITherm 2022 conference. Whether this is your first time attending or if you have attended before, we hope that you will feel energized by the interaction with your fellow attendees. For our first-time attendees, we hope you take advantage of all the networking opportunities to continue to grow your careers. ITherm 2023 will be held in Orlando, Florida, USA on May 30 – June 2, 2023, and we hope that you mark your calendars to be there as well. Please join us for the ITherm 2023 Program Planning meeting (open to all) to volunteer. Like never before we appreciate the dedication of this community and are eager to see you all again.


Dustin W. Demetriou
General Chair


Satish Kumar
Program Chair


Ashish Gupta
Vice Program Chair


Amy Marconnet
Communications Chair

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CONFERENCE DESCRIPTION

Sponsored by the IEEE's Electronics Packaging Society (EPS), ITherm 2022 (http://ieee-itherm.net) is the leading international conference for the scientific and engineering exploration of thermal, thermomechanical and emerging technology issues associated with electronic devices, packages and systems. ITherm 2022 will be held along with the 72nd Electronic Components and Technology Conference (ECTC 2022 - http://www.ectc.net), a premier electronics packaging conference at the Sheraton Hotel & Marina San Diego, CA USA. Joint registration for ITherm and ECTC is offered at a substantial discount.

CONFERENCE SUMMARY

- **Access to over 175 Technical Papers and presentations** organized across four Technical Tracks: Component-Level Thermal Management (TI), System-Level Thermal Management (TII), Mechanics & Reliability (M), and Emerging Technologies & Fundamentals (E)
- **3 Keynote Talks** covering the areas of Deep Learning with Analog In-Memory Compute, Thermal Management Challenges for Electric Vehicles, and Hyperdimensional Computing System Design & Thermal Management
- **Richard Chu ITherm Award and Seminar**
- **5 Technology-Talk sessions** providing deep dive talks on high profile topics
- **5 Panels** discussing the latest industry challenges and trends
- **47 Student Posters** showcasing the latest research with opportunities to network
- **Student Heat Sink Design Challenge** showcasing the latest in additive manufacturing
- **ECTC/ITherm Joint Diversity Panel** examining workforce diversification issues
- **16 Professional Development Courses** offered as a collaboration with ECTC
- **Heterogeneous Integration Roadmap (HIR) All-Day Workshop**

GENERAL INFORMATION

REGISTRATION

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

Opening Hours:

Tuesday, May 31	3:30 PM – 5:30 PM
Wednesday, June 1	6:30 AM – 5:30 PM
Thursday, June 2	7:00 AM – 5:30 PM
Friday, June 3	7:00 AM – 12:00 PM

Conference Registration Includes:

- Admission to All Conference Sessions
- Luncheons (Wednesday/Thursday/Friday)
- Digital Conference Proceedings

Fees (Onsite Registration)	IEEE Member	Non-Member	Student Member	Student Non-Member
Joint ITherm/ECTC Registration	1,225 USD	1,475 USD		
ITherm Registration	800 USD	950 USD	450 USD	540 USD
One-Day Registration	600 USD	720 USD		

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

MISCELLANEOUS INFORMATION

HOTEL AMENITIES

Sheraton San Diego Hotel & Marina features:

- Located in the heart of San Diego harbor
- 24-Hour Front Desk
- Hotel Airport Shuttle: Complimentary
- Complimentary internet in Lobby Area
- Several Restaurants
- Valet and Self-Service Parking (Fee) for Guests
- Business Center, Gift Shop, Guest Launderette
- Complimentary access to the Fitness Center

GENERAL EMERGENCY INFORMATION

Sheraton Security Personnel respond to all emergencies 24 hours. Security direct extension is 2328 and outside line is 619-692-2328. The security team is CPR, AED and First aid certified. All Emergency response plans are on file and distributed to all departments. Plans are viewed by all new associates in orientation and annually by all staff.

COMMITTEE MEETINGS

ITherm EXECUTIVE COMMITTEE

The ITherm Executive Committee meeting will take place in Del Mar (Bay Tower Lobby Level) on Wednesday June 1st, from 6:30 to 7:30 PM. *By invitation only.*

ITherm 2023 PROGRAM PLANNING

The ITherm 2023 Program Planning meeting will take place in Bel Aire (Bay Tower Lobby Level), on Thursday June 2nd, from 7:00 to 8:00 PM. *Open to all current and future contributors.*

ITherm 2022 ORGANIZERS DINNER

The ITherm 2022 Organizers Dinner will take place on Thursday June 2nd, from 8:00 to 10:00 PM. *By invitation only*.

ASME K-16 COMMITTEE

The ASME K-16 Committee meeting will take place in Coronado A (Bay Tower 4th Floor) on Wednesday June 1st, from 7:30 to 8:30 PM. *Open to Committee Members and to all interested in becoming involved.*

ASME JOURNAL OF ELECTRONIC PACKAGING

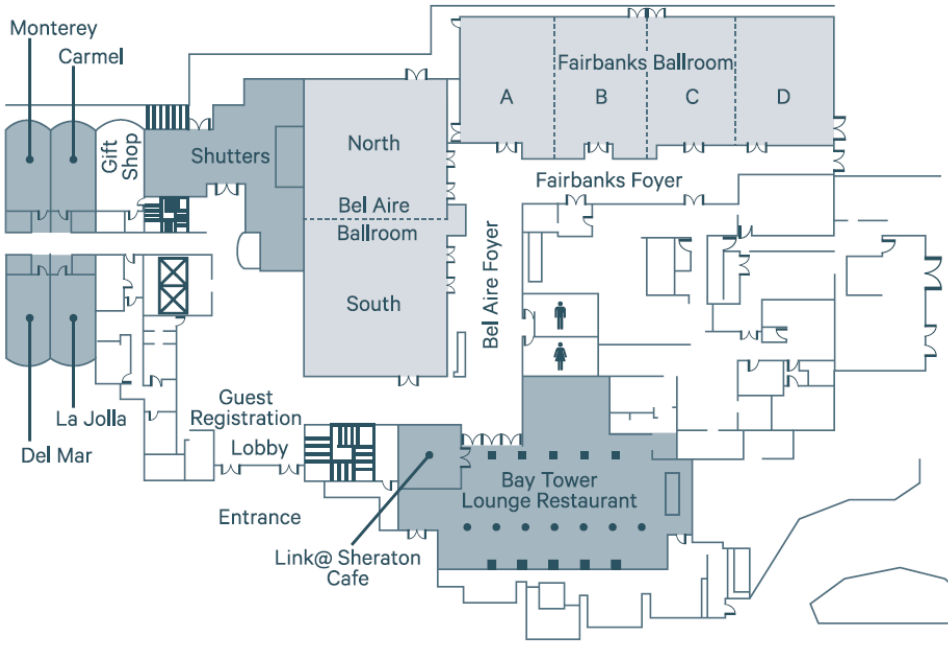
Journal of Electronic Packaging meeting hosted by Editor Y. C. Lee will be held in Coronado A (Bay Tower 4th Floor) on Wednesday June 1st, from 8:30 to 9:00 PM. *Open to all who are interested.*

CONFERENCE SITEMAP

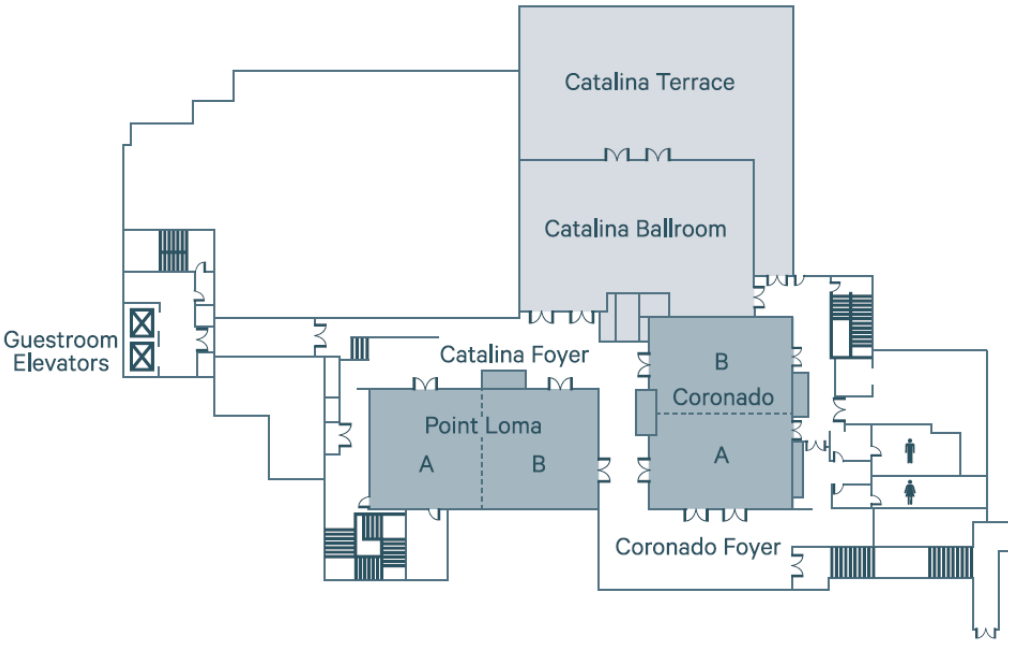
SHERATON SAN DIEGO HOTEL AND MARINA MAP

ITherm 2022 MEETING LOCATIONS (BAY TOWER LOBBY AND 4TH FLOOR MAP)

Bay Tower Lobby Level



Bay Tower 4th Floor



SPONSORS & EXHIBITORS

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CONFERENCE SPONSORS

EXHIBITORS

PARTNERS

CONFERENCE ORGANIZATION COMMITTEE

ORGANIZATION COMMITTEE		
General Chair	Dustin W. Demetriou	IBM Corporation
Program Chair	Satish Kumar	Georgia Institute of Technology
Vice Program Chair	Ashish Gupta	Intel Corporation
Communications Chair	Amy Marconnet	Purdue University
COMPONENT-LEVEL THERMAL MANAGEMENT TRACK		
Chair	Stephanie Allard	IBM Corporation
Co-Chair	Luca Amalfi	Nokia Bell Labs
Co-Chair	Darin Sharar	Army Research Labs
SYSTEM-LEVEL THERMAL MANAGEMENT TRACK		
Chair	Amir H. Shooshtari	University of Maryland
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Co-Chair	Chandra Mohan Jha	Intel Corporation
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Chair	Sukwon Choi	Penn State University
Co-Chair	Milnes David	IBM
Co-Chair	Jimil Shah	TMG Core
MECHANICS & RELIABILITY TRACK		
Chair	Przemyslaw Gromala	Bosch
Co-Chair	David Huitink	University of Arkansas
Co-Chair	Jin Yang	Intel Corporation
SPECIAL TECHNICAL CONTRIBUTIONS		
Keynote Chair	John Thome	EPFL
Keynote Co-Chair	Justin Weibel	Purdue University
Technology-Talk Chair	Weihua Tang	Intel Corporation
Technology-Talk Co-Chair	Naveenan Thiagarajan	GE
Technology-Talk Co-Chair	Madhusudan Iyengar	Google
Panels Chair	Victor Chiriac	Global Cooling Technology Group, LLC
Panels Co-Chair	Przemyslaw Gromala	Bosch
Panels Co-Chair	Mahsa Ebrahim	Loyola Marymount University
Poster Session Chair	Arjang Shahriari	Qualcomm
Poster Session Co-Chair	Mahsa Ebrahim	Loyola Marymount University
Poster Session Co-Chair	Joseph Hanson Vázquez	Intel Corporation
PDC Short Course Chair	Jeffrey Suhling	Auburn University
PDC Short Course Co-Chair	Kitty Pearsall	Boss Precision, Inc.
Diversity Panel Chair	Cristina Amon	University of Toronto

EPS/K16 Student Design Competition	Sameer Rao	University of Utah
EPS/K16 Student Design Competition	Joshua Gess	Oregon State University
EPS/K16 Student Design Competition	Amy Marconnet	Purdue University
EPS/K16 Student Design Competition	Naveen Thiagarajan	GE
EPS/K16 Student Design Competition	Ronald Warzoha	US Naval Academy
EPS/K16 Student Design Competition	John (Jack) Maddox	University of Kentucky
EPS/K16 Student Design Competition	Joe Alexandersen	University of Southern Denmark
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Administrative Assistant	Damaris David	ITherm
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Technical Program and Design	Ashish Gupta	Intel Corporation
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Publicity	John (Jack) Maddox	University of Kentucky
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Richard Chu ITherm Award Co-Chair	Koneru Ramakrishna	Thermal Consultant
Richard Chu ITherm Award Co-Chair	Yogendra K. Joshi	Georgia Institute of Technology
Best Paper Award Chair	Yogendra K. Joshi	Georgia Institute of Technology
Best Paper Award Co-Chair	Koneru Ramakrishna	Thermal Consultant
Best Paper Award Co-Chair	Jeffrey Suhling	Auburn University
INTERNATIONAL ITHERM AMBASSADORS		
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Ambassador	Rishi Raj	IIT Patna, India
Ambassador	Ryan Enright	Nokia Bell Labs, Ireland

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 Brunschwiler	IBM Research – Zurich
Vadim Gektin	Qualcomm
Madhusudan Iyengar	Google
Yogendra K. Joshi	Georgia Institute of Technology
Gary B. Kromann	Consultant
Tom Lee	Xilinx
Michael Ohadi	University of Maryland
Alfonso Ortega	Villanova University
Koneru Ramakrishna	Thermal Consultant
Bahgat Sammakia	State University of New York at Binghamton
Jeffrey Suhling	Auburn University
Sandeep Tonapi	Anveshak
Justin Weibel	Purdue University

ITherm 2022 BEST PAPER AWARD

Award Committee Members:
Prof. Yogendra K. Joshi, Georgia Institute of Technology, USA, Committee Chair
Dr. Koneru Ramakrishna, Thermal Consultant, USA, Committee Co-Chair
Prof. Jeffrey Suhling, Auburn University, USA, Committee Co-Chair
Prof. Damena Agonafer, Washington University, USA
Dr. Stephanie Allard, International Business Machines Corporation, Canada
Prof. Mehmet Arik, Auburn University, USA
Prof. Sushil H. Bhavnani, Auburn University, USA
Prof. Kuo-Ning Chiang, National Tsing Hua University, Taiwan
Dr. Victor A. Chiriac, Global Cooling Technology Group, USA
Prof. Sukwon Choi, Pennsylvania State University, USA
Dr. M. Baris Dogruoz, Maxar Technologies Company, USA
Dr. Krishna Darbha, Microsoft Corporation, USA
Prof. Pradip Dutta, Indian Institure of Science, India
Dr. Przemyslaw J. Gromala, Robert Bosch GmbH, Germany
Dr. Madhusudhan Iyengar, Google LLC, USA
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Prof. Xiabing Luo, Huazhong University of Science and Technology, Wuhan, China
Prof. John Maddox, University of Kentucky, USA
Dr. Ravi Mahajan, Intel Corporation, USA
Prof. Tim Persoons, Trinity College, University of Dublin, Ireland
Prof. Roger Schmidt, Syracuse University, USA
Prof. Amir H. Shooshtari, University of Maryland, USA
Prof. Andrew Tay, formerly of National University of Singapore, Singapore

LAST YEAR'S BEST PAPERS (ITherm 2021)

COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

PROF. AVRAM BAR-COHEN BEST PAPER	BEST PAPER - RUNNER UP
Development of Microgravity Boiling Experiments aboard the International Space Station from Terrestrial Adverse Gravity Outcomes for a Ratcheted Microstructure with Engineered Nucleation Sites Karthekeyan Sridhar (Auburn University), Vinod Narayanan (University of California Davis) and Sushil Bhavnani (Auburn University)	**Assessing the impact of novel polymers and thermal management in a power electronics module using machine learning approaches** Palash V. Acharya, Manojkumar Lokanathan, Abdelhamid Ouroua, Robert Hebner (University of Texas at Austin), Shannon Strank (Army Research Lab South, Austin) and Vaibhav Bahadur (University of Texas at Austin)

SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

PROF. AVRAM BAR-COHEN BEST PAPER	BEST PAPER - RUNNER UP
On the Thermal Efficiencies of Cascading Heat Exchangers: An Experimental Approach - I Prabhakar Subrahmanyam, Pooya Tadayon, Ying-Feng Pang, Arun Krishnamoorthy and Amy Xia (Intel Corp.)	**Hybrid Two-Phase Cooling Technology For Next-Generation Servers: Thermal Performance Analysis** Raffaele L. Amalf, Francois P. Faraldo, Todd Salamon, Ryan Enright (Nokia Bell Labs), Filippo Cataldo (Micro-technologies department Via Piave), Jackson B. Marcinichen and John. R. Thome (JJ Cooling Innovation)

EMERGING TECHNOLOGIES AND FUNDAMENTALS TRACK

PROF. AVRAM BAR-COHEN BEST PAPER	BEST PAPER - RUNNER UP
Process Recipes for Additively Printed Copper-Ink Flexible Circuits using Direct Write Methods Pradeep Lall, Jinesh Narangaparambil, Kyle Schulze (Auburn University), and Curtis Hill (NASA Marshall Space Flight Center)	**Toward High-Throughput Thermal Characterization of Combinatorial Thin-Film Solid State Phase Change Materials** Adam A. Wilson, Darin J. Sharar, Jay R. Maddux, Michael Fish (US Army Research Laboratory), and Iain Kierzewski (General Technical Service)

MECHANICS AND RELIABILITY TRACK

PROF. AVRAM BAR-COHEN BEST PAPER	BEST PAPER - RUNNER UP
Prognostic and RUL Estimations of SAC105, SAC305, and SnPb Solders under Different Drop and Shock Loads using Long Short-Term Pradeep Lall, Tony Thomas (Auburn University) and Ken Blecker (US Army CCDC-AC)	**Augmented finite element method (AFEM) for the linear steady-state thermal and thermomechanical analysis of heterogeneous integration architectures** Venkatesh Avula, Vanessa Smet, Yogendra Joshi and Madhavan Swaminathan (Georgia Institute of Technology)

KEYNOTES

Vijay Narayanan
IBM

Mark Jennings
Ford Motor Company

Tajana Šimunić Rosing
University of California, San Diego

K-1: ACCELERATING DEEP LEARNING WITH ANALOG IN-MEMORY COMPUTE
WEDNESDAY, JUNE 1, 9:00 – 10:00 AM (BEL AIRE)

Presenter: Vijay Narayanan, IBM

Abstract: Artificial Intelligence (AI) is all around us today – augmenting our capabilities and enriching our experiences - but it was less than a decade ago that the first key breakthroughs in deep learning were made. Tremendous progress has been made since in expanding AI applications as well as the accuracy of AI models, often by developing larger models that are trained on larger datasets. However, this explosive growth in model size and the concomitant increase in required compute is unsustainable without significant innovations across the hardware stack. We will present a novel non-von Neumann computational approach that envisions artificial neural networks mapped to arrays of non-volatile memory (NVM) elements. These NVM elements act as artificial synapses and encode the weights of a neural network that execute compute operations in-memory and constant time, thereby enabling significant power performance benefits. Analog NVM synapses are attractive given their non-volatility, analog tunability and maturity of the technology. This talk details innovations across materials, algorithms, and architecture to enable acceleration of AI inference and training jobs. Indeed, novel compute paradigms combined with heterogeneous integration technologies that address key bandwidth & connectivity challenges will be needed to enable energy efficiency improvements by orders of magnitude to power the AI of tomorrow.

Biography: Dr. Vijay Narayanan received his B.Tech. in Metallurgical Engineering from the Indian Institute of Technology, Madras (1995), and his M.S. (1996) and Ph.D. (1999) in Materials Science and Engineering from Carnegie Mellon University. After completing post-doctoral research at Arizona State University, Dr. Narayanan joined the IBM T. J. Watson Research Center in 2001 where he pioneered High-k /Metal Gate Research and Development from the early stages of materials discovery to development and implementation in manufacturing. These High-k/Metal Gate materials form the basis of all recent IBM systems processors and of most low-power chips for mobile devices. Currently, Dr. Narayanan is an IBM Fellow and Senior Manager at IBM Research where he is the strategist for Physics of AI and leads a worldwide IBM team developing Analog Accelerators for AI applications within the IBM Research AI Hardware Center. Dr. Narayanan is an IEEE Senior Member and was elected a Fellow of the American Physical Society in 2011. He is an author of over 100 journal and conference papers, holds more than 230 US patents, and has edited one book: "Thin Films On Silicon: Electronic And Photonic Applications".

K-2: THERMAL MANAGEMENT CHALLENGES FOR BATTERY ELECTRIC VEHICLES
THURSDAY, JUNE 2, 9:00 – 10:00 AM (BEL AIRE)

Presenter: Mark Jennings, Ford Motor Company

Abstract: In recent years, several key external drivers and technology trends have greatly accelerated the move towards electrification for on road vehicle propulsion. These drivers include societal concerns for climate change, the ongoing push for continuous improvement of air quality, rapid expansion of renewable energy sources and the emergence of vehicle connectivity. In response, Ford has greatly increased its investments in vehicle electrification and is moving aggressively into the development and deployment of battery electric vehicles across its product portfolio. Battery electric propulsion systems feature highly efficient components that present unique thermal management challenges compared with established internal combustion engine propulsion systems. This talk will discuss several of these critical challenges particularly with respect to battery thermal management and related interactions with other subsystems (e.g., cabin climate control) during cold and hot ambient vehicle operation. The associated system design trade-offs and impacts to key vehicle level attributes will be highlighted including the importance to overall vehicle energy management, range and performance. Key differences across the spectrum of vehicle applications and the significant emerging role of vehicle connectivity will also be discussed.

