Final Conference Program

The 20th Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems

ITherm

VIRTUAL

2021

Live Virtual Events
June 1 – 4, 2021

Sponsored by the IEEE's Electronics Packaging Society (EPS), ITherm 2021 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. In addition to on-demand paper presentations made available until July 6, 2021, ITherm 2021 Virtual has live keynote presentations by prominent speakers, the Richard Chu ITherm award presentation, panel discussions, invited tech talks, student poster and networking, student heat sink, and student overclocking competitions. Registered attendees will be able to join live each day of the conference for one-time plenary events with options to interact with the presenters starting at 10:30 AM Eastern Daylight Time (EDT). An Exhibitor forum will allow participants to interact and to learn about the latest in thermal and thermal-mechanical technologies.

LIVE VIRTUAL EVENTS (JUNE 1 – 4, 2021)

- **3 Keynote Talks** covering the areas of computing and the environment, 5G and new challenges for our communication networks, and engineering lessons for the future
- **Richard Chu ITherm Award and Seminar**
- **3 Technology-Talks** providing deep dive talks on high profile topics
- **4 Panels** discussing the latest industry challenges and trends
- 38 Student Posters showcasing the latest research in an interactive networking environment using Gather
- **Student Heat Sink Design Challenge**
- **Student Overlocking Competition**
- Announcement of the **ITherm 2021 Awards**

ON-DEMAND CONTENT (JUNE 1 - JULY 6, 2021)

- **Access to over 150 Technical Papers and On-Demand Presentations** organized across four Technical Tracks
- **ECTC/ITherm Joint Diversity Panel**
- **14 Professional Development Courses** offered as a collaboration with ECTC
- **Heterogeneous Integration Roadmap** virtual workshop

PARTNER CONFERENCES

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WELCOME LETTER

On behalf of the organizing committee, it is our great pleasure to welcome you to ITherm 2021, the leading international conference for scientific and engineering exploration of thermal, thermo-mechanical and emerging technology issues associated with electronic devices, packages, and systems. ITherm 2021 will again be held virtually this year and taking our learnings from converting from an in-person to virtual event last year, we are very pleased to offer a program with significant expansion of live elements on a new, engaging virtual platform. ITherm 2021 Virtual is packed with live events spanning the entire conference. Join us at 10:30 AM Eastern each day on June 1 - 4 for daily live events including: 3 Keynote Talks covering the areas of computing and the environment, 5G and new challenges for our communication networks, and engineering lessons for the future; an Invited Presentation by the recipient of the Richard Chu ITherm Award for Excellence; 4 Panel Sessions that will allow for live interaction with topical experts; and 3 Technology-Talk sessions providing deep dive talks on high profile topics. As part of this live program, we are very pleased to bring back our Student Poster and Networking Session via the platform Gather, where you can interact in real-time conversations with student authors of 35+ posters. Also returning is the joint ASME K-16 / IEEE EPS Student Design Challenge (sponsored by GE) and a new rendition of the IEEE EPS Student Overclocking Competition.

In addition to the live program, a wealth of pre-recorded content will be available to registered attendees from June 1 – July 6, including over 150 technical papers across 4 Technical Tracks and a joint ECTC/ITherm Diversity Panel with the theme *diversity does matter and can drive enhanced business performance*. All ITherm 2021 Virtual registrants will also have access to the recording of the Heterogeneous Integration Roadmap Workshop held as part of the 71st ECTC Virtual Event. Lastly, a set of 14 Professional Development Courses are being offered as a collaboration between ITherm and ECTC conferences, with separate registration through the ECTC website.

Our sincerest thanks to everyone who has contributed in any way to the launch of ITherm 2021. In navigating the uncertainty of the conference mode, we recognize that we asked many of you to prepare for two ITherm conferences in a year where taking any morsel of time for service would have been deeply appreciated. We could not have brought you this conference, of which we are together so proud, without the help of every contributor who is listed in this program. In particular, we would like to recognize our track chairs and co-chairs, tech talk and panel session organizers, and student session organizers, to name a few. We are especially thankful this year for the guidance of our Executive Committee. Last but not least, our thanks go out to each of this year's sponsors and exhibitors for the critical role their support provides to ITherm.

Thank you for participating in the ITherm 2021 Virtual conference and making it possible by your virtual attendance. Whether this is your first time or if you attended before, we hope that you will leverage this this year's virtual conference platform to interact with your fellow attendees using the features available and connect with them through the ITherm LinkedIn group. We are fully committed to hosting ITherm 2022 as an in-person event from May 31 - June 3, 2022. Please join us for the ITherm 2022 Program Planning meeting (open to all) to volunteer. Like never before do we appreciate the camaraderie of this community and are eager to see you all again soon.