Biography: Mark Jennings is Senior Technical Leader for Vehicle Energy Management & Propulsion Systems Analysis for Ford Motor Company working in Ford's Research & Advanced Engineering organization on electrified powertrain systems. Mark's work at Ford on electrified powertrain systems has covered a range of system technologies encompassing mild/medium hybrid electric vehicle (HEV) systems, full HEV systems, plug-in HEV systems, battery electric vehicles and fuel cell electric vehicles. Throughout his years at Ford, he has led numerous efforts to define and assess new electrified powertrain system concepts. Through this work he has played a significant role in defining Ford's powertrain electrification strategy. He has also been a leader in establishing and applying model-based development and optimization methodologies towards the advancement of electrification technologies for vehicle propulsion. Mark has BS, MS and PhD degrees in Mechanical Engineering.

K-3: HYPERDIMENSIONAL COMPUTING SYSTEM DESIGN & THERMAL MANAGEMENT
FRIDAY, JUNE 3, 9:00 – 10:00 AM (BEL AIRE)

Presenter: Tajana Šimunić Rosing, University of California, San Diego

Abstract: In today's world technological advances are continually creating more data than what we can cope with. Much of data processing will need to run at least partly on devices at the edge of the internet, but training state of the art neural networks at the edge is too costly. Hyperdimensional (HD) computing is a class of light-weight learning algorithms that is motivated by the observation that the human brain operates on a lot of data in parallel. HD computing uses high dimensional random vectors (e.g., ~10,000 bits) to represent data, making the model robust to noise and HW faults. It uses search, along with three base operations: permutation, addition (or bundling/consensus sum) and multiplication (circular convolution / XOR). Addition allows us to represent sets, multiplication expresses conjunctive variable binding, and permutation enables encoding of causation and time series. Hypervectors are compositional - they enable computation in superposition, unlike standard neural representations. Systems that use HD computing to learn can be accelerated directly in memory and storage and have been shown to be accurate, fast and very energy efficient. Most importantly, such systems can explain how they made decisions, resulting in devices that can learn directly from the data they obtain without the need for the cloud. In this talk I will present some of my team's recent work on hyperdimensional computing theory, software and hardware infrastructure, including: i) novel algorithms supporting key cognitive computations in high-dimensional space such as classification, clustering, regression and others, ii) hardware acceleration of HD computing on GPUs, FPGAs, in memory and storage, along with software infrastructure to support it, iii) thermal management strategies to address thermal issues that arise when learning algorithms, such as HD computing, are accelerated in memory and storage.

Biography: Tajana Simunic Rosing is a Full Professor, a holder of the Fratamico Endowed Chair, ACM & IEEE Fellow, and a director of System Energy Efficiency Lab at UCSD. Her research interests are in energy efficient computing, computer architecture, distributed and embedded systems. She is leading a number of projects, including efforts funded by DARPA/SRC JUMP CRISP program, with focus on design of accelerators for analysis of big data including machine learning, image/video processing and bioinformatics; DARPA, NSF and SRC funded projects on Hyperdimensional Computing, SRC funded project acceleration of 3rd generation Fully Homomorphic Encryption, and NSF AI TILOS center projects on federated learning and AI-based chip design. She recently headed the effort on SmartCities that was a part of DARPA and industry funded TerraSwarm center. Tajana led the energy efficient datacenters theme in MuSyC center, and a number of large projects funded by both industry and government focused on power and thermal management. From 1998 until 2005 she was a full time research scientist at HP Labs while also leading research efforts at Stanford University. She finished her PhD in EE in 2001 at Stanford, concurrently with finishing her Masters in Engineering Management. Her PhD topic was dynamic management of power consumption. Prior to pursuing the PhD, she worked as a senior design engineer at Altera Corporation.

PROFESSIONAL DEVELOPMENT COURSES

A set of 16 Professional Development Courses (PDCs) are being offered as a collaboration between ITherm and ECTC conferences. Each of these courses are presented by world-class experts, enabling participants to broaden their technical knowledge base. All PDC courses will be held on Tuesday, May 31, 2022, the first day 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 website: https://www.ectc.net/registration/ or at the ECTC registration desk located in the Seascape Foyer on the Lobby Level of the Marina Tower.

2022 PROFESSIONAL DEVELOPMENT COURSES

MORNING COURSES 8:00 AM – 12:00 PM

1. Achieving High Reliability of Lead-Free Solder Joints -- Materials Considerations
   Course Leader: Ning-Cheng Lee (Consultant)
2. Wafer-Level Chip-Scale Packaging (WCSP) Fundamentals
   Course Leader: Patrick Thompson (Texas Instruments, Inc.)
3. Fundamentals of RF Design and Fabrication Processes of Fan-Out Wafer/Panel Level Packages and Interposers
   Course Leader: Ivan Ndip and Markus Wöhrmann (Fraunhofer IZM)
4. Eliminating Failure Mechanisms in Advanced Packages
   Course Leader: Darvin Edwards (Edwards Enterprises)
5. Packaging and Heterogeneous Integration for Automotive Electronics and Advanced Characterization of EMCs
   Course Leaders: Przemyslaw Gromala (Robert Bosch GmbH)
6. Avoiding inelastic strains in solder joint interconnections of IC packages
   Course Leaders: Ephraim Suhir (Portland State University)
7. Flip Chip Technologies
   Course Leader: Shengmin Wen (JCET) and Eric Perfecto (IBM Research)
8. Reliable Integrated Thermal Packaging for Power Electronics
   Course Leaders: Patrick McCuskey (University of Maryland)

AFTERNOON COURSES 1:15 AM – 5:15 PM

9. Additive Flexible Hybrid Electronics – Manufacturing and Reliability
   Course Leader: Pradeep Lall (Auburn University)
10. From Wafer to Panel Level Packaging
    Course Leaders: Tanja Braun and Michael Töpper (Fraunhofer IZM)
11. Fan-out Wafer/panel-level Packaging and Chiplet Design and Heterogeneous Integration Packaging
    Course Leader: John Lau (Unimicron)
12. Reliability Engineering Testing Methodology and Statistical Knowledge for Qualifications of Consumer and Automotive Electronic Components
    Course Leader: Fen Chen (GM Cruise)
13. Introduction of Two-Phase Cooling of High-Power Electronics
    Course Leader: John R. Thome (JJ Cooling Innovation)
14. Multi-Physics Modeling and Simulation in Electronic Packaging Theory, Implementation and Best Practices
    Course Leader: Xuejun Fan (Lamar University)
15. Polymers in Wafer Level Packaging
    Course Leaders: Jeffrey Gotro (InnoCentrix, LLC)
16. Thermal Management of Electronics
    Course Leaders: Jaime Sanchez (Intel Corporatio

HETEROGENEOUS INTEGRATION ROADMAP (HIR) WORKSHOP

TUESDAY, MAY 31, 8:00 AM – 5:00 PM, PACIFIC BALLROOM C (MARINA TOWER)

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

Heterogeneous Integration uses packaging technology to integrate dissimilar chips, devices or components with different materials and functions, and from different fabless design houses, foundries, wafer materials, feature sizes and companies into a system or subsystem. 23 Technical working groups will present on their areas of expertise. This workshop is a full-day event with the following schedule, incorporating two ECTC 2022 special sessions.


William Chen
(ASE)


Bill Bottoms
(3MT Solutions)


Ravi Mahajan
(Intel)

HIR
HETEROGENEOUS INTEGRATION ROADMAP

HIR Only Registration: https://www.ectc.net/registration/eRegistrationHIR/input.cfm
For more information, please visit: https://eps.ieee.org/technology/heterogeneous-integration-roadmap.html

08:00 am - 08:45 am - HIR Overview & 23 Chapter Updates
08:45 am - 10:15 am - Future Networks & Beyond - Panel Organizer: Tim Lee
10:15 am - 11:45 am - HIR Selected Topics - Panel Organizer: Amr Helmy (ECTC special session)
11:45 am - 12:15 pm - LUNCH
12:15 pm - 01:45pm - Packaging for HPC and Data Center - Panel Organizer: Kanad Ghose
01:45 pm - 03:15 pm - Next Gen Pkg Challenges - Panel Organizer: Jan Vardaman (ECTC special session)
03:15 pm - 04:45 pm - Medical, Health and Wearables - Panel Organizer: Mark Poliks
04:45 pm - 05:00 pm - Wrap-up

YOUNG PROFESSIONALS NETWORKING PANEL

TUESDAY, MAY 31, 7:00 – 7:45 PM, SILVER PEARL 3 (MARINA TOWER)

Chairs: Yan Liu (Medtronic) and Adeel Bajwa (Kulicke and Soffa)

This event is designed just for you – young professionals (including current graduate students). 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 PRESIDENT'S PANEL SESSION

TUESDAY, MAY 31, 7:45-9:15 PM, SILVER PEARL 1 & 2 (MARINA TOWER)

STATE-OF-THE-ART HETEROGENEOUS INTEGRATED PACKAGING PROGRAM

Chairs: Kitty Pearsall (EPS President; Boss Precision, Inc.) and Christopher Riso (Booz Allen Hamilton)

The EPS President's Panel at this year's ECTC explores the Department of Defense (DoD) State of The Art (SOTA) Heterogeneous Integrated Packaging (SHIP) program. The primary goal of the SHIP program is the development of a sustainable business and operational model for addressing government needs in the Microelectronics (ME) packaging industry. SHIP will leverage the expertise of commercial industry to develop and demonstrate a novel model to ensure sustained DoD access to secure heterogeneous integration, advanced packaging, and test of SOTA advanced packaging and create a catalog of solution components which consist of both die and package components, IP, protocols, tool sets, and design/manufacturability and test methodologies. The session will describe present and future technology implementations for both SHIP Digital and SHIP RF.

Panelists: Darren Crum (Office of the Undersecretary of Defense for Research and Engineering)
John Sotir (Intel Corporation)
Ted Jones (Qorvo Inc.)

ECTC/ITherm DIVERSITY AND CAREER GROWTH PANEL AND RECEPTION

WEDNESDAY, JUNE 1, 6:30-7:30 PM, SILVER PEARL 3 (MARINA TOWER)

SOLVING DIVERSIFICATION CHALLENGES AND WORKFORCE RETENTION ISSUES

Chairs: Cristina Amon (University of Toronto) and Kimberly Yess (Brewer Science, Inc)

Moderator: Françoise Von Trapp (3D InCites)

The microelectronics industry is in the midst of a workforce crisis that began long before we heard the word: COVID 19. Companies are desperately seeking new young talent while simultaneously trying to retain the workforce they've worked so hard to build. By 2022, it's well understood that a diverse and inclusive workforce improves innovation, productivity, and the bottom line, yet companies in the microelectronics industry struggle to recruit both women and under-represented minorities to fill thousands of open positions. In this discussion, we will address these challenges head on with some practical advice from the trenches. Each of our panelists bring real-life experience associated with attracting and retaining a diverse and inclusive workforce, and they are ready to share tips. So come prepared with your questions and leave with actionable items.

Panelists: Bina Hallamn (IBM)
Antoinette Hamilton (Lam Research)
Najwa Khazal (Edwards)
KT Moore (Cadence)

RICHARD CHU ITherm AWARD FOR EXCELLENCE

THERMAL MANAGEMENT OF HIGH FLUX ELECTRONICS UTILIZING FILM EVAPORATION AND ENHANCED FLUID DISTRIBUTION SYSTEM (FEEDS)

AWARD LUNCHEON TALK, WEDNESDAY, JUNE 1, 12:00 PM – 1:30 PM, FAIRBANKS BALLROOM

Presented by 2022 Awardee Prof. Michael Ohadi (U. of Maryland)

Abstract:
The increasing power densities of electronic devices due to more compact packaging requirements presents new opportunities and challenges for thermal management of electronics. Adequate cooling of the emerging high flux devices is required to increase the reliability and operational capabilities. Over the past few decades, microchannel heat sinks among other solutions have been implemented to dissipate high heat fluxes. Furthermore, convective heat transfer coefficients have been increased by using two-phase flow and by reducing hydraulic diameters of the channels. However, this can incur increases in pressure drop and pumping power requirements. To tackle this limitation, a novel cooling technique, film evaporation with enhanced fluid distribution system (FEEDS) has been demonstrated to simultaneously enhance the heat transfer coefficient while avoiding increased pressure drop and pumping power requirements. The FEEDS cooler is a manifold-microchannel system in which an array of manifolds is positioned perpendicularly on a system of parallel microchannels. In this work, a FEEDS cooler was designed and developed to manage high heat fluxes of electronic components. The designed manifold geometry was additively manufactured out of Inconel 625 by means of a direct metal laser sintering (DMLS) printer. Two-phase tests were performed with R-245fa refrigerant as the working fluid at three different mass fluxes (350, 700, and 1050 kg/m2-s), and the respective heat transfer and pressure drop characteristics were measured. The proposed manifold-microchannel configuration was able to dissipate heat flux of 1365 W/cm2 at 44% outlet vapor quality. Additionally, this FEEDS cooler has shown a relatively constant heat transfer coefficient over the surface, suggesting a stable liquid film.

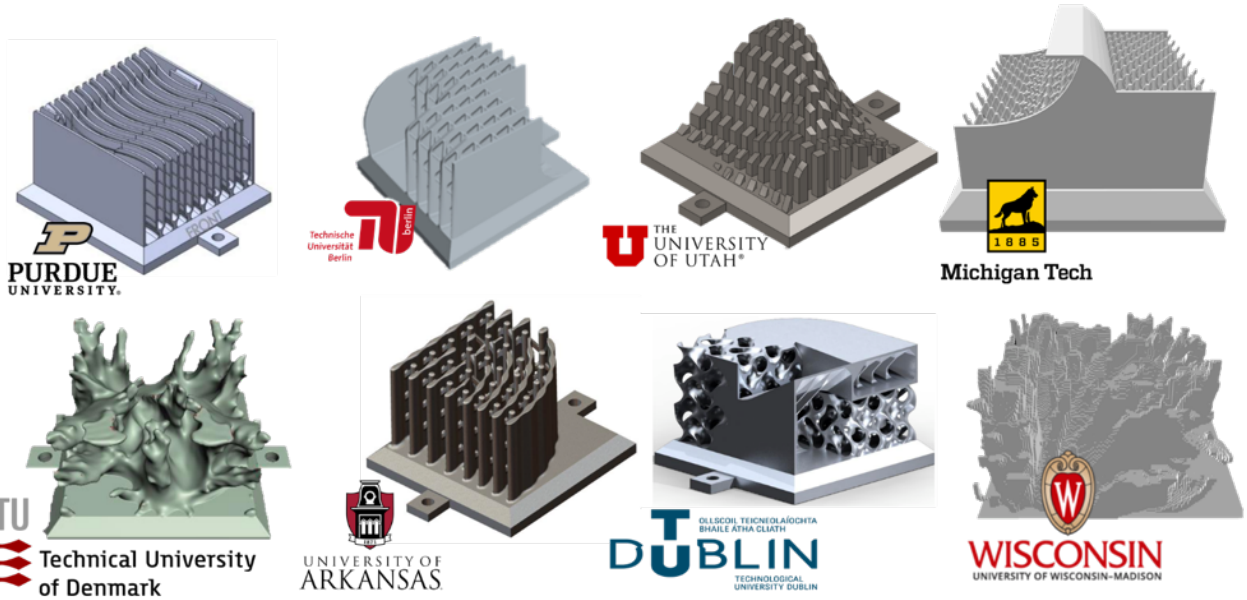
Michael Ohadi is a Minta Martin Professor of Mechanical Engineering and a co-founder of the Center for Environmental Energy engineering (CEEE) at the University of Maryland, College Park. Ohadi's research has focused on heat transfer enhancement of single phase and two-phase flows through process intensification utilizing multi-scale design optimization, materials, and manufacturing techniques. For more than 25 years he has led an industrial consortium in Advanced Heat Exchangers and Process Intensification techniques with member companies from the U.S., Asia, and Europe. From 2016 to 2020, Ohadi served as Program Director (PD) at the U.S. department of energy, Advanced Research Project Agency-energy (ARPAE), where he led the development of programs in thermal management and energy conversion systems, including lightweight and ultra-efficient electric motors, and associated power electronics for de-carbonization/electrification of aviation. Ohadi received his Ph.D. in mechanical engineering from the University of Minnesota and joined the University of Maryland in 1990. He is a fellow member with both ASME and ASHRAE. He has published more than 300 peer reviewed technical articles in his fields of expertise and is the recipient of the 2021 ASME Heat Transfer Memorial Award.

STUDENT HEAT SINK DESIGN CHALLENGE

WEDNESDAY, JUNE 1, 5:00-6:30 PM, BEL AIRE (BAY TOWER LOBBY LEVEL)

The Student Heat Sink Design Challenge is a team competition in which students design, analyze, and optimize an additively manufactured, aluminum 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 the University of Utah.

2022 ASME/K-16 and IEEE/EPS Student Semi-Finalist Heat Sink Designs



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ADVANCED BATTERIES
ENERGY HARVESTING
GREEN DATA CENTERS
binghamton.edu/s3ip

TECHNOLOGY-TALK SESSIONS

TT-3: RELIABILITY CHALLENGES IN EMERGING TECHNOLOGIES AND APPLICATIONS
WEDNESDAY, JUNE 1, 1:30 – 3:00 PM, BEL AIRE NORTH

Session Chair: Emre Armagan (Intel)

RELIABILITY CONCERNS IN HETEROGENEOUSLY INTEGRATED PACKAGES

Speaker: Ganesh Subbarayan (Purdue University)

Abstract: Heterogeneous Integration provides a powerful and cost-effective means for building complex Systems-in-Package (SiPs). Recently, sophisticated examples of heterogeneously integrated packages containing nearly 50 dies, many fabricated by different vendors on different technological nodes, have been demonstrated. In general, integration of large number of dies leads to a polynomial increase in material interfaces, which are potential locations for increased thermal resistance and mechanical fracture. Also, the larger sized multi-die packages result in complex chip-package interactions, while the smaller solder bump size results in joints that are largely made of brittle intermetallic compounds. In this talk, I will broadly describe the reliability concerns in heterogeneously integrated packages and illustrate through examples the thermo-mechanical behavioral characterization necessary for their reliability assessment. Specifically, I will describe (1) an assessment of stress induced by Through Silicon Vias (TSV) and its impact on mobility and (2) modeling and experimental characterization of phase growth under current and elevated temperature (electromigration) in microbumps. Underlying the examples are sophisticated multiphysics computational models for moving (phase) boundaries as well as fabricated test devices.

Ganesh Subbarayan is a Professor of Mechanical Engineering at Purdue University and the Co-Director of the Purdue-Binghamton SRC Center for Heterogeneous Integration Research in Packaging (CHIRP). He began his professional career at IBM Corporation (1990-1993). He holds a B.Tech degree in Mechanical Engineering (1985) from the Indian Institute of Technology, Madras and a Direct Ph. D. (1991) in Mechanical Engineering from Cornell University. Dr. Subbarayan's research is broadly concerned with modeling and experimentally characterizing failure in microelectronic devices and assemblies. He was a pioneer in using geometric models directly for analysis, popularly referred to as Isogeometric Analysis. Among others, Dr. Subbarayan is a recipient of the 2005 Mechanics Award from the ASME EPP Division and the NSF CAREER award. He is a Fellow of ASME as well as IEEE, and he served as the Editor-in-Chief of IEEE Transactions on Advanced Packaging during 2002-2010.

THERMAL PERFORMANCE AND RELIABILITY OF HIGH-PERFORMANCE BARE DIE FCBGA PACKAGES

Speaker: Kuang C Liu (Intel)

Abstract: With the explosive increase in heterogenous BGA packaging and increasing power levels, bare die packaging is an interest as way to extract the maximum thermal value. This study experimentally quantifies thermal performance of bare die packages against packages that employ built integrated heat spreaders. Thermal resistances are characterized using thermal test vehicles on several form factors and conditions. Selected configurations are subjected to typical reliability conditions to ascertain the failure mechanisms and infer their reliability. Mechanical design studies and other packaging considerations investigated to optimize the thermal performance. Final product performance is predicted using simulations and benchmarked against other technologies.

KC (Kuang) Liu is packaging technologist in ATTD (Assembly Test and Technology Development) for Intel. He specializes in thermo-mechanical packaging behavior and package-system interactions. He graduated with a dual BS in Mechanical and Aerospace Engineering from University of Arizona, MS and PhD from Arizona State University, and served as a postdoctoral fellow at Army Research Labs. Prior to Intel, he has worked in automotive and aerospace industries.