Justin A. Weibel
General Chair

Dustin W. Demetriou
Program Chair

Satish Kumar
Vice Program Chair

Ashish Gupta
Communications Chair

LIVE PROGRAM SCHEDULE

All Times EDT	Day 1 Tue, June 1	Day 2 Wed, June 2	Day 3 Thurs, June 3	Day 4 Fri, June 4
10:30 - 11:30	**Keynote 1** Jon Koomey Koomey Analytics *That Does not Compute: Facts and Fiction about Computing and the Environment*	**Keynote 2** Theodore (Tod) Sizer Nokia Bell Labs *COVID-19 and 5G: The Lasting Impact and New Challenges for our Communication Networks*	**Keynote 3** Jayathi Murthy UCLA *Engineering in the Time of Corona: Some Lessons for the Future*	**Richard Chu ITherm Award for Excellence** Cristina Amon University of Toronto *Thermal Management of Lithium-Ion Batteries for Electric Vehicles: a Multiscale Cell-to-Vehicle Hierarchical Perspective*
Break				
11:45 – 12:45	**Panel Session 1** *Thermo/Mechanical Management of Advanced Mobile / Telecom, Wireless, and Computing Devices*	**Panel Session 2** *Model-based Design of Novel Electronic Components and Systems*	**Panel Session 3** *Two-Phase Liquid Cooling Systems for High Power Electronics*	**EPS Overclocking Competition** (11:45 – 12:15) Break **Best Paper Awards Ceremony** (12:30 – 1:00)
Break				
1:00 – 2:00	**Tech Talk Session 1** *Reliability Challenges in Emerging Technologies and Applications*	**Tech Talk Session 2** *Heterogeneous Integration*	**Tech Talk Session 3** *Battery Thermal Management*	End ITherm 2021
Break				
2:15 – 3:15	**Joint ASME K-16 / IEEE EPS Student Heat Sink Competition** *Sponsored by GE*	**Student Poster and Networking Event** *Hosted on the interactive platform Gather*	**Panel Session 4** *Thermal Challenges in Next-Generation Opto-Electronic Systems*	
3:15 – 4:15	End Day 1		End Day 3	
4:30 - 5:30		**ASME K-16 Committee Meeting**		

GENERAL INFORMATION

REGISTRATION

We invite you to register for ITherm 2021 using our online registration page. Registration includes access to all virtual live and on-demand events associated with ITherm 2021 Virtual and an electronic copy of the conference proceedings.

The registration fees for ITherm 2021 Virtual are:

- IEEE Member: $150
- Non-Member: $225
- IEEE Life Member: $75
- Student: $75

Note that the e-mail entered upon registration will be granted access to the live virtual events. Please register at least 24 hours prior to the event to ensure that your access credentials are valid. Registration will remain open through the close of the conference on July 6, 2021.

COMMITTEE MEETINGS

ASME K-16 COMMITTEE

The ASME K-16 Committee meeting will take place on Wednesday June 2, 2021, from 4:30 – 5:30 PM EDT. The meeting is *open to Committee Members and to all interested in becoming involved.* Join the meeting using this link.

ITherm 2022 PROGRAM PLANNING

The ITherm 2022 Program Planning meeting will take place on Monday June 7, 2021, from 11:30 AM – 12:30 PM EDT. *This meeting is open to all current and future contributors.* Join the meeting using this link.

ENGAGEZ VIRTUAL CONFERENCE PLATFORM

We are working with IEEE Meetings, Conference, and Events (MCE) to bring the event to you using the Engagez virtual conference environment. Detailed instructions for navigating the environment can be accessed using this URL. Registered attendees can access Engagez using this URL.

CONFERENCE ATTENDEE AND SPEAKER INTERACTION

The Engagez virtual event environment includes a Social Lounge, allowing registered attendees to interact with other attendees. The Social Lounge allows for both direct messaging and the ability to Book a Meeting using built-in video conferencing. Mechanisms for asking questions during ITherm 2021 Virtual will depend on the event type.

Live Events: Attendees can submit questions directly in the session Q&A window within Engagez.

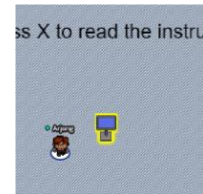
On-demand Sessions: Attendees are encouraged to utilize the Social Lounge to ask questions directly to the authors.

GATHER VIRTUAL POSTER SESSION

The ITherm 2021 student poster and networking event will feature a live and interactive session via the Gather platform which allows multiple people to hold separate conversations in parallel. These instructions are provided to help familiarize you with the platform.

Navigating the Virtual Environment: Use the arrow keys on your keyboard to move your avatar around and interact with poster presenters, other attendees, and objects (e.g., instruction monitor, poster stands, etc.). Once you walk your avatar close to another person, you will be able to communicate with them via voice, video, or chat.

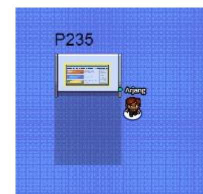
1. When you enter the virtual environment, you can move your avatar around and interact with objects by pressing **X** on your keyboard. Once you join, please read the instruction manual placed next to the reception desk.



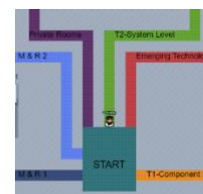
2. At the entrance of each room, there is a board showing the list of all the posters in that specific room. You can walk your avatar close to the board and press **X** to review the list and find the number of your desired poster.

3. You can walk to the reception area where you can find the poster session chairs **(Chair_Mahsa, Chair_Arjang, Chair_Joe).** Chairs will also walk around the environment to help with any inquiries during the session. You can also directly message the Chairs if you have any questions.

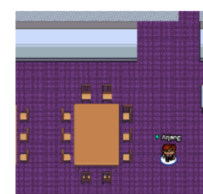
4. In each room, you can move your avatar next to the poster of interest. Poster numbers are provided above the stand. You can press **X** to view the poster. You can communicate with the poster presenter by walking close to their avatars. Once you are in the shaded area, you can have a private conversation with the people inside that area.



5. All rooms and the routes to access them are color-coded to make it more convenient for attendees to navigate throughout the virtual environment Orange: Thermal I – Component Level; Green: Thermal II – System Level; Red: Emerging Technologies; Dark Blue / Light Blue: Mechanics and Reliability; Purple: Private Rooms



6. Aside from the poster rooms and common areas, you can gather in one of the private rooms / desks by moving your avatar to one of the chairs to have an individual or group discussion with access to whiteboards to write/draw.



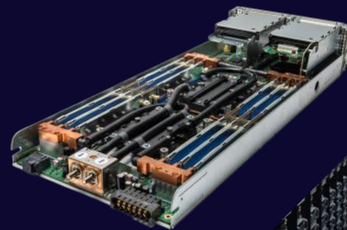
CONFERENCE ORGANIZATION COMMITTEE

General Chair	Justin A. Weibel	Purdue University
Program Chair	Dustin W. Demetriou	IBM Corporation
Vice Program Chair	Satish Kumar	Georgia Institute of Technology
Communications Chair	Ashish Gupta	Intel Corporation
COMPONENT-LEVEL THERMAL MANAGEMENT TRACK		
Chair	Kamal Sikka	IBM Corporation
Co-Chair	Stephanie Allard	IBM Corporation
Co-Chair	Darin Sharar	Army Research Labs
SYSTEM-LEVEL THERMAL MANAGEMENT TRACK		
Chair	Amir H. Shooshtari	University of Maryland
Co-Chair	Patrick Shamberger	Texas A&M University
Co-Chair	Chandra Mohan Jha	Intel Corporation
EMERGING TECHNOLOGIES & FUNDAMENTALS TRACK		
Chair	Amy Marconnet	Purdue University
Co-Chair	Sukwon Choi	Penn State University
Co-Chair	Lauren Boteler	Army Research Labs
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	JJ Cooling Innovation
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	Amy Marconnet	Purdue University
Panels Co-Chair	Przemyslaw Gromala	Bosch
Poster Session & Art-in-Science Chair	Mahsa Ebrahim	Loyola Marymount University
Poster Session Co-Chair	Arjang Shahriari	Qualcomm
Poster Session Co-Chair	Joseph Hanson Vázquez	Intel Corporation
PDC Short Course Chair	Jeffrey Suhling	Auburn University
PDC Short Course Co-Chair	Kitty Pearsall	IBM Corporation
Diversity Panel Representative	Cristina Amon	University of Toronto
Diversity Panel Representative	Amy Fleischer	Cal Poly
EPS/K16 Student Design Competition	Amy Marconnet	Purdue University
EPS/K16 Student Design Competition	Joshua Gess	Oregon State University