CHALLENGES IN MODELING OF LEAD-FREE SOLDER JOINT RELIABILITY

Speaker: Jeffrey C. Suhling (Auburn University)

Abstract: The microstructure, mechanical response, and failure behavior of lead-free solder joints in electronic assemblies are constantly evolving when exposed to isothermal aging and/or thermal/mechanical cycling environments. Traditional finite element based predictions for solder joint reliability during thermal cycling accelerated life testing are based on solder constitutive equations (e.g., Anand viscoplastic model) and failure models (e.g. energy dissipation per cycle model) that do not evolve with changes in the material microstructure or damage accumulation. Thus, there can be significant errors in the calculations with lead free SAC alloys that illustrate dramatic aging phenomena. In this talk, we report on an improved reliability prediction framework that utilizes constitutive relations and failure criteria that incorporate aging effects (microstructural evolution) and/or damage accumulation (micro crack growth and propagation). As a part of this work, a revised set off Anand viscoplastic stress-strain relations for solder have been developed that included material parameters that evolve with the thermal history of the solder material. In addition, a damage mechanics framework has been established to also evolve the material constants with damage accumulation occurring during cyclic loading. After development of such advanced tools, we have applied these approaches to predict reliability of PBGA components attached to FR-4 printed circuit boards that were subjected to thermal cycling and correlated the results with thermal cycling accelerated life testing experimental data for aged and non-aged assemblies.

Jeffrey C. Suhling received his Ph.D. degree in Engineering Mechanics in 1985 from the University of Wisconsin. He then joined the Department of Mechanical Engineering at Auburn University, where he currently holds the rank of Quina Distinguished Professor and Department Chair. From 2002-2008, he served as Center Director for the NSF Center for Advance Vehicle Electronics. His research interests include solid mechanics, stress and strain analysis, material characterization, experimental mechanics, advanced and composite materials, finite element analysis and computational mechanics, additive manufacturing, electronic packaging, and silicon sensors. Dr. Suhling has authored or co-authored over 500 technical publications, and has an H-Index of 55 on Google Scholar. He has advised over 100 graduate students at Auburn University. He is a Fellow of ASME, and is a member of IEEE, SMTA, IMAPS, SEM, and TAPPI. He served as Chair of the Electrical and Electronic Packaging Division of ASME during 2002-2003, and was on the EPPD Executive Committee from 1998-2003. Dr. Suhling was the Technical Program Chair of the ASME InterPACK ‘07 Conference, and General Chair of the ASME InterPACK ‘09 Conference. He currently serves as Vice President for Education for the IEEE Electronics Packaging Society, and was the General Chair of the 2019 IEEE ITherm Conference.

TT-5: THERMAL MANAGEMENT OF ELECTRIC MOTORS EMBEDDED ELECTRONICS FOR MOBILITY APPLICATIONS, THURSDAY, JUNE 2, 8:00 – 9:00 AM, BEL AIRE NORTH

Session Chair: Michael Ohadi (University of Maryland) and Peter De Bock (ARPA-E)

INTEGRATED THERMAL MANAGEMENT FOR AVIATION CLASS ELECTRIC DRIVE TRAINS

Speakers: Jagadeesh Tangudu and Kimberly Saviers (Raytheon Technologies Research Center)


Abstract: Electrified Aviation Propulsion (EAP) offers to promise reduction in aviation emissions by way of improvements in aircraft performance along with novel propulsion system architectures. One of the key technology enablers to meet this vision is through high performance Electric Drive Train (EDT) technologies, which promises revolutionary improvements in EDT's power density and efficiency, which will enable a wide range of EAP applications, and reduce both aviation and passenger vehicle carbon footprint. Integrated thermal management, designed to maximize system power density, enables efficient electrified aircraft. Thermal management of electric machines, such as motors and generators, traditionally takes the form of a finned air-cooled outer jacket on the machine. However, the performance of this configuration is very limiting due to the high thermal resistance between the motor coils (primary heat source) and the surrounding air (primary heat sink). New, and highly integrated, thermal management technologies increase the machine power density to a level that can meet some of the stringent requirement of electric aviation. This talk provides an in-depth review of various TM solutions for aviation applications and presents gaps, opportunities, merits, and challenges.

Jagadeesh K. Tangudu is currently working as Technology Portfolio Manager, Strategic Technologies and Partnership Program Office overseeing both IRAD and CRAD in the areas of Electrification, Sustainability, Autonomy and AI/ML for RTRC. He received his bachelor's in engineering degree from Andhra University, India; the master's in engineering degree from Indian Institute of Science Bangalore, Bangalore, India, and the M.S. and Ph.D. degrees in electrical and computer engineering from University of Wisconsin-Madison, Madison. Since 2011, he has been with Raytheon Technologies Research Center (previously, United Technologies Research Center), East Hartford, CT, developing advanced electrical machines and Electrification related technologies for various RTX businesses including Wind, Elevator, Air conditioners, Aviation and Defense applications. Prior to his doctoral thesis work, he worked with GE Global Research Center and GE Energy for four years working on large turbo generator, next-generation locomotive electric machines.

Kimberly R. Saviers is a Principal Engineer at Raytheon Technologies Research Center (RTRC). She is responsible for the development of advanced methods to design thermal/fluid components for cooling of power electronics and microelectronics. Her areas of expertise include heat transfer, topology optimization methods, and design for additive manufacturing. While at RTRC, she has led the development of design methods and demonstrations of advanced additively manufactured thermal components, such as cold plates and heat sinks. Along with technology development, she has transferred knowledge of the new technologies to several Raytheon businesses, enabling competitive business advantage. At the RTRC facility, she serves as the lab owner of Thermal Systems Lab, which is a 5,000 sq. ft. flexible lab space that includes various test rigs for heat exchangers, additively manufactured test coupons, thermal interface materials, thermoelectrics, and more. Dr. Saviers earned her doctorate degree at the School of Mechanical Engineering at Purdue University, where she was also a Graduate Research Assistant in the Birck Nanotechnology Center.

FUTURE OF THERMAL MANAGEMENT IN THE WORLD OF ELECTRIC AIRCRAFT PROPULSION

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

Abstract: Our growing environmental and economic need for more efficient transportation has led to substantial efforts to electrify air travel, which currently accounts for 3-4% of primary energy consumption and carbon emissions in the US. A significant roadblock identified by the Department of Energy is the relatively low power density of commercial motors today designed for flight. The current state-of-the-art for electric motor power density is 4-6 kW/kg, usually excluding the weight of the electronic and thermal management systems required to operate it. The DOE has set aggressive targets to advance motor technology to power densities in excess of 12 kW/kg and overall system efficiencies above 93%. In this talk we present a motor design with a predicted peak power density >13 kW/kg and overall efficiency >93.5%. In addition to leveraging advances in lightweight and thermally conductive materials, a key enabling strategy to achieve this power density was iterative co-design of the motor, electronic components, and the thermal management system. We highlight how introducing thermal management requirements and strategies at the beginning of the design process substantially impacted the final design. Key enabling technologies used to achieve high power density include 1) microchannel cooling of motor windings, 2) novel dielectric films with improved thermal and electric performance, and 3) integration of electronic components into the thermal management system of the motor. This achievement of 3x improvement over state-of-the-art emphasizes the exceptional performance enhancements made possible by considering both electronic and thermal constraints equally at the outset of the design process.

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 and became tenured in 2020. 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 36 peer-reviewed journal articles and two patents. His current research interests lie at the intersection of chemistry, mechanics, and physics to alter transport and reactivity.

TT-7: FUTURE OF DATA CENTER COOLING: WASTE HEAT REUSE AND RECOVERY AND SUSTAINABILITYTHURSDAY, JUNE 2, 1:30 – 3:00 PM, BEL AIRE NORTH

Session Chairs: Dereje Agonafer (Univ. of Texas at Arlington) and Bahgat G. Sammakia (Binghamton)

MANAGING DATA CENTER CHALLENGES IN THE AGE OF AI

Speaker: Ali Heydari (Nvidia)

Abstract: Artificial intelligence and machine learning applications are about to permanently change design of data centers where liquid will be coming closer than ever as the common medium to cool the core of computational servers from GPU, CPU, Switch, and other components. Hybrid air and liquid cooling with direct to chip cooling design is going to be the low hanging fruit of choice for designers where liquid will be used to directly cool high heat density components while air will continue to cool other components. Design of Liquid plumbing, selection of cooling distribution units, selection of compatible wetted materials list and reliability/serviceability issues are some of the challenges that industry is striving to resolve as we see more data centers preparing to embrace liquid for cooling servers and other IT equipment. Utilizing CFD, FNM and Omniverse tools to create digital twins of high heat density data centers to address many challenges of high heat density data centers in the age of AI is presented.

Ali Heydari is Distinguished engineer and Data Center Technologist at Nvidia in charge of all data center cooling technology development at Nvidia. In this role, he is developing direct to chip liquid cooling technologies using cold plates, cooling distribution units and manifolds for cooling of Nvidia's high heat density data centers. Prior to Nvidia, he worked as senior director in charge of Rigetti's Quantum Computers using the most futuristic technology in today's data center compute. Accomplishments include, setting up the first Quantum Cloud Services enabling over the cloud access of the Quantum Computers. Prior to that he served as Senior Technical Director and Chief Data Center Architect at Baidu, the largest search engine and AI company in China. In this role, he was server and data center architect in charge of hardware and data center design, development and deployment in China's largest data center search and AI company. Formerly, he was Senior Hardware Engineer at Twitter where he was responsible for grounds up development of Twitter's data center ODM server development. Earlier, he was Senior Hardware Engineer at Facebook where he helped in developing Facebook's original OCP server and data center products. Prior to that he worked at Sun Microsystems and spend about 10 years as Associate Professor of Mechanical Engineering at Sharif University of Technology in Iran. He received his B.S. in mechanical engineering from University of Illinois, Urbana, M.S., Ph.D. in mechanical engineering and M.A. in applied mathematics from University of California, Berkeley. He has over 25 issued patents in data center cooling technologies.

LIQUID COOLING IN THE CLOUD

Speaker: Husam Alissa (Microsoft)

Abstract: The chip industry is running into limits of all scaling laws (Moore's and Dennard's). A new generation of chips and architectures with superior performance and monetization per VM is required. Those new architectures will include higher densities systems that will have higher power and cooling demand. Liquid cooling technology is one of the pillars for unlocking next generation HW.

Dr. Husam Alissa is a Director of Advanced Cooling & Performance in Microsoft's Cloud Operation & Innovation, Advanced Development Team. His focus areas include systems (chip-server-datacenter), cooling (air, direct to chip, immersion, and cryogenics), performance, architecture, reliability, efficiency, sustainability, and TCO, with more than fifty publications in these fields and multiple patents. His work has received many recognitions including DCD Award for Mission Critical Tech Innovation, IEEE Micro Top Picks, New York State Assembly Early Career Achievement, IEEE TCPMT Best Paper Award, ASME InterPACK Outstanding Paper Award, and S3IP Distinguished Doctorate Dissertation Award. He is a member of IEEE, ASHRAE TC9.9, ASME, Open Compute, and iMasons.

ENERGY EFFICIENT COMPUTING, ANYTIME, ANYWHERE

Speaker: Peter de Bock (ARPA-E)

Abstract: Data Centers and Computing form the backbone of significant economic activity that is growing significantly. With that growth, the energy and water usage footprint of this industry is growing accordingly. As we consider a future of more powerful and diverse chipsets, can we think of innovative ways to make sustainable solutions for this industry? If we think beyond the individual components towards the system level, it can be shown that improvements in heat transfer at the chip level can potentially reduce the energy and water usage significantly.

Dr. Peter de Bock currently serves as Program Director at the Advanced Research Projects Agency-Energy (ARPA-E). At ARPA-E Dr. de Bock manages programs in zero-carbon hybrid aviation propulsion systems and efficiency of electronic systems. Prior to joining ARPA-E, Dr. de Bock worked at GE Research as Principal Engineer Thermosciences. Dr. de Bock is the former chair of ASME K-16 committee on Heat Transfer in Electronics equipment and holds 50+ patents and publications. Dr. de Bock received his Ph.D. in Mechanical Engineering from the University of Cincinnati and holds MSc degrees from University of Twente in the Netherlands, and University of Warwick in the UK.

TT-9: THERMAL-MECHANICAL CHALLENGES IN WEARABLES
FRIDAY, JUNE 3, 8:00 – 9:00 AM, BEL AIRE NORTH

Session Chair: Naveenan Thiagarajan (GE Research, US)

ENGINEERING WEARABLE MATERIALS FOR THERMAL CHALLENGES

Speaker: Amy Marconnet (Purdue University)

Abstract: Wearable and mobile devices with limited heat dissipation pathways are becoming ubiquitous. But they require integration of dissimilar materials and components with a high density of interfaces and placing additional constraints on device performance. A particular challenge for wearable electronics is optimizing and tuning the thermal transport to dissipate heat to the environment without exceeding safety limits for human contact and while maintaining the mechanical flexibility for user comfort. Woven materials consisting of high thermal conductivity fibers have shown significant promise in meeting these multi-functional needs. From a filament to fabric and composite perspective, we have developed new metrology tools to evaluate these systems and provide feedback as we engineer high thermal conductivity, flexible materials for wearable and flexible electronics.

Amy Marconnet is an Associate Professor of Mechanical Engineering and a Perry Academic Excellence Scholar at Purdue University. She received a B.S. in Mechanical Engineering from the University of Wisconsin – Madison in 2007, and an M.S. and a PhD in Mechanical Engineering at Stanford University in 2009 and 2012, respectively. She then worked briefly as a postdoctoral associate at the Massachusetts Institute of Technology, before joining the faculty at Purdue University in August 2013. At Purdue, Dr. Marconnet has made significant contributions to the field of heat transfer developing an interdisciplinary research program to evaluate, understand, and control the physical mechanisms governing the thermal transport properties of materials, machines, and systems. In 2017, she won the Woman Engineer of the Year Award from the ASME Electronics & Photonics Packaging Division and, in 2020, she was recognized as the Outstanding Graduate Student Mentor for Mechanical Engineering by the College of Engineering at Purdue and the Bergles-Rohsenow Young Investigator Award in Heat Transfer from ASME.

SEMICONDUCTOR PACKAGING CHALLENGES FOR AUTOMOTIVE APPLICATIONS

Speaker: Pradeep Lall (Auburn University)

Abstract: Electronics are increasingly being used in automotive platforms for a variety of mission-critical and safety-critical activities, such as guidance, navigation, control, charging, sensing, and operator interaction. Over the last two decades, automotive platforms have expanded to incorporate hybrid electric vehicles and fully-electric vehicles. Much of the electronics is located under the hood of the car or in trunk where temperatures and vibration levels are far higher than in consumer office applications. During the vehicle's use-life, electronics in the automotive underhood may be exposed to sustained high temperatures of 125-150°C for extended periods of time. The automotive electronics council (AEC) has graded electronics for automotive purposes into four categories: grade-0, grade-1, grade-2, and grade-3. Grade-0 components have the most demanding criteria of the four grade categories, with predicted power temperature cycling ranging from -40°C to +150°C for 1000 cycles and ambient temperature cycling ranging from -55°C to +150°C for 2000 cycles. Furthermore, the grade-0 components are expected to be capable of sustaining high temperature storage for 1000 hours at 175°C. With the introduction of new packaging architectures, the area of packaging applications has continued to evolve, allowing for powerful computing on mobile automobile platforms. New materials and integration technologies have also emerged, allowing for a tighter integration of electronics sensing and processing into the structural characteristics of the vehicle. The automobile platform faces a series of constraints that are particular to the real-time context for enabling sophisticated functionality.

Pradeep Lall is the MacFarlane Endowed Distinguished Professor with the Department of Mechanical Engineering and Director of the NSF-CAVE3 Electronics Research Center at Auburn University. He holds Joint Courtesy Appointments in the Department of Electrical and Computer Engineering and the Department of Finance. He is a member of the technical council and academic co-lead of automotive TWG and asset monitoring TWG of NextFlex Manufacturing Institute. He is the author and co-author of 2-books, 14 book chapters, and over 750 journal and conference papers in the field of electronics reliability, manufacturing, safety, test, energy efficiency, and survivability. Dr. Lall is a fellow of the ASME, fellow of the IEEE, a Fellow of NextFlex Manufacturing Institute, and a Fellow of the Alabama Academy of Science. He is recipient of the IEEE Biedenbach Outstanding Engineering Educator Award, Auburn University Research Advisory Board's Advancement of Research and Scholarship Achievement Award, IEEE Sustained Outstanding Technical Contributions Award, NSF-IUCRC Association's Alex Schwarzkopf Award, Alabama Academy of Science Wright A, Gardner Award, IEEE Exceptional Technical Achievement Award, ASME-EPPD Applied Mechanics Award, SMTA's Member of Technical Distinction Award, Auburn University's Creative Research and Scholarship Award, SEC Faculty Achievement Award, Samuel Ginn College of Engineering Senior Faculty Research Award, Three-Motorola Outstanding Innovation Awards, Five-Motorola Engineering Awards, and over Forty Best-Paper Awards at national and international conferences. Dr. Lall is the founding faculty advisor for the SMTA student chapter at Auburn University and member of the editorial advisory board for SMTA Journal.

TT-11: STACKED DIES THERMAL MANAGEMENT
FRIDAY, JUNE 3, 1:30 – 3:00 PM, BEL AIRE NORTH

Session Chair: Madhusudan Iyengar (Google) and Weihua Tang (Intel)

THERMAL IMPACT OF 3D TECHNOLOGY OPTIONS

Speaker: Herman Oprins (Imec)

Abstract: 3D integration technology enables heterogeneous system scaling by offering higher I/O densities, shorter interconnect lengths, higher bandwidth and smaller form factors compared to 2D packaging solutions. In recent years, many products have been released taking advantage of this technology to combine logic, memory and imaging components into 3D stacked die, or 2.5D interposer configurations. Due to the vertical integration of thinned silicon chips using adhesive materials with low thermal conductivity, the strong thermal coupling between the tiers in the 3D stack, and the difficulty to remove heat from within the 3D die stack, thermal management is one of the major challenges of 3D integration technology. In this talk, I will discuss the thermal impact of the recent scaling trends in 3D die and wafer stacking technologies, the thermal opportunities of 3D functional partitioning, thermal management options for 3D packages and thermal test vehicles for the experimental analysis of stacked die systems.

Herman Oprins is Principal Member of Technical staff and R&D team leader at imec, where he is leading the thermal modeling and characterization team. He holds a M.Sc and Ph.D in Mechanical Engineering from the K.U.Leuven, Belgium. He joined imec in 2003, where he has been involved in the thermal experimental characterization, thermal modeling and thermal management solutions ranging from device level, over chip level to the system level. His activities cover a wide range of electronic applications including advanced chip packages, 3D system integration, Si photonics, CMOS device scaling, back-end of line interconnect, GaN power transistors, photovoltaic modules and microfluidics.

PROSPECTIVE OF THERMAL DESIGN: HOW TO MINIMIZE THERMAL RESISTANCE IN 3D SYSTEM

Speaker: Hiroyuki Ryoson (Dexerials Corporation)

Abstract: Artificial Intelligence Semiconductor devices and computer systems have evolved as feature sizes have been continuously reduced. On the other hand, three-dimensional technology has been considered since the 1980s, mainly from the viewpoint of monolithic ICs. Since the late 1990s, 3D technology is widely studied for the hybrid structure including a package from the die-level to wafer-level, e.g., how to stack semiconductor elements and how to connect between stacked dies with the vertical interconnects such as TSVs. Today, the main approach for 3D technologies is the microbump approach. However, this approach has a large thermal problem because a BEOL layer and an interconnection layer have a large thermal resistance. Then microbump approach total thermal resistance is large. WOW alliance has proposed the bumpless process, so-called BBCube (Bumpless Build Cube), which is a kind of via-last process. In this approach, the TSVs fully connect from bottom to top, and they are formed by copper, which thermal conductivity is high enough to reduce the thermal resistance of the BEOL layer and interconnect layer. Then total thermal resistance of the bumpless approach is expected to be small. The thermal advantages are shown in this presentation.

Mr. Hiroyuki Ryoson is Executive Chief Engineer for materials and device development of Dexerials corporation in corporate research and developing division. Mr. Hiroyuki Ryoson received his B.Tech. (1988) and his M.S. (1990) in Mechanical Engineering from Kyoto University, Kyoto Japan. After graduate from university Mr. Hiroyuki Ryoson joined Sony Corporation in 1990, where he developed several thermal management devices and materials. They are a kind of sync jet air cooling device, a thin vapor chamber, a high thermal conductive thermal interface material using carbon fiber, or an electrical magnetic noise suppression high thermal conductive TIM. And Mr. Hiroyuki Ryoson is a researcher of WOW alliance from 2016 in Tokyo Institute of Technology, where he researches thermal management technologies for 3D stacked ICs or other applications.

BIOINSPIRED EVAPORATIVE COOLING FOR HIGH-POWERED HETEROGENOUS INTEGRATED CHIPS

Speaker: Damena Agonafer (Washington University)

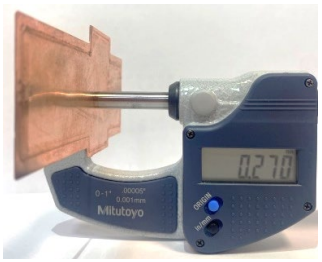
Abstract: The demand for data centers and corresponding power requirements continues to rise pushing 3% global electricity use in the US. The demand for data centers for a variety of requirements including for online education has been accentuated during the COVID-19 pandemic the world is facing now. The failure of voltage scaling with transistor gate scaling since the mid-2000s has resulted in the failure of Dennardian scaling resulting in increased power density with new technology nodes. To limit chip power, with every new generation of transistors, an increasing part of the silicon remains inactive or dark limiting the performance of the processors. In addition, the recent emphasis on applications such as artificial intelligence and data mining is pushing power limits of GPUs and CPUs used on data center servers. The next generation of high-powered microelectronic devices will require advanced thermal management solutions for dissipating large heat fluxes that will soon exceed 1 kW/cm2. The performance of state-of-art cooling technologies are lagging the maximum heat dissipation requirements due to either inherent limits of physics or technical constraints (e.g., high operating pressures). Such high heat dissipation requires aggressive cooling strategies for ensuring reliable performance of these electronic components. Two-phase cooling technologies, such as microscale evaporation, are of growing interest for electronics cooling due to their high heat removal capacity and with the added benefit of isothermal characteristics. In particular, the use of dielectric fluids will greatly simplify the use of two-phase flow cooling in 2.5 or 3D heterogeneous integrated systems. In this talk, I will identify the key mechanisms of microscale evaporation and address how geometrical features from microstructures and surface nanocoatings affect contact line dynamics, thermocapillary flow, and interfacial transport during the different stages of the evaporation process.

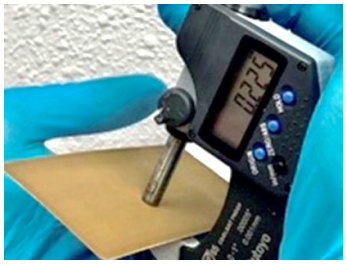
Damena Agonafer is an Assistant Professor in the Mechanical Engineering and Materials Science Department at Washington University. He is also a faculty adviser at the Institute of Materials Science and Engineering and a faculty advisor to the National Science of Black Engineers local WashU chapter. As a PhD candidate at the University of Illinois, Professor Agonafer was the recipient of the Alfred P. Sloan fellowship award. After his PhD, Damena joined Professor Ken Goodson's Nanoheat lab as a Postdoctoral Scholar in the Mechanical Engineering Department at Stanford University. Professor Agonafer's research interest is at the intersection of thermal-fluid sciences, electrokinetics and interfacial transport phenomena, and renewable energy. He is a three-time recipient of the Google Research Award, Sloan Research Fellowship Award, Cisco Research Award, NSF CAREER Award, and American Society of Mechanical Engineer's Early Career award. In 2020, he was awarded an STTR grant from the Office of Naval Research (ONR). Also last year, he was one of 85 early-career engineers in the US selected to attend the 2021 National Academy of Engineering's 26th annual US Frontiers of Engineering symposium which is a forum for "outstanding early career engineers met for an intensive 2-1/2-day symposium to discuss cutting-edge developments in four areas" including "Transforming the Climate Change Discussion: The Role of Direc

KELVIN THERMAL

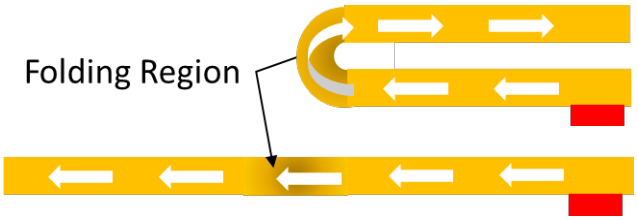
Unique and Useful TGPs (Vapor Chambers)

Thin TGPs (0.275, 0.225, & 0.150mm and good for 5-10W)

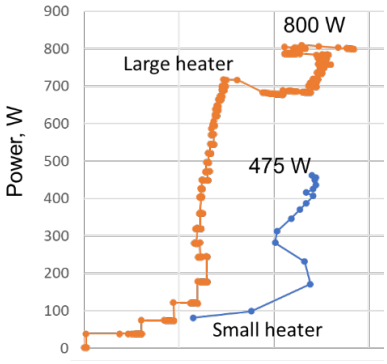


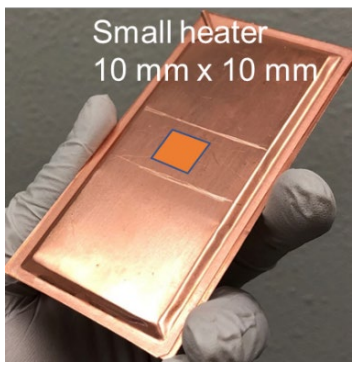


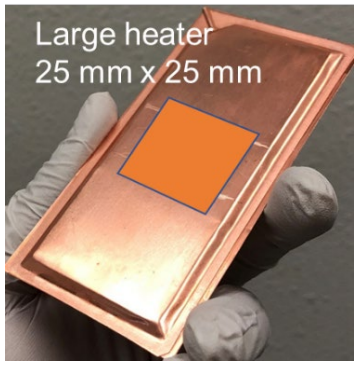

Foldable TGPs (over 200,000 folding cycles with 180° & $R_{bending}$=3mm)

High Power TGPs (475 W from a 10mm x 10mm heater)







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PANEL SESSIONS

P-2: THERMAL, MECHANICAL AND ELECTRICAL PERFORMANCE CHALLENGES OF ADVANCED MOBILE, TELECOM, WIRELESS, COMPUTE AND IOT DEVICES
WEDNESDAY, JUNE 1, 10:30 AM – 12:00 PM, BEL AIRE NORTH

Moderator: Victor Chiriac (Global Cooling Technology Group LLC)

Abstract: The digital world requires higher performance, more data and faster processors. Heterogeneous Computing involves the central processing units (CPUs), the graphics processing units (GPUs), high speed interconnects and other elements that push forward the computing industry. The emergence of 5G leads to significant rise in mobile communication, IoT technology, providing the infrastructure needed to carry huge amounts of data, allowing for a smarter and more connected world – enabling Smart Cities, connected roads, advanced transportation (Self-driving cars), AR/VR, AI robotics, Digital healthcare, smart Sports and more. A panel of experts will share their vision on the future of small to large electronics thermal management and other advanced system level thermo-mechanical-electrical challenges and solutions of the future.

Panelists: Raj Pendse (Facebook)
John Thome (GCTG LLC)
Ross Smith (RADX)
Sam Graham (University of Maryland)
Shlomo Novotny (ChillDyne)
Kinzy Jones (Magic Leap)






P-4: THERMAL CHALLENGES IN NEXT-GENERATION SEMICONDUCTOR, CONSUMER ELECTRONICS AND DATA CENTER COOLING
WEDNESDAY, JUNE 1, 3:30 – 5:00 PM, BEL AIRE NORTH

Moderators: Mahsa Ebrahim (Loyola Marymount University) and Arjang Shahriari (Qualcomm)

Abstract: Recent trends in mobile broadband, video/gaming, cloud, high-performance computing (HPC), 5G network, automotive, and Internet of Things (IoT) as well as a drive for ever-increasing efficiency is growing a need for more complex thermal solutions. Higher power with enhanced thermally constrained KPIs in a smaller space is a predominant theme for future thermal management of the electronics industry. A panel of experts from industry and academia will share their vision and discuss the importance of thermal management solutions for semiconductors, consumer electronics, and data centers.

Panelists: Taravat Khadivi (Meta)
Cheng Chen (Meta)
Yogendra Joshi (Georgia Tech)
Timothy Fisher (UCLA)
Alfonso Ortega (Villanova University)





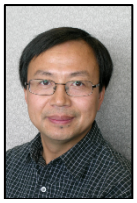
PANEL SESSIONS (Continued)

P-6: THERMO-MECHANICAL RELIABILITY CHALLENGES IN POWER ELECTRONICS
THURSDAY, JUNE 2, 10:30 AM – 12:00 PM, BEL AIRE NORTH

Moderators: David Huitink (University of Arkansas) and Przemyslaw Gromala (Robert Bosch GmbH)

Abstract: Electrification revolutionizes almost every aspect of our society. To meet these new demands, new materials, new technologies and new innovative cooling solution are within major research and development areas. In addition, artificial intelligence and machine learning will pave the way for new reliability concept such condition-based maintenance. Our Panel will consist of diversity of experts from academia and industry who will share their vision about thermo-mechanical challenges and opportunities in Power electronics. In our panel, we will discuss: Thermal Mechanical Challenges in EV/HEV Power Module, AI-based Reliability Assessment of Power Electronic Systems, and Simulations Solutions for Power Electronics Reliability.

Panelists: Yong Liu (OnSemi)
H. Alan Mantooth (University of Arkansas)
Paul Paret (NREL)
Patrick McCluskey (University of Maryland)
David Geb (Ansys)





P-8: ADVANCES IN TWO-PHASE COOLING OF ELECTRONICS
THURSDAY, JUNE 2, 3:30 – 5:00 PM, BEL AIRE NORTH

Moderator: John R. Thome (JJ Cooling Sàrl)

Abstract: Two-phase cooling is a game-changing reality as for higher power electronics and energy-savings for data centers, power electronics, Edge computing, automotive electronics, batteries, aerospace, 5G telecom, satellites and other industries, including full electronic racks. This includes both pumped and passive cooling systems. Passive cooling includes both thermosyphons and pulsating heat pipes. As an example, new two-phase loop thermosyphon air-cooled heat sinks are available for higher heat duties and lower fan power consumption in 2U servers. New two-phase simulation/design tools have been validated and described in publications. These new novel solutions are on the table to significantly save cooling electrical energy consumption with respect to current technologies. The panel will cover these topics as well as how two-phase cooling fits into the overall scheme of industry-wide developments.

Panelists: Jackson Marcinichen (JJ Cooling Innovation)
Peter de Bock (ARPA-e/DOE)
Scott Holland (Wieland Microcool)
Justin Weibel (Purdue University)




PANEL SESSIONS (Continued)

P-10: THERMAL CHALLENGES OF TRANSIENT LOADS FOR DEFENSE APPLICATIONS
FRIDAY, JUNE 3, 10:30 AM – 12:00 PM, BEL AIRE NORTH

Moderator: Mark S. Spector (Office of Naval Research)

Abstract: Modern land, sea, and air warfare technologies are trending towards significantly higher power loads with highly dynamic behavior that present unique challenges in thermal system design. Traditional design approaches assume steady state operation and rely on overdesign to meet worst-case scenarios. Therefore, tremendous opportunities exist to reduce the size, weight and power consumed by thermal management systems associated with these loads. This panel will discuss recent progress on innovative components, dynamic modeling tools, and advanced control strategies to address these challenges.

Panelists: Todd Bandhauer (Colorado State University), Michael Fish (Army Reserch Lab), Partick Shamberger (Texas A&M University), Kevin McCarthy (PC Krause and Associates), Neera Jain (Purdue University)





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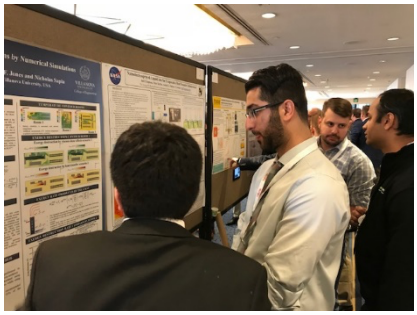
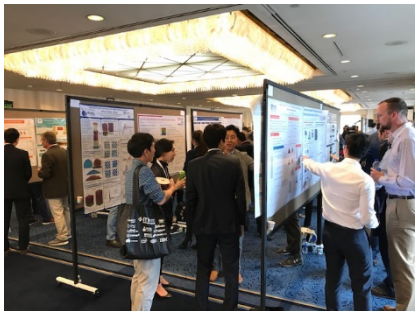
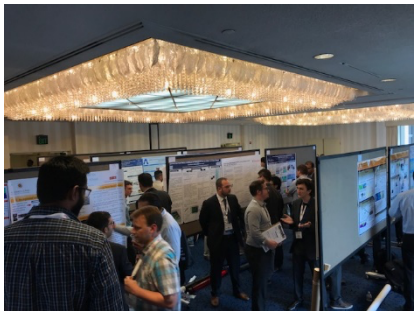
STUDENT POSTER SESSION

THURSDAY, JUNE 2, 5:00-7:00 PM, FAIRBANKS BALLROOM (BAY TOWER LOBBY LEVEL)

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.

LIST OF STUDENT POSTERS

Track	Poster #	Student Name	School	Paper #	Paper Title
Thermal I Component Level	1	Xinyue Chang	KU Leuven	P177	Thermal analysis of advanced back-end-of-line structures and the impact of design parameters
	2	Amitav Tikadar	Georgia Institute of Technology	P178	Comparison between Direct Winding Heat Exchanger and Slot-liner Confined Evaporative Cooling of Electric Motor
	3	Aaron Smith	Auburn University	P192	Flow Visualization of Turbulent Jet Impingement with Engineered Surface Modifications through Particle Image Velocimetry
	4	Samuel Kim	Georgia Institute of Technology	P339	Device-level transient cooling of Beta-Ga2O3 MOSFETs
Thermal II System Level	5	Tayler Shelly	Purdue University	P102	A Dynamic Co-Simulation Framework for the Analysis of Battery Electric Vehicle Thermal Management Systems
	6	Ryan Smith	Georgia Institute of Technology	P107	Evaporative Cooling of High Power Density Motors: Design and Analysis
	7	Gabriel Parent	Université de Sherbrooke	P174	Boiling and condensation of a dielectric liquid in a closed enclosure for electronics cooling applications
	8	Qianying Wu	Stanford University	P182	Two-phase thermofluidic modeling and validation of a multi-zone microchannel evaporator
	9	Camilo Escobar	University of Toronto	P195	Effect of Cell-to-Cell Thermal Imbalance and Cooling Strategy on Electric Vehicle Battery Performance and Longevity
	10	Christopher Barrow	University of Kentucky	P227	Optimization of Hydrogen Generator for UAVs

Thermal II System Level	11	Michael Shanks	Purdue University	P307	Control of a Hybrid Thermal Management System: A Heuristic Strategy for Charging and Discharging a Latent Thermal Energy Storage Device
	12	Veeresh Ayyagari	University of Maryland College Park	P311	Performance Characterization of a Novel Low-Cost Additively Manufactured PCM-to-Air Polymer Composite Thermal Energy Storage for Cooling Equipment Peak Load Shifting
	13	Zhengda Yao	University of Maryland College Park	P 321	Design of a Microchannel Heat Exchanger for Extreme Environments (MHXEE)
	14	Andrew Manion	Purdue University	P360	Development of a Graph-based Modeling Framework for Transient Exergy Analysis
Emerging Technologies and Fundamentals	15	David Coenen	KU Leuven	P108	Circuit-level thermal modelling of Silicon Photonic Transceiver Array using Machine Learning
	16	Maureen Winter	Purdue University	P124	The Effect of Fin Array Height and Spacing on Heat Transfer Performance during Pool Boiling from Extended Surfaces
	17	Abhijeet Banthiya	Purdue University	P132	Topology optimization of an air-cooled heat sink for transient heat dissipation using a homogenization approach
	18	Rachel McAfee	Oregon State University	P173	Zener Diode Reverse Breakdown Voltage as a Simultaneous Heating and Temperature Sensing Element
	19	Diego Vaca	Georgia Institute of Technology	P180	CYTOP for bonding highly oriented pyrolithic graphite to be used as heat spreader in mobile devices
	20	Yangyang Lai	Binghamton University	P232	The Optimal Solution of Reflow Oven Recipe based on Physics-guided Machine Learning Model
	21	Jacek Nazdrowicz	Lodz University of Technology	P251	Analysis of temperature variation influence on damping coefficient and Q-factor of 2-DOF vibratory rotational velocity sensor
	22	Kartik Goyal	Auburn University	P289	Component Attachment to Inkjet Additive Printed Circuits to achieve flexible signal filters using Silver and Copper Nanoparticle Metal Inks
	23	Kenny Yu	Trinity College Dublin	P290	Quantifying interfacial thermal conductance at solid-liquid interfaces using frequency-domain thermoreflectance and analytical methods
	24	Hyesoo Jang	Auburn university	P291	Reliability Characterization and Modeling of Flexible LCO battery Under Flexing and Calendar Aging for SOH degradation analysis
Mechanics and Reliability	25	Chongyang Cai	Binghamton University	P244	Characterization of Constitutive Equation of Sn-Bi by Studying Creep Behavior of Flip Chip Solder Joints
	26	Aathi Raja Ram Pandurangan	Auburn University	P283	Effect of Long-Term Isothermal Exposure on Chip/Underfill Interfacial Crack Growth Under Mode – I Fatigue Loading
	27	Vishal Mehta	Auburn University	P294	Effect of Evolution of High Strain Rate Properties on Plastic-Work of SAC305 Alloy with 100℃ Aging for Periods up to 240-days
	28	Padmanava Choudhury	Auburn University	P296	Influence of Sustained High Temperature Exposure on the Interface Bond Strength between TIM-Copper Substrates
	29	Mrinmoy Saha	Auburn University	P300	Evolution of High-Temperature and Low-Temperature High Strain Rate Properties for SAC-R after Sustained Exposure to 50°C

Mechanics and Reliability	30	Ved Soni	Auburn University	P308	Accelerated Life Cycling of Additively Printed Flexible Linear Charging Circuits and its Effect on Evolution of Line Resistance and Charging Current
	31	Vikas Yadav	Auburn University	P316	High Strain Rate Materials Characterization at Low Test Temperatures for Thermally Aged SAC-Q Solder Alloys
	32	Yunli Zhang	Auburn University	P317	Investigation of Epoxy Molding Compounds in Sustained High Temperature Environment up to 1 year
	33	Jinesh Narangaparambil	Auburn University	P324	Influence of Component Interconnect with Printed Copper Circuits on Realized Mechanical and Electrical Characteristics in FHE Applications
	34	Sai Sanjit Ganti	Purdue University	P328	Non-Intrusive Two-Way Coupling for Multiscale Analysis of Electronic Packages
	35	Madhu Kasturi	Auburn University	P332	Modeling Effect of Underfill Property Evolution on the FCBGA Reliability at Sustained Automotive Underhood Temperatures
	36	Sungmo Jung	Auburn University	P333	Reliability Assessment of Cu-Al WB under Automotive Temperatures in Presence of Ionic Contamination and Voltage Bias
	37	Huanyu Liao	Purdue University	P335	Sharp Interface Simulation of IMC Growth and Void Evolution in Solder Microbumps
	38	Sudarshan Prasanna Prasad	Purdue University	P337	Novel Test Device for Non-destructive Experimental Characterization of Void Evolution in Microscale Solder Joints subjected to Thermal Aging
	39	John Harris	University of Arkansas	P343	Investigation of Transient Liquid Phase Bonding to Low Temperature Co-Fired Ceramic Substrates
	40	Chetan Jois	Purdue University	P348	Phase Field Simulations of Solder Void Evolution under Thermal Aging
	41	Palash Vyas	Auburn University	P371	Drop Shock Performance of SAC-Bi Alloys Compared to SnPb
	42	Mohammad Al Ahsan	Auburn University	P372	The Effect of Bismuth Content on Mechanical Property Evolution of SAC+Bi Lead Free Solders Subjected to Long Term Thermal Exposures
	43	S M Hasan	Auburn University	P373	Evolution of the Creep Behavior for SAC305 Lead Free Solder Exposed to Various Thermal Profiles
	44	Mohamed el amine BELHADI	Auburn University	P374	Indentation Creep Properties Evolution of Lead-Free Solder Joints Subjected to Thermal Cycling
	45	Mohammad Ashraful Haq	Auburn University	P375	Mechanical Behavior and Microstructure Evolution in SAC+Bi Lead Free Solders Subjected to Mechanical Cycling
	46	Debabrata Mondal	Auburn University	P376	A Crystal Plasticity Finite Element Modeling to Explain the Effects of β-Sn Crystal Orientation on SAC305 Solder Ball Deformation
	47	Duha Ali	Auburn University	P370	Fatigue and Shear Properties of Novel Lead-free Solder Joints with Low Melting Temperatures

LAST YEAR'S BEST POSTERS (ITherm 2021)

COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

BEST POSTER	OUTSTANDING POSTER
Optimization of an Embedded Phase Change Material Cooling Strategy Using Machine Learning Meghavin Bhatasana (Purdue University)	**Experimental Characterization of Cascaded Vapor Chambers for Spreading of Non-Uniform Heat Loads** Soumya Bandyopadhyay (Purdue University)

SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

BEST POSTER	OUTSTANDING POSTER
Experimental Validation of Composite Phase Change Material Optimized for Thermal Energy Storage Achutha Tamraparni (Texas A&M University)	**Segmented Thermal Management with Flash Cooling for Heterogeneous Wafer-Scale Systems** Ujash Shah (UCLA)

EMERGING TECHNOLOGIES AND FUNDAMENTALS TRACK

BEST POSTER	OUTSTANDING POSTER
Two-Fluid Modeling of Dense Particulate Suspensions for Electronics Cooling Pranay Nagrani (Purdue University)	**A Machine-Learning-Based Surrogate Model for Internal Flow Nusselt Number and Friction Factor in Various Channel Cross Sections** Saeel Shrivallabh Pai (Purdue University)

MECHANICS AND RELIABILITY TRACK

BEST POSTER	OUTSTANDING POSTER
Augmented Finite Element Method (AFEM) for Steady-state Thermal and Thermomechanical Modeling of Heterogeneous Integration Architectures Venkatesh Avula (Georgia Institute of Technology)	**Effect of Surface Preparation and Cure-Parameters on the Interface Properties of Flexible Encapsulation in FHE Applications** Padmanava Choudhury (Auburn University)

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S Gondipalli
S Narumanchi
S Rangarajan
Stephanie Allard
Steven Dunford
S Manoharan
S Sarangi
Sukwon Choi
Sung-W Moon
Sushant Anand
Travis Mayberry
T Shimokusu
Ved Soni
Vibhash Jha
Vibin S Simon
V Vaikunthanat
Vishal Mehta
Vishal Zade
Whit Vinson
W A Malatesta
William Gerstler
Wu Huan
Xiang Zhang
Xiaojin Wei
Xiaopeng Qu
Xiaoyang Ji
Yajing Zhao
Y Manaserh
Yanguang Zhou
Yangyang Lai
Yangying Zhu
Yash Ganatra
Yaser Hadad
Y Kamotani
Yaxiong Chen
Yi Ren
Yifan Li
Yimin Zhou
Yingru Song
Yiwen Song
Yoav Peles
Yonaton Saadon
Youngjoon Su
Yu Liu
Yuan Zhang
Yuanchen Hu
Yue Qiu
Yueming Deng
Yun Zhang
Zach Gilvey
Zach Owens
Zenghao Zhu
Zhaoxi Yao
Zhe Cheng
Zhengmao Lu
Zongqing Ren
Zubin Padiya

CONFERENCE TECHNICAL PROGRAM

TRACKS & SESSIONS

COMPONENT-LEVEL THERMAL MANAGEMENT

- TI-1A: Component Level Cooling I
- TI-1B: Power Electronics and Transistor Cooling I
- TI-2: TIMs and Heat Spreaders I
- TI-3: Thermal Management of HI Packaging
- TI-4: Power Electronics and Transistor Cooling II
- TI-5: TIMs and Heat Spreaders II
- TI-6: Jet Impingement
- TI-7: Component Level Cooling II
- TI-8: Thermal Modeling and Analysis
- TI-9: Component Level Cooling III
- TI-10: Two Phase Cooling
- TI-11: Heat Pipes and Vapor Chambers I
- TI-12: Heat Pipes and Vapor Chambers II

SYSTEM-LEVEL THERMAL MANAGEMENT

- TII-1: Immersion Cooling and Refrigeration
- TII-2: Air Cooling Techniques and Heat Exchangers I
- TII-3: Automotive, Batteries and Thermal Storage
- TII-4: Liquid Cooling Solutions I
- TII-5: Mobile, Telecommunication Systems, and Internet of Things
- TII-6: Automotive, Batteries and Thermal Storage
- TII-7: Air Cooling Techniques and Heat Exchangers II
- TII-8: Liquid Cooling Solutions II
- TII-9: Data Center Thermal Management
- TII-10: Thermal Management in Electric Aircraft
- TII-11: Advanced Modeling of Thermal Systems
- TII-12: Liquid Cooling Solutions III

EMERGING TECHNOLOGIES & FUNDAMENTALS

- E-1: Thermal Management Strategies 1
- E-2: Thermal Management Strategies 2
- E-3: Nanoscale Heat Transfer
- E-4: Machine Learning and AI
- E-5: Metrology Techniques
- E-6: Additive Manufacturing 1
- E-7: Additive Manufacturing 2
- E-9: Reliability Physics
- E-10: Multi-Phase Heat Transfer

MECHANICS & RELIABILITY

- M-1: Analysis and Characterization of Crack and Interface Failure I
- M-2: Solder Constitutive Law and Property/Reliability Characterization I
- M-3 Solder Constitutive Law and Property/Reliability Characterization II
- M-4: Thermal and Mechanical Characterization of Battery and Power Electronics
- M-5: Material and Process Characterization of Advanced Electronic Packages I
- M-6: Material and Process Characterization of Advanced Electronic Packages II
- M-7: Reliability of Electronic Components under Harsh Environment
- M-8A: Analysis and Characterization of Crack and Interface Failure II
- M-8B: Thermal-Mechanical Coupled Design and Characterization
- M-9 Artificial Intelligence/Machining Learning Application to Electronic Packaging
- M-10: BGA Package Mechanical Properties and Reliability I
- M-11A: BGA Package Mechanical Properties and Reliability II
- M-11B: Lead Free Solder Characterization and Reliability I
- M-12A: Lead Free Solder Characterization and Reliability II
- M-12B: Mechanics and FEA of Integrated Electronic Packages

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

7:00 AM	**Speakers' Breakfast, Fairbanks Ballroom**	
	E-1: Thermal Management Strategies 1 Point Loma A	**TI-1A: Component Level Cooling I** Coronado A
	Session Chairs: *Darshan Pahinkar (Florida Institute of Technologies), Saket Karajgikar (Facebook)*	Session Chairs: *Ronald Warzoha (United States Naval Academy), Darin Sharar (Army Research Laboratory)*
8:00 AM	**Topology optimization of an air-cooled heat sink for transient heat dissipation using a homogenization approach (p132)** Abhijeet Banthiya, Serdar Ozguc, Liang Pan, Justin Weibel (Purdue University)	**High Performance Compliant Heat Sinks (p115)** Mark Schultz (IBM TJ Watson Research)
8:20 AM	**High Performance Pulsating Heat Pipe for Electronics Cooling (p149)** Haris Constantinou (EPFL), Sebastien Lani (CSEM), Gautier Rouaze, John Thome (JJ Cooling Innovation)	**Microprocessor Performance with Multiple Cooling Approaches (p117)** Mark Schultz, Pritish Parida, Timothy Chainer (IBM TJ Watson Research)
8:40 AM	**CYTOP for bonding highly oriented pyrolithic graphite to be used as heat spreader in mobile devices (p180)** Diego Vaca, Vanessa Smet, Yogendra Joshi, Satish Kumar (Georgia Institute of Technology)	**Analysis of thermal management strategies for packaging high power fiber optic waveguides (p356)** Adam Wilson, Michael Fish, Robert Hoffman, Darin Sharar (US Combat Capabilities Development Command Army Research Laboratory)
9:00 AM	**K-1 Keynote: Accelerating Deep Learning with Analog In-Memory Compute** Bel Aire Vijay Narayanan, IBM 	
10:00 AM	**Refreshment Break, Catalina Ballroom**	

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

Speakers' Breakfast, Fairbanks Ballroom

TII-1: Immersion Cooling and Refrigeration Coronado B	**M-1: Analysis and Characterization of Crack and Interface Failure I** Point Loma B	**TI-1B: Power Electronics and Transistor Cooling I** Bel Aire North
Session Chairs: *Raffaele Luca Amalfi (Nokia Bell Labs), Xiang Zhang (Oregon State University), Amir Shooshtari (University of Maryland)*	Session Chairs: *SB Park (Binghamton University SUNY), KE PAN (Binghamton University)*	Session Chairs: *Yuanchen Hu (IBM), Jeffrey Didion (NASA)*
Modeling the Steady-State Performance of SMA-based Elastocaloric Refrigeration Cycle. (p103) Sarah Nguyen, Joshua Radice, Andrew Smith (United States Naval Academy), Darin Sharar, Adam Wilson (Army Research Laboratory), Brian Donovan, Ronald Warzoha (United States Naval Academy)	**Effect of Long-Term Isothermal Exposure on Chip/Underfill Interfacial Crack Growth Under Mode-I Fatigue Loading (p283)** Pradeep Lall, Aathi Pandurangan (Auburn University)	**Embedded Cooling with 3D Manifold for High Power Application to 3020W Power (p110)** Jianyu Du (China University of Geosciences), Yuchi Yang (Peking University), Huaiqiang Yu, Yulong Liu (Electronics Technology Group Corporation), Jiajie Kang (China University of Geosciences), Wei Wang (Peking University)
Multi-Scale Electroplated Porous Coating for Immersion Cooling of Electronics (p168) Yaser Nabavi Larimi, Omidreza Ghaffari, Alireza Ganjali, Chady Al Sayed (Universite De Sherbrooke), Francis Grenier, Simon Jasmin (Systemex Energies Inc), Luc Frechette, Julien Sylvestre (Universite De Sherbrooke)	**Study of Interface Reliability of PCB-UF Interface in FCBGAs under Sustained High Temperature Operation in Automotive Underhood Environments (p297)** Pradeep Lall, Padmanava Choudhury (Auburn University)	**Dynamic Thermal Management of Power Transistors using Holey Silicon-Based Thermoelectric Cooling (p197)** Jiajian Luo, Jungyun Lim (University of California Irvine), Archana Venugopal, Jingjing Chen (Texas Instruments), Zongqing Ren, Jaeho Lee (University Of California Irvine)
Boiling and Condensation of a Dielectric Liquid in a Closed Enclosure for Electronics Cooling Applications (p174) Gabriel Parent, Alireza Ganjali, Omidreza Ghaffari, Chady Al Sayed, Luc Frechette, Julien Sylvestre (Universite De Sherbrooke)	**Sharp Interface Simulation of IMC Growth and Void Evolution in Solder Microbumps (p335)** Huanyu Liao, Chetan Jois, Sudarshan Prasad, Ganesh Subbarayan (Purdue University)	**Device-level Transient Cooling of β-Ga2O3 MOSFETs (p339)** Samuel Kim (Georgia Tech), James S. Lundh, Daniel Shoemaker (Pennsylvania State University), Bikramjit Chatterjee (Georgia Tech), Andrew Green, Kelson Chabak, Kyle Liddy (AFRL), Samuel Graham (U. of Maryland), Sukwon Choi (Pennsylvania State University)

K-1 Keynote: Accelerating Deep Learning with Analog In-Memory Compute

Bel Aire

Vijay Narayanan, IBM

Abstract: Artificial Intelligence (AI) is all around us today – augmenting our capabilities and enriching our experiences - but it was less than a decade ago that the first key breakthroughs in deep learning were made. Tremendous progress has been made since in expanding AI applications as well as the accuracy of AI models, often by developing larger models that are trained on larger datasets. However, this explosive growth in model size and the concomitant increase in required compute is unsustainable without significant innovations across the hardware stack. We will present a novel non-von Neumann computational approach that envisions artificial neural networks mapped to arrays of non-volatile memory (NVM) elements. These NVM elements act as artificial synapses and encode the weights of a neural network that execute compute operations in-memory and constant time, thereby enabling significant power performance benefits. Analog NVM synapses are attractive given their non-volatility, analog tunability and maturity of the technology. This talk details innovations across materials, algorithms, and architecture to enable acceleration of AI inference and training jobs. Indeed, novel compute paradigms combined with heterogeneous integration technologies that address key bandwidth & connectivity challenges will be needed to enable energy efficiency improvements by orders of magnitude to power the AI of tomorrow.

Refreshment Break, Catalina Ballroom

DAY 1 SESSIONS: WEDNESDAY, JUNE 1, 10:30 – 1:30 PM

	E-2: Thermal Management Strategies 2 Point Loma A	TI-2: TIMs And Heat Spreaders I Coronado A
	Session Chairs: *Satyam Saini (University of Texas at Arlington), Xiaopeng Qu (Microsoft)*	Session Chairs: *Anil Yuksel (IBM Corporation), Stephanie Allard (IBM)*
10:30 AM	**Featured Paper Presentation** **Pulsating Heat Pipe Fin Plates for Enhancing Natural and Forced Convection Cooling of Electronics: Experimental Campaign (p273)** Gautier Rouaze, Jackson Marcinichen, John Thome (JJ Cooling Innovation SARL), Kangnin Xiong, Winston Zhang (Novark Technologies)	**Featured Paper Presentation** **Spatial Thermal Conductivity Variation of Particulate-Filled Thermal Interface Materials (p340)** Zechen Zhang, Piyush Kulkarni, Matthias Daeumer, Ahmad Gharaibeh (Binghamton University), Je-Young Chang (Intel), Bahgat Sammakia, Scott Schiffres (Binghamton University)
11:00 AM	**Reworkable & rehealable packaging materials from the introduction of orthogonal dynamic covalent chemistries (p194)** Teddie Magbitang, Lucas Moore, Roy Yu, Kamal Sikka, Akhiro Horibe, Rudy Wojtecki (IBM)	**TIM Coverage Evaluation for High Performance Computing Application (p152)** Shane Lin, Ken Zhang, Vito Lin, David Lai, Yu-Po Wang (Siliconware Precision Industries Co Ltd)
11:20 AM	**Chip-level Thermal Simulation for a Multicore Processor Using a Multi-Block Model Enabled by Proper Orthogonal Decomposition (p329)** Lin Jiang, Anthony Dowling, Yu Liu, Ming-Cheng Cheng (Department of Electrical And Computer Engineering Clarkson University)	**Effects of sedimentation induced filler thermal conductivity gradients on thermal reliability of potted components (p169)** Tejas Manohar Kesarkar (Bosch Global Software Technologies Private Limited), Gabor Balogh (Robert Bosch Kft), Nitesh Kumar Sardana (Bosch Global Software Technologies Private Limited), Thomas Rupp (Robert Bosch GmbH)
11:40 AM	**Equivalent thermal conductivity of a composite structure considering heat spreading on neighboring layers (p381)** Young Hoon Hyun, Bruce Won Lee, Ki Wook Jung, Byeong Yeon Cho, Yunhyeok Im, Dan Oh (Samsung Electronics Co Ltd)	**Non-Destructive Evaluation of Thermal Interface Materials using Modulated Heating of Selective Cores (p338)** Piyush Kulkarni, Zechen Zhang, Fatemeh Rafsanjani Hejripour (Binghamton University), Je-Young Chang (Intel), Bahgat Sammakia, Scott Schiffres (Binghamton University)
12:00 PM	 **Luncheon & Richard Chu ITherm Award for Excellence Presentation** Fairbanks Ballroom Michael Ohadi, University of Maryland **Abstract**: The increasing power densities of electronic devices due to more compact packaging requirements presents new opportunities and challenges for thermal management of electronics. Adequate cooling of the emerging high flux devices is required to increase the reliability and operational capabilities. Over the past few decades, microchannel heat sinks among other solutions have been implemented to dissipate high heat fluxes. Furthermore, convective	

DAY 1 SESSIONS: WEDNESDAY, JUNE 1, 10:30 – 1:30 PM

TII-2: Air Cooling Techniques and Heat Exchangers

Coronado B

Session Chairs: *Shadi Mahjoob (California State University Northridge), Solomon Adera (University of Michigan), Amir Shooshtari (University of Maryland)*

Featured Paper Presentation

Online Server Fan Failure Prediction by Vibration Analysis Augmented by Hardware and Software Telemetry (p213)
Derssie Mebratu, Jaiber John, Romir Desai, Rahul Khanna (Intel)

Air Leakage Impact on System Thermal Behavior in 3U Chassis (p113)
Feng Qi, Biber Catherina, Ming Zhang, Casey Winkle (Intel)
(virtual)

A Novel Outdoor Edge Server Design with Hybrid Air Cooling and Refrigeration (p211)
Liwen Guo, Tzuchun Hung, Cheng-Hua Huang, Minghua Duan, Chiming Jao, Vinson Lin, Robert Yuan (Foxconn), Dechao Kong, Hai Du, Xiaojin Fan, Dong Xun (Baidu), Jun Zhang, Min Wu, Wenqing Lv, Carrie Chen, Candy He, Nishi Ahuja, Qing Qiao (Intel Corporation)

M-2: Solder Constitutive Law and Property/Reliability Characterization I

Point Loma B

Session Chairs:
Sathya Raghavan (IBM), Pavan Rajmane (Qualcomm)

Featured Paper Presentation

High Strain Rate Mechanical Properties of M758 Solder at Extreme Surrounding Temperatures, with 100oC Isothermal Aging for up to 180 Days (p293)
Pradeep Lall, Vishal Mehta, Jeff Suhling, Ken Blecker (Auburn University)

Characterization of Constitutive Equation of Sn-Bi by Studying Creep Behavior of Flip Chip Solder Joints (p244)
Chongyang Cai, Ke Pan, Karthik Deo, Yangyang Lai , Junbo Yang , Jing Wang , Seungbae Park (SUNY - Binghamton)

Effect of SAC105 Solder Alloys High Strain Rate Property Evolution on Plastic Work at Low Operating Temperatures (p315)
Pradeep Lall, Vikas Yadav, Jeff Suhling (Auburn University), David Locker (US Army CCDC-AvMC)

High Strain Rate Materials Characterization at Low Test Temperatures for Thermally Aged SAC-Q Solder Alloys (p316)
Pradeep Lall, Vikas Yadav, Jeff Suhling (Auburn University), David Locker (US Army CCDC-AvMC)

P-2: Thermal, Mechanical and Electrical Performance Challenges of Advanced Mobile, Telecom, Wireless, Compute and IOT Devices

Bel Aire North

Moderator:
Victor Chiriac (Global Cooling Technology Group LLC)

Thermal, Mechanical and Electrical Performance Challenges of Advanced Mobile, Telecom, Wireless, Compute and IoT Devices

Abstract: The digital world requires higher performance, more data and faster processors. Heterogeneous Computing involves the central processing units (CPUs), the graphics processing units (GPUs), high speed interconnects and other elements that push forward the computing industry. The emergence of 5G leads to significant rise in mobile communication, IoT technology, providing the infrastructure needed to carry huge amounts of data, allowing for a smarter and more connected world – enabling Smart Cities, connected roads, advanced transportation (Self-driving cars), AR/VR, AI robotics, Digital healthcare, smart Sports and more. A panel of experts will share their vision on the future of small to large electronics thermal management and other advanced system level thermo-mechanical-electrical challenges and solutions of the future.

Panelists:
Raj Pendse (Facebook)
John Thome (GCTG LLC)
Ross Smith (RADX)
Sam Graham (University of Maryland)
Shlomo Novotny (ChillDyne)
Kinzy Jones (Magic Leap)

Luncheon & Richard Chu ITherm Award for Excellence Presentation

Fairbanks Ballroom

heat transfer coefficients have been increased by using two-phase flow and by reducing hydraulic diameters of the channels. However, this can incur increases in pressure drop and pumping power requirements. To tackle this limitation, a novel cooling technique, film evaporation with enhanced fluid distribution system (FEEDS) has been demonstrated to simultaneously enhance the heat transfer coefficient while avoiding increased pressure drop and pumping power requirements. The FEEDS cooler is a manifold-microchannel system in which an array of manifolds is positioned perpendicularly on a system of parallel microchannels. In this work, a FEEDS cooler was designed and developed to manage high heat fluxes of electronic components. The designed manifold geometry was additively manufactured out of Inconel 625 by means of a direct metal laser sintering (DMLS) printer. Two-phase tests were performed with R-245fa refrigerant as the working fluid at three different mass fluxes (350, 700, and 1050 kg/m2-s), and the respective heat transfer and pressure drop characteristics were measured. The proposed manifold-microchannel configuration was able to dissipate heat flux of 1365 W/cm2 at 44% outlet vapor quality. Additionally, this FEEDS cooler has shown a relatively constant heat transfer coefficient over the surface, suggesting a stable liquid film.

DAY 1 SESSIONS: WEDNESDAY, JUNE 1, 1:30 – 3:30 PM		
	E-3: Nanoscale Heat Transfer Point Loma A	**TI-3: Thermal Management of HI Packaging** Coronado A
	Session Chairs: *Ronald Warzoha (United States Naval Academy), Jingjing She (Georgia Tech)*	Session Chairs: *Scott Schiffres (State University of New York Binghamton), Monali Basutkar (IBM), Herman Oprins (IMEC)*
1:30 PM	**Featured Paper Presentation** **An Approximated Model of Boltzmann Transport Equation for Nano-Scale Thermal Analysis (p200)** Chih-Cheng Chang, Hong-Wen Chiou, Yu-Min Lee, (National Yang Ming Chiao Tung University) **(virtual)**	**Featured Paper Presentation** **Thermal modeling of Direct Bonded Heterogenous Integration (DBHi) MCM package with Si microcooler (p161)** Risa Miyazawa, Takashi Hisada, Marc Bergendahl, Aakrati Jain, Takashi Hisada, Kamal Sikka (IBM)
2:00 PM	**Full-field pump-probe thermoreflectance imaging for characterization of thin films and 3D integrated circuits (p189)** Sami Alajlouni, Kerry Maize, Ali Shakouri (Purdue University)	**Thermal perspective design Analysis of 3D stacked chip integrated by TSV, Micro-bump and TMV with SOC (p141)** Youngsang Cho, Kyoungmin Lee, Kyojin Hwang, Heeseok Lee, Yunhyeok Im, Minkyu Kim (Samsung Electronics)
2:20 PM	**Extending the thermal slip boundary condition at the solid-fluid interface (p285)** Joseph Thalakkottor (South Dakota School of Mines And Technology)	**Thermal-Aware Optimization of SoC Floorplan with Heterogenous Multi-Cores (p214)** Jongkyu Yoo, Taekeun An, Chigwan Oh, Youngsang Cho, Heeseok Lee, Yunhyeok Im, Minkyu Kim, Minsu Kim (Samsung Electronics)
2:40 PM	**Quantifying interfacial thermal conductance at solid-liquid interfaces using frequency-domain thermoreflectance and analytical methods (p290)** Kenny Yu (Trinity College Dublin), Ryan Enright (Nokia Bell Labs), David McCloskey (Trinity College Dublin)	**Thermal Design of a Chiplet Module using Monolithic die and 2.5D/3D packages (p302)** Eric Ouyang, Jayden Gu, Yonghyuk Jeong, Michael Liu (JCET Global), Ravi Agarwal, Yin Hang (Meta Platform)
3:00 PM	**Refreshment Break, Catalina Ballroom**	

DAY 1 SESSIONS: WEDNESDAY, JUNE 1, 1:30 – 3:30 PM

TII-3: Automotive, Batteries and Thermal Storage I

Coronado B

Session Chairs: *Patrick Shamberger (Texas A M), Michael Barako, Michael Barako (Northrop Grumman), Geoff Wehmeyer (Rice University)*

Featured Paper Presentation

Effect of Cell-to-Cell Thermal Imbalance and Cooling Strategy on Electric Vehicle Battery Performance and Longevity (p195)
Camilo Escobar, Zhe Gong, Carlos Da Silva, Olivier Trescases, Cristina Amon (University of Toronto)

A Dynamic Co-Simulation Framework for the Analysis of Battery Electric Vehicle Thermal Management Systems (p102)
Tyler Shelly, Justin Weibel, Davide Ziviani, Eckhard Groll (Purdue University)

Automotive Electrical Validation Thermal Tests Analysis (p109)
Cristina Mihaela Dragan (University Politehnica Timisoara and Continental Automotive Romania)

Optimization of Surface Structures for the Thermal Management of Heavy Duty Batteries Using Viscoelastic Coolants (p130)
Tamal Roy, Rico Luengo Miguel, David Taylor, Dimos Poulikakos, (ETH Zurich)

M-3: Solder Constitutive Law and Property/Reliability Characterization II

Point Loma B

Session Chairs:
Sathya Raghavan (IBM), Pavan Rajmane (Qualcomm)

Featured Paper Presentation

Novel Test Device for Non-destructive Experimental Characterization of Void Evolution in Microscale Solder Joints subjected to Thermal Aging (p337)
Sudarshan Prasanna Prasad, Chetan Jois, Ganesh Subbarayan (Purdue University)

The Effect of Bismuth Content on Mechanical Property Evolution of SAC+Bi Lead. Free Solders Subjected to Long Term Thermal Exposures (p372)
Mohammad Al Ahsan, S M Kamrul Hasan, Jeffrey Suhling, Pradeep Lall (Auburn University)

A Crystal Plasticity Finite Element Modeling to Explain the Effects of β-Sn Crystal Orientation on SAC305 Solder Ball Deformation (p376)
Debabrata Mondal, Jeffrey Suhling, Pradeep Lall (Auburn University)

Evaluation of Directional Properties of SAC305 Solder Joints Using the Nanoindentation Technique (p377)
Debabrata Mondal, Mohammad Ashraful Haq, Jeffrey Suhling, Pradeep Lall (Auburn University)

TT-3: Reliability Challenges in Emerging Technologies and Applications

Bel Aire North

Session Chairs:
Emre Armagan (Intel)

Reliability Concerns in Heterogeneously Integrated Packages
Ganesh Subbarayan (Purdue University)

Thermal Performance and Reliability of High-Performance Bare Die FCBGA Packages
Kuang C Liu (Intel)

Challenges in Modeling of Lead-Free Solder Joint Reliability
Jeffrey C. Suhling (Auburn University)

Refreshment Break, Catalina Ballroom

DAY 1 SESSIONS: WEDNESDAY, JUNE 1, 3:30 – 7:30 PM

	E-4: Machine Learning and AI Point Loma A	TI-4: Power Electronics and Transistor Cooling II Coronado A
	Session Chairs: *Yuanchen Hu (IBM), Paul Paret (National Renewable Energy Laboratory)*	Session Chairs: *Prabudhya Roy Chowdhury (IBM), Tuhin Sinha (Amazon)*
3:30 PM	**Featured Paper Presentation** **The Optimal Solution of Reflow Oven Recipe based on Physics-guided Machine Learning Model (p232)** Yangyang Lai, Ke Pan, Jonghwan Ha, Chongyang Cai, Junbo Yang, Pengcheng Yin, Jiefeng Xu, Seungbae Park (Binghamton University)	**Featured Paper Presentation** **Deep-Ultraviolet Thermoreflectance Thermal Imaging of GaN High Electron Mobility Transistors (p136)** Daniel Shoemaker, Anwarul Karim (Pennsylvania State University), Dustin Kendig (Microsanj), Hyungtak Kim (Hongik University), Sukwon Choi (Pennsylvania State University)
4:00 PM	**Circuit-level thermal modelling of Silicon Photonic Transceiver Array using Machine Learning (p108)** David Coenen (KU Leuven), Herman Oprins (Imec), Ingrid De Wolf (KU Leuven)	**Si3N4 Manifold Microchannels Cooling System for High Heat Flux Electronic Applications (p128)** Yue Qiu, Chirag Kharangate, Jennifer Carter, James McGuffin-Cawley (Case Western Reserve University)
4:20 PM	**SSD Thermal Throttling Profile Prediction Using Neural Network (p111)** Chaolun Zheng, Hedan Zhang, Steve Chi, Ning Ye (Western Digital Corporation)	**Advancement of GaN HEMT Power Electronics on Diamond Substrate (p151)** Mei-Chien Lu (Monte Rosa Technology) **(virtual)**
4:40 PM	**Deep Learning Neural Network Apprach for Correlation between Print Parameters and Realized Electrical Performance and Geometry on Ink-Jet Platform (p313)** Pradeep Lall, Tony Thomas, Kartik Goyal (Auburn University), Scott Miller (NextFlex Manufacturing Institute)	**The 3D Tesla Valve Manifold Two-Phase Cold Plate for the SiC Power Device Module (p159)** Xinmeng Li, Xin Zhang, Wei Li, Zhenyu Wang (Peking University), Xiaobin Zhang (Microelectronics Institute of Chinese Academy Of Sciences), Yongzhi Zhao (The Thirteenth Research Institute Of CETC)
5:00 PM	**Student Heat Sink Design Challenge** Bel Aire North **Semi-Finalists:** Purdue University, Technische Universität Berlin, The University of Utah, Michigan Tech, Technical University of Denmark, University of Arkansas, Technological University Dublin, University of Wisconsin - Madison	
6:30 PM	**ECTC/ITherm Diversity Panel and Reception** Silver Pearl 3 (Marina Tower) Moderators: Cristina Amon (University of Toronto); Kimberly Yess (Brewer Science, Inc) **Panelists:** Bina Hallamn (IBM), Najwa Khazal (Edwards), Antoinette Hamilton (Lam Research), KT Moore (Cadence)	

DAY 1 SESSIONS: WEDNESDAY, JUNE 1, 3:30 – 7:30 PM

TII-4: Liquid Cooling Solutions

Coronado B

Session Chairs: *Ajit Vallabhaneni (Qualcomm Technologies Inc), Krishna Vasanth Valavala (Intel), Chandra Mohan Jha (Intel Corporation)*

Featured Paper Presentation

Experimental Analysis and of a Dual-Evaporator Thermosyphon Cooling System for CPUs and GPUs (p218)
Filippo Cataldo, Yuri Carmelo Crea (Provides Metalmeccanica Srl), Raffaele Luca Amalfi (Nokia Bell Labs)

Experimental Characterization of a Compact Thermosyphon Cooling System Operating with R1234ze(E) and R1233zd(E) low-GWP refrigerants (p137)
Raffaele Luca Amalfi, Cong Hiep Hoang, Ryan Enright, John Kim (Nokia Bell Labs), Filippo Cataldo (Provides Metalmeccanica Srl), Jackson Braz Marcinichen, John Richard Thome (JJ Cooling Innovation Sarl)

A study on compatibility of thermal interface materials with coolants for data center immersion cooling (p350)
Liu Yu, Jin Yang, David Shia, Ming Zhang (Intel Corporation)
(virtual)

Study on cooling system for SR motors by pumpless forced convection boiling equipment with liquid dielectric coolant (p366)
Hirotsugu Aoyama, Shohei Ohashi, Yu Qiang (Yokohama National University)

M-4: Thermal and Mechanical Characterization of Battery and Power Electronics

Point Loma B

Session Chairs:
Ved Soni (Auburn University), David Huitink (University of Arkansas)

Featured Paper Presentation

Building reliable FE simulation models for a better behavior prediction of power electronic systems (p238)
Heiner Moeller, Rainer Dudek, Alexander Otto (Fraunhofer ENAS), Sven Rzepka (Technical University Of Chemnitz)

Accelerated Life Cycling of Additively Printed Flexible Linear Charging Circuits and its Effect on Evolution of Line Resistance and Charging Current (p308)
Pradeep Lall, Ved Soni (Auburn University), Scott Miller (NextFlex Manufacturing Institute

A Benchmark Study on the Thermal Performance and Life of Different Structures of SiC Chip Modules (p367)
Gakuto Hiraoka, Ryotaro Yoshikawa, Yuta Ito, Qiang Yu (Yokohama National University), Yuji Komatsu[2], Thomas Chiron (ZF Japan Co), Wolfgang Schön (ZF Friedrichshafen AG)

Evaluation of High cycle fatigue life of solder joint in Si power module (p368)
Yuta Hashimoto, Shingo Nakayama, Qiang Yu(Yokohama National University)

P-4: Thermal Challenges in Next-Generation Semiconductor, Consumer Electronics and Data Center Cooling

Bel Aire North

Moderators:
Mahsa Ebrahim (Loyola Marymount University) and Arjang Shahriari (Qualcomm)

Thermal Challenges in Next-Generation Semiconductor, Consumer Electronics and Data Center Cooling

Abstract: Recent trends in mobile broadband, video/gaming, cloud, high-performance computing (HPC), 5G network, automotive, and Internet of Things (IoT) as well as a drive for ever-increasing efficiency is growing a need for more complex thermal solutions. Higher power with enhanced thermally constrained KPIs in a smaller space is a predominant theme for future thermal management of the electronics industry. A panel of experts from industry and academia will share their vision and discuss the importance of thermal management solutions for semiconductors, consumer electronics, and data centers

Panelists:
Taravat Khadivi (Meta)
Cheng Chen (Meta)
Yogendra Joshi (Georgia Tech)
Timothy Fisher (UCLA)
Alfonso Ortega (Villanova University)

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.

The microelectronics industry is in the midst of a workforce crisis that began long before we heard the word: COVID 19. Companies are desperately seeking new young talent while simultaneously trying to retain the workforce they have worked so hard to build. By 2022, it's well understood that a diverse and inclusive workforce improves innovation, productivity, and the bottom line, yet companies in the microelectronics industry struggle to recruit both women and under-represented minorities to fill thousands of open positions. In this discussion, we will address these challenges head on with some practical advice from the trenches. Each of our panelists bring real-life experience associated with attracting and retaining a diverse and inclusive workforce, and they are ready to share tips. So come prepared with your questions and leave with actionable items.

DAY 2 SESSIONS: THURSDAY, JUNE 2, 8:00 - 10:00 AM

7:00 AM	**Speakers' Breakfast, Fairbanks Ballroom**	
	E-5: Metrology Techniques Point Loma A	**TI-5: TIMs And Heat Spreaders II** Coronado A
	Session Chairs: *Zhe Cheng (University of Illinois at Urbana-Champaign), Jungwan Cho (Sungkyunkwan University)*	Session Chairs: *Rinaldo Miorini (General Electric Research), Andrew Bayba (US Army Research Laboratory), Darin Sharar (Army Research Laboratory)*
8:00 AM	**Zener Diode Reverse Breakdown Voltage as a Simultaneous Heating and Temperature Sensing Element (p173)** Rachel McAfee (Oregon State University), Michael Fish (US Army Research Laboratory), Joshua Gess (Oregon State University)	**An Integrated Cooling Effect Package for High Performance Computing Chips (p112)** Bo-Jiun Yang, Tai-Yu Chen, Tsung-Yu Pan, Bing-Yeh Lin, Yu-Jin Li, Wen-Sung Hsu (Mediatek)
8:20 AM	**Design and Development of an Automated Lithium-Ion Battery Temperature and Internal Pressure Monitoring Device (p203)** Samba Gaye, Jana Catuche, Mehdi Kabir, Jiajun Xu (University of the District of Columbia)	**Thermal Fluid Assessment of Cylinders with Multiple Slots in Aligned Flow (p129)** Sultan Alshareef, Todd Harman, Timothy Ameel (University of Utah)
8:40 AM	**Thermal Characterization of Continuous Pitch Carbon Fiber 3D-Printed using a 6-Axis Robot Arm (p206)** Uday Sinan Olcun, Roger Kempers (York University)	**Layered Unsupervised Learning-based Identification and Quantification of Voids in Package Thermal Interface Materials (p228)** Rahul Lall, Kamal Sikka, Isabel De Sousa (IBM)
9:00 AM	**K-2 Keynote: Thermal Management Challenges for Battery Electric Vehicles** Bel Aire Mark Jennings, Ford Motor Company 	
10:00 AM	**Refreshment Break, Catalina Ballroom**	

DAY 2 SESSIONS: THURSDAY, JUNE 2, 8:00 - 10:00 AM

Speakers' Breakfast, Fairbanks Ballroom

TII-5: Mobile, Telecommunication Systems, And Internet of Things Coronado B	**M-5: Material and Process Characterization of Advanced Electronic Packages I** Point Loma B	**TT-5: Thermal Management of Electric Motors Embedded Electronics for Mobility Applications** Bel Aire North
Session Chairs: *Aastha Uppal (Intel), Columbia Mishra (Industry), Chandra Mohan Jha (Intel Corporation)*	*Session Chairs:* *Vishal Mehta (Auburn University), Jin Yang (Intel)*	Session Chair: *Michael Ohadi (University of Maryland) and Peter De Bock (ARPA-E)*
Thermal Model Simplification of Mobile Device with Adaptive Metamodel of Optimal Prognosis (AMOP) (p210) Yunhyeok Im, Hyungyung Jo, Chigwan Oh, Young-Sang Cho, Jongkyu Yoo, Heeseok Lee (Samsung Electronics), Myunghoon Lee, Vamsi Krishna Yaddanapudi (ANSYS)	**Evolution of Fatigue Reliability of UF-Substrate Interfaces under High Temperature Exposure (p295)** Pradeep Lall, Padmanava Choudhury (Auburn University)	**Integrated Thermal Management For Aviation Class Electric Drive Trains** Jagadeesh Tangudu and Kimberly Saviers (Raytheon Technologies Research Center)
An Advanced Fanless AIoT Smart Edge Gateway with Thickness Thermal Pad Design (p212) Huayong Yuan, Wei Chen (Tencent), Michael King, Aaron Wu, Barry Chen, Clio Chiu, Karen Tseng, Lulu Su, Richard Chang, Ryan Yang, Shoes Leu (Inventec), Allen Liang, Jun Zhang, Haibin Chen, Liang Liu, Danny Kuo, Kunye Zhu, Nishi Ahuja, Qing Qiao, Eric Li (Intel)	**Thermal Stability and Viscoelasticity Behavior of Underfill Encapsulants in Sustained High Temperature Environment up to 1 year (p320)** Pradeep Lall, Yunli Zhang, Jeff Suhling (Auburn University)	**Future of Thermal Management In the World of Electric Aircraft Propulsion** Jonathan R. Felts (Texas A&M University)
The study of Thermosyphon solution for high performance switch (p217) Yaoyin Fan, Peng Xiao, Wei Liu (Celestica) **(virtual)**	**Investigation of Transient Liquid Phase Bonding to Low Temperature Co-Fired Ceramic Substrates (p343)** John Harris, David Huitink (University of Arkansas)	

K-2 Keynote: Thermal Management Challenges for Battery Electric Vehicles

Bel Aire

Mark Jennings, Ford Motor Company

Abstract: In recent years, several key external drivers and technology trends have greatly accelerated the move towards electrification for on road vehicle propulsion. These drivers include societal concerns for climate change, the ongoing push for continuous improvement of air quality, rapid expansion of renewable energy sources and the emergence of vehicle connectivity. In response, Ford has greatly increased its investments in vehicle electrification and is moving aggressively into the development and deployment of battery electric vehicles across its product portfolio. Battery electric propulsion systems feature highly efficient components that present unique thermal management challenges compared with established internal combustion engine propulsion systems. This talk will discuss several of these critical challenges particularly with respect to battery thermal management and related interactions with other subsystems (e.g., cabin climate control) during cold and hot ambient vehicle operation. The associated system design trade-offs and impacts to key vehicle level attributes will be highlighted including the importance to overall vehicle energy management, range and performance. Key differences across the spectrum of vehicle applications and the significant emerging role of vehicle connectivity will also be discussed.

Refreshment Break, Catalina Ballroom

DAY 2 SESSIONS: THURSDAY, JUNE 2, 10:30 – 1:30 PM		
	E-6: Additive Manufacturing 1 Point Loma A	**TI-6: Jet Impingement** Coronado A
	Session Chairs: *David Deisenroth (National Institute of Standards and Technology), Todd Bandhauer (Colorado State U)*	Session Chairs: *Nicholas Jankowski (US Army Research Laboratory), Jay Maddux (US Army Research Laboratory), Darin Sharar (Army Research Laboratory), Travis Mayberry (Raytheon)*
10:30 AM	**Featured Paper Presentation** **Process Development for Fabrication of Copper Additive-Multilayer Circuits with Component Attachment using ECA and LTS (p323)** Pradeep Lall, Jinesh Narangaparambil, Kyle Schulze (Auburn University), Curtis Hill (QuantiTech Inc)	**Featured Paper Presentation** **Flow Visualization of Turbulent Jet Impingement with Engineered Surface Modifications through Particle Image Velocimetry (p192)** Aaron Smith, Sushil Bhavnani, Roy Knight (Auburn University)
11:00 AM	**Prediction of Electrical Performance and Print Geometry for Inkjet Additive Printed Circuits via Statistical Modeling (p288)** Pradeep Lall, Kartik Goyal (Auburn University), Scott Miller (NextFlex Manufacturing Institute)	**Heat Dissipation Characteristics of a Jetting Staggered Microchannel for Cooling a Large-area High-performance SOC Chip (p145)** Tingting Lian, Zhizhen Wang (Xiamen University), Hai Yuan (Xi'an Microelectronics Technology Institute), Yufeng Jin, Wei Wang (Peking University), Shenglin Ma (Xiamen University)
11:20 AM	**Performance of Component Interconnection Methods on Direct Write Additive Silver Circuits (p331)** Pradeep Lall, Jinesh Narangaparambil (Auburn University), Scott Miller (NextFlex National Manufacturing Institute)	**Hotspot Cooling Performance of Two-Phase Confined Jet Impingement Cooling at the Stagnation Zone (p281)** Tanvir Ahmed Chowdhury, Shawn Putnam (University of Central Florida)
11:40 AM		**Analysis of Jet and Cross Flow Interaction with Application in Hotspot Electronics Cooling (p345)** Christian Corvera, Shadi Mahjoob, (California State University Northridge)
12:00 PM	**Luncheon: ITherm Sponsors, Exhibitors, and Partners** Fairbanks Ballroom	

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

TII-6: Automotive, Batteries and Thermal Storage II

Coronado B

Session Chairs:
Krishna Shah (Academia), Jagadeesh Radhakrishnan (Industry), Chandra Mohan Jha (Intel Corporation)

Featured Paper Presentation

Development and Validation of Resistance-Capacitance Model for Phase Change Material Embedded in Porous Media (p135)
Tanjebul Alam, Daniel Bacellar, Jiazhen Ling, Vikrant Aute (University of Maryland)

Transient study of phase change material based hybrid heat sink for electronics cooling application. (p274)
Priyanka Borkar, Vijay Duryodhan (Indian Institute of Technology)
(virtual)

Control of a Hybrid Thermal Management System: A Heuristic Strategy for Charging and Discharging a Latent Thermal Energy Storage Device (p307)
Michael Shanks, Neera Jain (Purdue University)

Performance Characterization of a Novel Low-Cost Additively Manufactured PCM-to-Air Polymer Composite Thermal Energy Storage (p311)
Veeresh Ayyagari, Gargi Kailkhura, Raphael Mandel, Amir Shooshtari, Michael Ohadi (University of Maryland)

M-6: Material and Process Characterization of Advanced Electronic Packages II

Point Loma B

Session Chairs:
Vishal Mehta (Auburn University), Jin Yang (Intel)

Featured Paper Presentation

Development of a Numerical Simulation Model for Predicting the Temperature of a Flip-Chip Package (p183)
Juhyeon Lee, Sung Jin Kim (Korea Advanced Institute of Science and Technology), Bo-Seung Kim (Samsung Electronics)

Permeation of Moisture our of EPDM Rubber Hoses (p222)
Prabjit Singh, Larry Palmer (IBM)

Analysis of process-dependent mechanical properties of sintered copper nanoparticle pillars for the plating-free bumping by finite element method (p303)
Sayuri Kohara, Toyohiro Aoki, Chinami Marushima, Kuniaki Sueoka, Takashi Hisada (IBM Research-Tokyo), Christine Taylor (IBM Corporation)

Characterization of Viscoelastic Behavior of Epoxy Molding Compounds Subjected to Sustained High Temperature Environment up to 1 year (p319)
Pradeep Lall, Yunli Zhang, Jeff Suhling (Auburn University)

P-6: Thermo-Mechanical Reliability Challenges in Power Electronics

Bel Aire North

Moderators:
David Huitink (University of Arkansas) and Przemyslaw Gromala (Robert Bosch GmbH)

Thermo-Mechanical Reliability Challenges in Power Electronics

Abstract: Electrification revolutionizes almost every aspect of our society. To meet these new demands, new materials, new technologies and new innovative cooling solution are within major research and development areas. In addition, artificial intelligence and machine learning will pave the way for new reliability concept such condition-based maintenance. Our Panel will consist of diversity of experts from academia and industry who will share their vision about thermo-mechanical challenges and opportunities in Power electronics. In our panel, we will discuss: Thermal Mechanical Challenges in EV/HEV Power Module, AI-based Reliability Assessment of Power Electronic Systems, and Simulations Solutions for Power Electronics Reliability.

Panelists:
Yong Liu (OnSemi)
Patrick McCluskey (University of Maryland)
H. Alan Mantooth (University of Arkansas)
David Geb (Ansys)
Paul Paret (NREL)

Luncheon: ITherm Sponsors, Exhibitors, and Partners
Fairbanks Ballroom

DAY 2 SESSIONS: THURSDAY, JUNE 2, 1:30 – 3:30 PM		
	E-7: Additive Manufacturing 2 Point Loma A	**TI-7: Component Level Cooling II** Coronado A
	Session Chairs: *Georges Pavlidis (University of Connecticut), Ping-Chuan Wang (State University of New York at New Paltz), Felipe Valenzuela Gaete (Villanova University)*	Session Chairs: *Dishit Parekh (Intel), Omidreza Ghaffari (University of Sherbrooke)*
1:30 PM	**Featured Paper Presentation** **Development of Additive Manufactured Metal Wick Structures for Two-Phase Heat Transfer Applications (p230)** Ahmed Elkholy (York University), Jason Durfee (MAGNA Corporation), Roger Kempers (York University)	**Featured Paper Presentation** **Experimental analysis of heat transfer to shear-thinning viscoelastic coolants for optimizing surface topographies in immersed battery cooling systems (p150)** David Taylor, Leone Fasciati, Tamal Roy, Dimos Poulikakos (ETH Zuerich)
2:00 PM	**Component Attachment to Inkjet Additive Printed Circuits to Achieve Flexible RF Filters using Silver and Copper Nanoparticle Metal Inks (p289)** Pradeep Lall, Kartik Goyal (Auburn University), Scott Miller (NextFlex National Manufacturing Institute)	**Comparative Performance Investigation between Double-layered Wavy and Zig-Zag Microchannel Heatsinks for Effective cooling of Concentrated Photovoltaic cells (p164)** Dinumol Varghese, Fadi Alnaimat, Bobby Mathew (United Arab Emirates University Al Ain)
2:20 PM	**Interaction of Photonic Curing Process Parameters on Additively Printed Copper Circuits (p325)** Pradeep Lall, Jinesh Narangaparambil (Auburn University), Curtis Hill (QuantiTech Inc)	**Comparison between Direct Winding Heat Exchanger and Slot-liner Confined Evaporative Cooling of Electric Motor (p178)** Amitav Tikadar, Yogendra Joshi, Satish Kumar (Georgia Institute of Technology)
2:40 PM	**Intra- and inter-device passive thermal management using solid-solid Nickel Titanium phase change materials (p364)** Darin Sharar (US Army Research Laboratory), Christopher Peters (Raytheon), Kimberly Olver (Fibertek Inc), Adam Wilson, Harvey Tsang (US Army Research Laboratory), David Altman (Raytheon)	**Enhancing Efficiency and Lifetime of Photovoltaic Systems Through Passive Convective Cooling (p278)** Erik Soderholm, Eoin Cotter, David McCloskey (Trinity College Dublin)
3:00 PM	**Refreshment Break, Catalina Ballroom**	

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

TII-7: Cooling Techniques and Heat Exchangers II Coronado B	M-7: Reliability of Electronic Components Under Harsh Environment Point Loma B	TT-7: Future of data center cooling: Waste Heat Reuse and Recovery and Sustainability Bel Aire North
Session Chairs: *Patrick Shamberger (Texas A M), Taravat Khadivi (Meta), Gavin Stanley (Microsoft)*	Session Chairs: *Chongyang Cai (Binghamton University), Jun Zhang (Intel)*	Session Chair: *Dereje Agonafer (University of Texas at Arlington) and Bahgat G. Sammakia (Binghamton University)*
Featured Paper Presentation **Numerical Investigation of Adjustable Air Amplifiers as an Alternative to Fans in Data Centre Servers (p236)** Eoin Oude Essink (Technological University Dublin, Trinity College Dublin, Environmental Research Institute), Tim Persoons (Trinity College Dublin, Environmental Research Institute), Gordon O Brien (Trinity College Dublin), Sajad Alimohammadi (Technological University Dublin, Trinity College Dublin, Environmental Research Institute)	**Featured Paper Presentation** **Qualification of the Samtec SEAM and SEAF connectors for use as a printed circuit board assembly (PCBA) stacking connector in space applications (p252)** Neil Dalal, Nabid Farvez, Kyle Anderson, Allison Orr, Sharon Ling, Ryan Hacala, (Johns Hopkins University)	**Managing Data Center Challenges in the Age of AI** Ali Heydari (Nvidia)
Design of a Microchannel Heat Exchanger for Extreme Environments (MHXEE) (p321) Zhengda Yao, Raphael Mandel, Amir Shooshtari, Hugh Bruck, Michael Ohadi (University of Maryland)	**Optimal thermo-mechanical reliability design of 2.5D lidless package (p270)** Junbo Yang, Chongyang Cai, Pengcheng Yin, Ke Pan, Yangyang Lai, Jing Wang, Seungbae Park, (Binghamton University)	**Liquid Cooling in the Cloud** Husam Alissa (Microsoft)
Impact of Improved Ducting and Chassis Re-design for Air-Cooled Servers in a Data Center (p322) Himanshu Modi, Uschas Chowdhury, Dereje Agonafer (University of Texas At Arlington)	**Size Determination of Voids in the Soldering of Automotive DC/DC-Converters via IR Thermography (p272)** Nils Jahn (Chair), Martin Pfost (Chair of Energy Conversion TU Dortmund University)	**Energy Efficient Computing, Anytime, Anywhere** Peter de Bock (ARPA-E)
	Evaluation of Lifetime of Through-Hole Solder Joints Considering Mounting Process and Variation (p379) Tomohiro Tsuyuki, Qiang Yu, Yuki Ohno, Akihiro Takikawa, Hisataka Fukasu, Kouji Shio (Yokohama National University)	
Refreshment Break, Catalina Ballroom		

DAY 2 SESSIONS: THURSDAY, JUNE 2, 3:30 – 7:00 PM		
	M-8B: Thermal-Mechanical Coupled Design and Characterization Point Loma A	**TI-8: Thermal Modeling and Analysis** Coronado A
	Session Chairs: *Padmanava Choudhury (Auburn University), Jeff Suhling (Auburn University)*	Session Chairs: *Aakrati Jain (IBM), Herman Oprins (Imec)*
3:30 PM	**Featured Paper Presentation** **Impact of FEOL cross-heating on the thermal performance of advanced BEOL (p163)** Melina Lofrano, Bjorn Vermeersch, Herman Oprins, Seongho Park, Zsolt Tokei (Imec)	**Featured Paper Presentation** **Thermal analysis of advanced back-end-of-line structures and the impact of design parameters (p177)** Xinyue Chang, Herman Oprins, Melina Lofrano, Bjorn Vermeersch, Ivan Ciofi, Olalla Varela Pedreira, Zsolt Tokei, Ingrid De Wolf (Imec Leuven Belgium)
4:00 PM	**An Advanced Thermal and Mechanical Design Optimal for High Density Storage Server Reliability (p242)** Shiqiang Zheng, Zhilin Zheng, Hongmei Liu, Weihua Cao, Xin Wang, Jiajun Zhang (Kuaishou Technology), Jun Zhang, Yingqiong Bu, Xingping Ruan, Qing Qiao (Intel)	**Compact thermal modelling of magnetic components via real coded genetic algorithm (p138)** Anshuman Dey (University of British Columbia), Navid Shafiei, Rahul Khandekar (Alpha Technologies Ltd), Wilson Eberle, Ri Li (University Of British Columbia)
4:20 PM	**Reliability Assessment of Cu-Al WB under Automotive Temperatures in Presence of Ionic Contamination and Voltage Bias (p333)** Pradeep Lall, Sungmo Jung (Auburn University)	**Thermal Modeling and Analysis of High Bandwidth Memory in 2.5D Si-interposer Systems (p162)** Taehwan Kim, Jonggyu Lee, Jaechoon Kim, Eung Chang Lee, Heejung Hwang, Youngdeuk Kim, Dan Oh (Samsung Electronics) **(virtual)**
4:40 PM	**Phase Field Simulations of Solder Void Evolution under Thermal Aging (p348)** Chetan Jois, Sudarshan Prasad, Ganesh Subbarayan (Purdue University)	**Digital Twin Modeling and Simulation of the High-frequency Transformer Based on Electromagnetic-thermal Coupling Analysis (p216)** Zhaoxin Wang, Claus Leth Bak, Henrik Sorensen, Filipe Miguel Faria Da Silva, Qian Wang (Aalborg University)
5:00 PM	**Student Poster Networking Session and Reception** Fairbanks Ballroom	

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

TII-8: Liquid Cooling Solutions II

Coronado B

Session Chairs:
Roxana Family (University of Maryland), Betty Archer (Microsoft), Amir Shooshtari (University Of Maryland)

Featured Paper Presentation

Numerical evaluation of bimetallic self-adaptive fins acting as flow disturbing elements inside a microchannel (p266)
Montse Vilarrubi (Universitat de Lleida, Universal Smart Cooling S.L.), Desideri Regany, Francesc X Majos, Manel Ibanez, Joan Ignasi Rosell, Josep Illa, Ferran Badia (Universitat de Lleida), Amrid Amnache, Etienne Leveille, Rajesh Pandiyan (Universite de Sherbrooke), Luc G Frechette (Universite de Sherbrooke, Universal Smart Cooling S.L.), Jerome Barrau (Universitat de Lleida, Universal Smart Cooling S.L.)

Simulation of a Heat Pipe Test Fixture: Laminar, Internal, Forced Convection in a Tubed Cold Plate (p121)
Joshua Smay (Advanced Cooling Technologies)

Pool Boiling Performance of Surfaces Produced by Femtosecond Laser Surface Processing and Copper Hydroxide Nanoneedle Growth (p188)
Justin Costa-Greger (University Of Nebraska-Lincoln), George Damoulakis (University Of Illinois), Graham Kaufman, Suchit Sarin, Chase Pettit, Jeffrey Shield (University Of Nebraska-Lincoln), Constantine Megaridis (University Of Illinois), Craig Zuhlke, George Gogos (University Of Nebraska-Lincoln)

A Novel Cost-Efficient High-Performance Aluminum Cold Plate Solution for Liquid Cooling System (p209)
Xianguang Tan, Li Su, Hongmei Liu, Jiajun Zhang (Kuaishou University), Jun Zhang, Lijuan Feng, Wenbin Tian, Allen Liang, Hang Cheng, Nishi Ahuja, Qing Qiao (Intel)

M-8A: Analysis and Characterization of Crack and Interface Failure II

Point Loma B

Session Chairs:
KE PAN (Binghamton University), SB Park (Binghamton University SUNY)

Featured Paper Presentation

Correlation of Scanning Acoustic Microscopy and Transient Thermal Analysis to Identify Crack Growth in Solder Joints (p255)
Maximilian Schmid, Joseph Hermann , E Liu, Gordon Elger (Technische Hochschule Ingolstadt)

Interfacial Fracture Toughness of EMC/Substrate Interface Under Mode-I Dynamic Loading with Long-Term High Temperature Aging (p286)
Pradeep Lall, Aathi Pandurangan (Auburn University)

Evolution Of Interfacial Properties Under Long Term Isothermal Aging Of PCB/Potting Compound Interfacial Samples Under Pure Mode-I Loading (p287)
Pradeep Lall, Aathi Pandurangan (Auburn University), Ken Blecker (US Army CCDC-AC)

Influence of Sustained High Temperature Exposure on the Interface Bond Strength between TIM-Copper Substrates (p296)
Pradeep Lall, Padmanava Choudhury (Auburn University)

P-8: Advances in Two-Phase Cooling of Electronics

Bel Aire North

Moderator:
John R. Thome (JJ Cooling Sàrl)

Advances in Two-Phase Cooling of Electronics

Abstract: Two-phase cooling is a game-changing reality as for higher power electronics and energy-savings for data centers, power electronics, Edge computing, automotive electronics, batteries, aerospace, 5G telecom, satellites and other industries, including full electronic racks. This includes both pumped and passive cooling systems. Passive cooling includes both thermosyphons and pulsating heat pipes. As an example, new two-phase loop thermosyphon air-cooled heat sinks are available for higher heat duties and lower fan power consumption in 2U servers. New two-phase simulation/design tools have been validated and described in publications. These new novel solutions are on the table to significantly save cooling electrical energy consumption with respect to current technologies. The panel will cover these topics as well as how two-phase cooling fits into the overall scheme of industry-wide developments.

Panelists:
Jackson Marcinichen (JJ Cooling Innovation)
Peter de Bock (ARPA-e/DOE)
Scott Holland (Wieland Microcool)
Justin Weibel (Purdue University)

Student Poster Networking Session and Reception

Fairbanks Ballroom

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, JUNE 3, 7:00 - 10:30 AM

7:00 AM	**Speakers' Breakfast, Fairbanks Ballroom**	
	E-9: Reliability Physics Point Loma A	**TI-9: Component Level Cooling III** Coronado A
	Session Chairs: *Patrick McCluskey (University of Maryland College Park), Brian Donovan (United States Naval Academy)*	Session Chairs: *Adam Wilson (Army Research Laboratory), Travis Mayberry (Raytheon), Darin Sharar (Army Research Laboratory), Todd Bandhauer (Colorado State University)*
8:00 AM	**Analysis of temperature variation influence on damping coefficient and Q-factor of 2-DOF vibratory rotational velocity sensor (p251)** Jacek Nazdrowicz, Mariusz Jankowski, Adam Stawinski, Andrzej Napieralski (Lodz University of Technology)	**Thermoelectrics with Distributed Transport Properties for Higher SWAP-C Electronic Deep Cooling and Thermal Management. (p118)** Doug Crane, Bob Madigan, Lon Bell (DTP Thermoelectrics)
8:20 AM	**Reliability Characterization and Modeling of Flexible LCO battery Under Flexing and Calendar Aging for SOH degradation analysis (p291)** Pradeep Lall, Hyesoo Jang (Auburn University), Scott Miller (NextFlex National Manufacturing Institute)	
8:40 AM	**SOH Degradation of Curved and Flat Li-ion Thin Flexible Batteries Subjected to Flex-to-Install Testing at Various Fold Diameters (p312)** Pradeep Lall, Ved Soni (Auburn University)	**Natural Convection Heat Transfer Enhancement using Functionalized Nanodiamonds in Transformer Oil (p237)** Vinit Prabhu, Ethan Languri (Tennessee Tech University), Jim Davidson, David Kerns (International Femtoscience Inc), Lino Costa (University of Tennessee Space Institute), Glenn Wilson (Southern Company)
9:00 AM	**K-3 Keynote: Hyperdimensional Computing System Design & Thermal Management** Bel Aire Tajana Šimunić Rosing, University of California, San Diego 	
10:00 AM	**Refreshment Break, Catalina Ballroom**	

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

Speakers' Breakfast, Fairbanks Ballroom

TII-9: Data Center Thermal Management Coronado B	**M-9: Artificial Intelligence/ Machining Leaning Application to Electronic Packaging** Point Loma B	**TT-9: Thermal-Mechanical Challenges in Wearables** Bel Aire North
Session Chairs: *Arjang Shahriari (Qualcomm), Kanan Pujara (Intel Corporation), Amir Shooshtari (University of Maryland)*	Session Chairs: *Jinesh Narangaparambil (Auburn University), Karsten Meier (Technische Universitaet Dresden)*	Session Chair: *Naveenan Thiagarajan (GE Research, US)*
IT Equipment Cooling Assessment and Metrics (p131) James VanGilder, Wei Tian, Michael Condor (Schneider Electric)	**Parametric Study of The Geometry Design of Through-silicon Via in Silicon Interposer (p231)** Ke Pan, Yangyang Lai, Jiefeng Xu, Pengcheng Yin, Jonghwan Ha, Chongyang Cai, Junbo Yang, Seungbae Park (Binghamton University)	**Engineering Wearable Materials for Thermal Challenges** Amy Marconnet (Purdue University)
Multiphysics Thermal-Acoustics Modeling of a Server in a Data Center (p140) Pranay Nagrani, Arshad Alfoqaha, Dustin Demetriou, Seth Bard (IBM)	**Effect of High and Low Storage Temperatures, Storage Duration and Varying Depth of Discharge on Coin Cell SOH Degradation (p310)** Pradeep Lall, Ved Soni (Auburn University), Guneet Sethi, Kok Yiang (Amazon Lab 126)	**Semiconductor Packaging Challenges for Automotive Applications** Pradeep Lall (Auburn University)
An Advanced Cold Plate Liquid Cooling Rack Design for Hyperscale Data Center (p240) Yuehlin Tsai, Guilin Wang, Yuehong Jin, Sheng Li, Wenyi Fang, Guofeng Chen, Kai Wang (JD.COM Technology), Jun Zhang, Yuehong Fan, Yuyang Xia, Wenbin Tian, Hang Cheng, Xingping Ruan, Hongxing Zhou, Nishi Ahuja, Qing Qiao (Intel Corporation)	**Remaining Useful Life Estimation using a combined Physics of Failure and Deep Learning-based approach on SAC305 Solder PCBs Subjected to Thermo-Mechanical Vibration Loads (p314)** Pradeep Lall, Tony Thomas, Jeff Suhling (Auburn University), Ken Blecker (US Army CCDC-AC)	

K-3 Keynote: Hyperdimensional Computing System Design & Thermal Management

Bel Aire

Tajana Šimunić Rosing, University of California, San Diego

Abstract: In today's world technological advances are continually creating more data than what we can cope with. Much of data processing will need to run at least partly on devices at the edge of the internet, but training state of the art neural networks at the edge is too costly. Hyperdimensional (HD) computing is a class of light-weight learning algorithms that is motivated by the observation that the human brain operates on a lot of data in parallel. HD computing uses high dimensional random vectors (e.g., ~10,000 bits) to represent data, making the model robust to noise and HW faults. It uses search, along with three base operations: permutation, addition (or bundling/consensus sum) and multiplication (circular convolution / XOR). Addition allows us to represent sets, multiplication expresses conjunctive variable binding, and permutation enables encoding of causation and time series. Hypervectors are compositional - they enable computation in superposition, unlike standard neural representations. Systems that use HD computing to learn can be accelerated directly in memory and storage and have been shown to be accurate, fast and very energy efficient. Most importantly, such systems can explain how they made decisions, resulting in devices that can learn directly from the data they obtain without the need for the cloud. In this talk I will present some of my team's recent work on hyperdimensional computing theory, software and hardware infrastructure, including: i) novel algorithms supporting key cognitive computations in high-dimensional space such as classification, clustering, regression and others, ii) hardware acceleration of HD computing on GPUs, FPGAs, in memory and storage, along with software infrastructure to support it, iii) thermal management strategies to address thermal issues that arise when learning algorithms, such as HD computing, are accelerated in memory and storage.

Refreshment Break, Catalina Ballroom

DAY 3 SESSIONS: FRIDAY, JUNE 3, 10:30 – 1:30 PM		
	E-10: Multi-Phase Heat Transfer Point Loma A	**TI-10: Two Phase Cooling** Coronado A
	Session Chairs: *Solomon Adera (University of Michigan), Douglas Hopkins (North Carolina State University), Mark Schultz (IBM), Jorge Padilla (Google), Sadegh Khalili (IBM)*	Session Chairs: *Todd Bandhauer (Colorado State U), Caleb Anderson (Colorado State), Darin Sharar (Army Research Laboratory)*
10:30 AM	**Featured Paper Presentation** **The Effect of Fin Array Height and Spacing on Heat Transfer Performance during Pool Boiling from Extended Surfaces (p124)** Maureen Winter, Justin Weibel (Purdue University)	**Featured Paper Presentation** **Hollow Micropillar Evaporator for Cooling Wide Bandgap Silicon Carbide Power Converters (p378)** Vivek Manepalli, Kidus Guye, Erdong Song, Alex Dutton, Daniel Luberda, Quan Chau, Yousof Nayfeh (Washington University in Saint Louis), Troy Beechner (RCT Systems), Sean Hoenig, Michael Ellis (Advanced Cooling Technologies), Damena Agonafer (Washington University in Saint Louis)
11:00 AM	**Exploring the Design Features of Wettability-Patterned Surfaces for Condensation Heat Transfer (p122)** Mohamad Jafari Gukeh, George Damoulakis, Constantine Megaridis (University of Illinois at Chicago)	**Study of the Impact of the Airflow and Filling Ratio on the Thermal Performances of a Two-Phase Immersion Cooling Prototype (p170)** Omidreza Ghaffari, Chady Al Sayed, Manuel Vincent (Universite De Sherbrooke), Francis Grenier, Simon Jasmin (Systemex Energies Inc), Luc Frechette, Julien Sylvestre (Universite De Sherbrooke)
11:20 AM	**Numerical Analysis of Passive Manifold Microchannel Heat Exchanger Enhancements (p207)** Daniel Jovin, Jun Jie Harrison Hui, Kim Tiow Ooi (Nanyang Technological University	**Comparison of R-1233zd and HFE-7000 Condenser Performance in Pumped Two-Phase Cooling Systems (p186)** Aaditya Pegallapati, Nitin Karwa (Honeywell International Inc)
11:40 AM	**Exhibitor Talk** **Unique and useful TGPs: thin, light, foldable, high power, or super large** Y. C. Lee (Kelvin Thermal Technologies Inc.)	**Two-phase modeling for porous microchannel evaporators (p219)** Johannes Kohler Mendizabal, Raffaele Luca Amalfi, Ryan Enright (Nokia Bell Labs)
12:00 PM	**Luncheon: ITherm Awards & Organizer Recognitions** Fairbanks Ballroom	

DAY 3 SESSIONS: FRIDAY, JUNE 3, 10:30 – 1:30 PM

TII-10: Thermal Management in Electric Aircraft

Coronado B

Session Chairs:
Martinus Arie (Amazon), Amir Shooshtari, Farah Singer (University of Maryland)

Featured Paper Presentation

Evaporative Cooling of High Power Density Motors: Design and Analysis (p107)
Ryan Smith, Amitav Tikadar, Satish Kumar, Yogendra Joshi (Georgia Institute Of Technology)

Optimization of Hydrogen Generator for UAVs (p227)
Christopher Barrow (University of Kentucky), Geo Jong Kim (Korea Research Institute of Chemical Technology), Cutler Phillippe (University Of Illinois Urbana-Champaign), John Maddox, Hyun Tae Hwang (University Of Kentucky)

In-slot Cooling Channel for High Power Density Electric Motor with Encapsulation Channels (p306)
Zhaoxi Yao, Raphael Mandel, Patrick McCluskey (University Of Maryland)

Thermal Management Performance of an Additively Manufactured Jet Impingement Cooler for Power Electronics (p362)
Reece Whitt, David Huitink (University of Arkansas)

M-10: BGA Package Machanical Properties and Reliability I

Point Loma B

Session Chairs:
Kartik Goyal (Auburn University), Abhishek Deshpande (Qualcomm Technologies)

Featured Paper Presentation

Assembly Reliability of eWLP, Die-, and Die-Size BGAs (p148)
Reza Ghaffarian (JPL-NASA)

Thermal and Mechanical Lid Design for a Multi-Chip Modular Flip-Chip Package (p166)
Javed Shaikh, Krishnendu Saha, Stephan Stoeckl, Eng Huat Goh (Intel Corporation) **(virtual)**

Copper Trace Failures in Ball Grid Array (BGA) Packages under Sequential Harmonic Vibration and Temperature Cycling (p223)
Abhishek Deshpande, Idowu Olatunji, Manuel Bascolo, Abhijit Dasgupta (Center for Advanced Life-Cycle Engineering University of Maryland), Ulrich Becker, Gabor Jokai (Robert Bosch GmbH)

Effect of Thermal Mechanical Solutions on Solder Joint Reliability of Bare-Die BGA with Substrate Stiffener (p301)
Phil Geng (Intel Corporation)

P-10: Thermal Challenges of Transient Loads for Defense Applications

Bel Aire North

Moderator:
Mark S. Spector (Office of Naval Research)

Thermal Challenges of Transient Loads for Defense Applications

Abstract: Modern land, sea, and air warfare technologies are trending towards significantly higher power loads with highly dynamic behavior that present unique challenges in thermal system design. Traditional design approaches assume steady state operation and rely on overdesign to meet worst-case scenarios. Therefore, tremendous opportunities exist to reduce the size, weight and power consumed by thermal management systems associated with these loads. This panel will discuss recent progress on innovative components, dynamic modeling tools, and advanced control strategies to address these challenges.

Panelists:
Todd Bandhauer (Colorado State University)
Partick Shamberger (Texas A&M University)
Neera Jain (Purdue University)
Michael Fish (Army Reserch Lab)
Kevin McCarthy (PC Krause and Associates)

Luncheon: ITherm Awards & Organizer Recognitions
Fairbanks Ballroom

DAY 3 SESSIONS: FRIDAY, JUNE 3, 1:30 – 3:30 PM		
	M-11B: Lead Free Solder Characterization and Reliability I Point Loma A	**TI-11: Heat Pipes and Vapor Chambers I** Coronado A
	Session Chairs: *Reza Ghaffarian (Jet Propulsion Laboratory), Phil Geng (Intel Corporation)*	Session Chairs: *K Matsumoto (IBM), Ankur Miglani (IIT Indore), Chirag Kaharangate (Case Western Reserve University)*
1:30 PM	**Featured Paper Presentation** **Effect of Evolution of High Strain Rate Properties on Plastic-Work of SAC305 Alloy with 100℃ Aging for Periods up to 240-days (p294)** Pradeep Lall, Vishal Mehta, Jeff Suhling (Auburn University), Ken Blecker (US Army CCDC-AC)	**Featured Paper Presentation** **Vapor-Chamber Performance Evaluation: The Challenge of Impartial Cross-Platform Comparison (p116)** George Damoulakis, Mohamad Jafari Gukeh, Constantine M Megaridis (University of Illinois at Chicago)
2:00 PM	**Effect of Prolonged Storage on High strain rate Mechanical properties of QSAC10 and QSAC20 Solders after Exposure to Isothermal Aging of 50C (p299)** Pradeep Lall, Mrinmoy Saha, Jeff Suhling (Auburn University)	**Heatpipe Thermal Performance in Heatpipe Heatsink (p139)** Yuanchen Hu, Milnes David, John Madalengoitia (IBM)
2:20 PM	**Evolution of High-Temperature and Low-Temperature High Strain Rate Properties of SAC-R Solder after Sustained Exposure to 50°C (p300)** Pradeep Lall, Mrinmoy Saha, Jeff Suhling (Auburn University), Ken Blecker (US Army CCDC-AC)	**Design and Thermal Performance Testing of a Vapor Chamber Containing a Wettability Patterned Condenser for High-Heat Flux Applications (P146)** Anant Kumar Yadav, Nagesh Devidas Patil (Indian Institute of Technology Bhilai) **(virtual)**
2:40 PM	**Fatigue and Shear Properties of Novel Lead-free Solder Joints with Low Melting Temperature (p370)** Xin Wei, Mohamed El Amine Belhadi , Palash Pranav Vyas (Auburn University), A R Nazmus Sakib (NXP Semiconductors), SaD Hamasha, Haneen Ali (Auburn University)	**A Novel One-Step Process to Fabricate A Polymeric Thermal Ground Planes (p191)** Doriane Hassaine Daoudji, Samaneh Karami, Etienne Leveille, Amrid Amnache, Anthony Ouellet, Mahmood Salim Shirazy, Luc FreChette (University of Sherbrooke)
3:00 PM	**Refreshment Break, Catalina Ballroom**	

DAY 3 SESSIONS: FRIDAY, JUNE 3, 1:30 – 3:30 PM

TII-11: Advanced Modeling of Thermal Systems Coronado B	M-11A: BGA Package Mechanical Properties and Reliability II Point Loma B	TT-11: Stacked Dies Thermal Management Bel Aire North
Session Chairs: *Ameya Limaye (Intel Corporation), Anali Soto (Industry), Chandra Mohan Jha (Intel Corporation)*	Session Chairs: *Kartik Goyal (Auburn University), Abhishek Deshpande (Qualcomm Technologies)*	Session Chairs: *Madhusudan Iyengar (Google) and Weihua Tang (Intel)*
Featured Paper Presentation **Package Level Thermal Analysis of Backside Power Delivery Network (BS-PDN) Configurations (p257)** Herman Oprins, Jose Luis Ramirez , Bjorn Vermeersch , Geert Van Der Plas , Eric Beyne (Imec)	**Featured Paper Presentation** **Influence of Component Interconnect with Printed Copper Circuits on Realized Mechanical and Electrical Characteristics in FHE Applications (p324)** Pradeep Lall, Jinesh Narangaparambil (Auburn University), Scott Miller (NextFlex National Manufacturing Institute)	**Thermal Impact of 3D Technology Options** Herman Oprins (Imec)
From 2.5D to 3D Chiplet Systems: Investigation of Thermal Implications with HotSpot 7.0 (p184) Jun-Han Han (University of Virginia), Xinfei Guo (Shanghai Jiao Tong University), Kevin Skadron, Mircea Stan (University of Virginia)	**Non-Intrusive Two-Way Coupling for Multiscale Analysis of Electronic Packages (p328)** Sai Sanjit Ganti, Yaxiong Chen, Ganesh Subbarayan (Purdue University)	**Prospective of Thermal Design: How to Minimize Thermal Resistance in 3D System** Hiroyuki Ryoson (Dexerials Corporation)
Development of a Graph-based Modeling Framework for Transient Exergy Analysis (p360) Andrew Manion (Purdue University), William Malatesta (Naval Air Systems Command Power and Energy Division), Neera Jain (Purdue University)	**Modeling Effect of Underfill Property Evolution on the FCBGA Reliability at Sustained Automotive Underhood Temperatures (p332)** Pradeep Lall, Madhu Kasturi, Haotian Wu, Jeff Suhling, Edward Davis (Auburn University)	**Bioinspired Evaporative Cooling for High-Powered Heterogenous Integrated Chips** Damena Agonafer (Washington University)
Thermal analysis of boiling pot with single coil induction cooker (p363) Chia-Wei Lin, Hsueh-Che Liu, Hua-Yi Hsu, Yu-Lun Chang (National Taipei University of Technology), Yu-Chen Lin (Purdue University), Ying-Yuan Chen, Chun-Wei Lin (Delta, Inc.) Ming-Shi Huang, Hua-Yi Hsu (National Taipei University of Technology)	**Drop Shock Performance of SAC-Bi Alloys Compared to SnPb (p371)** Palash Vyas, Mohamed El Amine Belhadi , Xin Wei, Ehab Hamasha, Abdallah Alakayleh, Arvind Srinivasan, Raj Kiran Akula, Sad Hamasha, Jeff Suhling, Pradeep Lall (Auburn Unversity)	
Refreshment Break, Catalina Ballroom		

DAY 3 SESSIONS: FRIDAY, JUNE 3, 3:00 – 4:30 PM		
	TI-12: Heat Pipes and Vapor Chambers II Coronado A	**TII-12: Liquid Cooling Solutions III** Coronado B
	Session Chairs: *Risa Miyazawa (IBM), Chirag Kharangate (Case Western Reserve University)*	Session Chairs: *Patrick Shamberger (Texas A & M), Betty Archer (Microsoft), Roxana Family (University of Maryland)*
3:00 PM	**Featured Paper Presentation** **Design Optimization of an Aluminum-Pentane Grooved Heat Pipe Embedded in a Device Wall (p125)** Samet Saygan, Emre Esen, Yigit Akkus (ASELSAN Inc)	**Featured Paper Presentation** **Two-phase thermofluidic modeling and validation of a multi-zone microchannel evaporator (p182)** Qianying Wu (Nokia Bell Labs and Stanford University), Todd Salamon (Nokia Bell Labs)
3:30 PM	**Hybrid Vapor Chamber-based Cooling System for Power Electronics (p114)** George Damoulakis, Congbo Bao, Mohamad Jafari Gukeh, Arani Mukhopadhyay, Sudip K Mazumder, Constantine M Megaridis (University of Illinois at Chicago)	**Thermal Management of Two-Sided Heat Load on a Cold Plate Considering the Friction Stir Welding Process (p120)** Murat Parlak, Ergun ORS, Vedat YAGCI (Aselsan)
3:50 PM	**Channel Design to Effectively Increase Oscillation Amplitude in Micro-pulsating Heat Pipes (p179)** Chuljae Jung, Sung Jin Kim (KAIST)	**Pool Boiling Heat Transfer Enhancement Using Femtosecond Laser Surface Processed Aluminum in Saturated PF-5060 (p187)** Justin Costa-Greger, Logan Pettit, Andrew Reicks, Suchit Sarin, Chase Pettit , Jeffrey Shield , Craig Zuhlke , George Gogos (University of Nebraska-Lincoln)
4:10 PM	**Air-cooled closed loop thermosyphon cooling system experimental campaign: effects of working fluid, heat load and air flow rate (p256)** Enzo Minazzo, Gautier Rouaze, Jackson Marcinichen, John Thome (JJ Cooling Innovation SARL), Winston Zhang (Novark Technologies)	

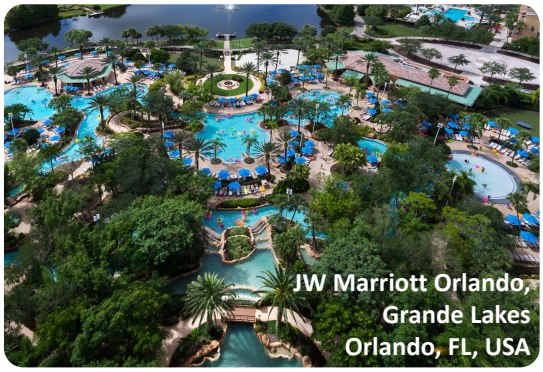
DAY 3 SESSIONS: FRIDAY, JUNE 3, 3:00 – 4:30 PM	
M-12A: Lead Free Solder Characterization and Reliability II Point Loma B	**M-12B: Mechanics and FEA Of Integrated Electronic Packages** Point Loma A
Session Chairs: *Reza Ghaffarian (Jet Propulsion Laboratory), Phil Geng (Intel Corporation)*	Session Chairs: *John Harris (University of Arkansas), Pradeep Lall (Auburn University)*
Featured Paper Presentation **Evolution of the Creep Behavior for SAC305 Lead Free Solder Exposed to Various Thermal Profiles (p373)** S M Kamrul Hasan, Mohammad Al Ahsan, Jeffrey Suhling, Pradeep Lall (Auburn University)	**Featured Paper Presentation** **Damage Progression in Electronic Molding Compounds under Sustained High Temperature for up to 1 year in Automotive Underhood Environments (p317)** Pradeep Lall, Yunli Zhang (Auburn University)
Indentation Creep Properties Evolution of Lead-free Solder Joints Subjected to Thermal Cycling (p374) Mohamed El Amine Belhadi, Xin Wei, Xin Wei, Qais Qasaimeh, Palash Pranav Vyas, Rong Zhao, Ehab Hamasha, Duha Ali, Jeff Suhling, Sa'd Hamasha, Pradeep Lall, Haneen Ali, Barton Prorok (Auburn University)	**Finite Element Modeling Strategies for Studying Mechanical Design Tradeoffs in Heterogeneously Integrated Packages (p357)** David Halbrooks, Ganesh Subbarayan (Purdue University), Huayan Wang, Gamal Rafai-Ahmed, Suresh Ramalingam (Xilinx Inc)
Mechanical Behavior and Microstructure Evolution in SAC+Bi Lead Free Solders Subjected to Mechanical Cycling (p375) Mohammad Ashraful Haq, Mohd Aminul Hoque, Jeffrey Suhling, Pradeep Lall (Auburn University)	**Performance analysis of the analog path of Read-Out Integrated Circuit for MEMS structures under temperature variation. (p359)** Mariusz Jankowski, Jacek Nazdrowicz, Andrzej Napieralski (Lodz University of Technology)

NOTES

Abstracts Due: September 4, 2022

ITherm ORLANDO, FL 2023

May 30 – June 2, 2023



22nd Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems

Important Dates

Abstract Deadline:	**Sept. 4, 2022**
Notification of Acceptance:	Oct. 17, 2022
Draft Paper Submission:	Dec. 19, 2022
Reviews Returned:	Feb. 6, 2023
Final Paper Submission:	Mar. 6, 2023

Call for Abstracts

The IEEE ITherm Conference 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 2023 will be a physical conference held along with the 73rd ECTC. Joint ITherm/ECTC registrations will be available at a significant discount. All abstracts are followed by full papers to be peer reviewed and published in the IEEE Xplore ITherm proceedings, with no technical presentation-only submissions. Student first authors will have the opportunity to apply for ITherm travel grants in order to participate in a Student Poster and Networking Session. ITherm 2023 will also feature keynotes by prominent speakers, vendor exhibits, panel discussions, invited technology talks, ECTC/ITherm joint networking events and short courses, an art-in-science exhibition, and a student design competition. Original papers are solicited in the following areas of interest:

Component-Level Thermal Management

- 3D Packaging & Heterogeneous Integration
- Package-Integrated Thermal Management
- 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, Photovoltaics, and Optoelectronics
- Thermal Management of Electric Machines
- Pulsed Power Dissipation

Mechanics & Reliability

- Thermo-Mechanical Modeling and Simulation
- Mechanics and Reliability of Solder Joints and Interconnects
- Materials Characterization, Processing, and 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

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
- Thermal Management in Electric Aircraft
- Modeling of Complex Thermal Systems
- Next-Gen Electronics Systems Co-Design

Emerging Technologies and Fundamentals

- Boiling, Evaporation, and Condensation
- Convection in Microchannels, Microgaps, and Jets
- Pulsating / Oscillating and Non-Conventional Heat Pipes
- Nanoscale and Transistor-Level Thermal Transport
- Novel Materials and Fabrication Techniques
- Measurement and Diagnostic Techniques
- Numerical Methods, Nano-to-Macro Scale
- Experimental Methods, Nano-to-Macro Scale
- Prognostic Health Management and Reliability Analysis
- Wearable, Flexible, and Printed Electronics
- Additive Manufacturing
- Silicon Fabrication for Thermal Management Devices
- Predictive Analytics and Machine Learning

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Program Inquiries To:
Dr. Ashish Gupta, Program Chair, ashish.x.gupta@intel.com
Prof. Amy Marconnet, Vice Program Chair, amy.marconnet.itherm@gmail.com

Prof. Satish Kumar, General Chair, satish.kumar@me.gatech.edu
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CONFERENCE PROGRAM OVERVIEW

ITherm 2022: Program Overview

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 31, 2022												
	ECTC/ITherm Joint Professional Development Courses (PDC)				Luncheon for PDC Course Attendees	ECTC/ITherm Joint Professional Development Courses (PDC)				ECTC/ITherm Young Professionals Networking Panel 5:30 - 7:00 PM		EPS President's Panel 7:30 - 9:00 PM
	ECTC / ITherm Heterogeneous Integration Roadmap Workshop											
Day-1: Wednesday, June 1, 2022												
Speakers' Breakfast	E-1	K-1 Keynote	Coffee Break	E-2	Luncheon Richard Chu ITherm Award Presentation	E-3	Coffee Break	E-4	Student Heat Sink Design Challenge	ITherm Executive Committee		ASME K-16 and Journal of Electronic Packaging 7:30 - 9:00 pm
	TI-1A			TI-2		TI-3		TI-4		ECTC / ITherm Diversity Panel		
	TII-1			TII-2		TII-3		TII-4				
	M-1			M-2		M-3		M-4				
	TI-1B			P-2		TT-3		P-4				
	ITherm Sponsors & Exhibits					ITherm Sponsors & Exhibits						
Day-2: Thursday, June 2, 2022												
Speakers' Breakfast	E-5	K-2 Keynote	Coffee Break	E-6	Luncheon ITherm Sponsors and Partners	E-7	Coffee Break	M-8B	Student Poster Networking Session and Reception 5:00 - 7:00	ITherm 2023 Program Planning 7:00 - 8:00		ITherm Organizers' Dinner (by Invitation)
	TI-5			TI-6		TI-7		TI-8				
	TII-5			TII-6		TII-7		TII-8				
	M-5			M-6		M-7		M-8A				
	TT-5			P-6		TT-7		P-8				
	ITherm Sponsors & Exhibits					ITherm Sponsors & Exhibits						
Day-3: Friday, June 3, 2022												
Speakers' Breakfast	E-9	K-3 Keynote	Coffee Break	E-10	Luncheon ITherm Best Paper Awards & Organizer Recognitions	M-11B	3:00 - 4:30					
	TI-9			TI-10		TI-11	TI-12					
	TII-9			TII-10		TII-11	TII-12					
	M-9			M-10		M-11A	M-12A					
	TT-9			P-10		TT-11	M-12B					
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Emerging	Tech Talk
Thermal I	Panel
Thermal II	Meeting
Mechanics	Meal
Keynote	Special Event
PDC	**Legend**

ITherm SAN DIEGO, CA 2022