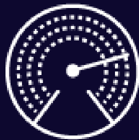
ADMINISTRATIVE		
Administrative Assistant	Damaris David	ITherm
Sponsoring & Exhibitor Chair	Gary B. Kromann	Consultant, Austin, TX
Sponsoring & Exhibitor Co-Chair	Joshua Gess	Oregon State University
Finance Chair	Milnes David	IBM Corporation
Finance Co-Chair	John (Jack) Maddox	University of Kentucky
Operations Chair	Pritish Parida	IBM Research
NSF Interactions Chair	Mahsa Ebrahim	Loyola Marymount University
COMMUNICATION		
Paper Management Database	Sandeep Tonapi	Anveshak
Conference Proceedings Manager	Paul Wesling	ITherm
Technical Program and Design	Dustin Demetriou	IBM Corporation
Technical Program and Design	Satish Kumar	Georgia Institute of Technology
Webmaster	Shashank Thakur	Anveshak
Outreach & Engagement	Vaibhav Bahadur	University of Texas at Austin
Publicity	John (Jack) Maddox	University of Kentucky
Social & Social Media	Farah Singer	ULC Technologies, LLC
AWARD COMMITTEE		
Richard Chu ITherm Award Chair	Sushil Bhavnani	Auburn University
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		
Ambassador	Roger Kempers	York University, Canada
Ambassador	Poh Seng Lee	NUS, Singapore
Ambassador	Mehmet Arik	Ozyegin University, Turkey
Ambassador	Rishi Raj	IIT Patna, India
Ambassador	Ryan Enright	Nokia Bell Labs, Ireland

DIRECT LIQUID COOLING

Trusted for 20 Years



Intel S9200WK Server System



Performance

Facilities peak performance for higher powered or overclocked processors

Efficiency

Significant reduction in data center energy consumption

Density

Enables 100% utilization of rack and data center spaces

Frontera Supercomputer

Patented Split-Flow & Skived Coldplates

A key component of the Server Module, CoolIT Systems Split-Flow & Skived Coldplates. Skiving manufacturing technology is a unique metal forming process widely used in copper and aluminium heat sink construction, and most recently adopted for high-performance liquid cooling coldplate construction.

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

CoolIT coldplates are designed to have an extremely low profile to allow them to fit in 1U applications, yet not compromise performance capabilities.

The CoolIT Systems RX3 is an example of a high-performance coldplate. This coldplate is compatible with the 3rd Gen Intel® Xeon® Scalable Processor (Ice Lake). By supporting the necessary flow rate, this coldplate can reach a thermal resistance of 0.03°C/W or lower for high-density processors such as Ice Lake.

CoolIT RX3 Coldplate

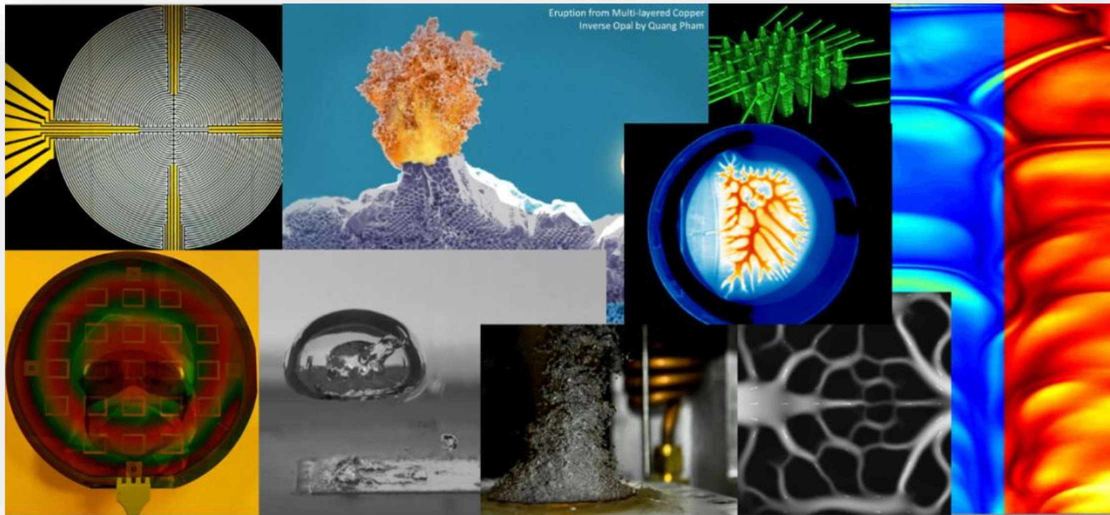
sales@coolitsystems.com
www.coolitsystems.com

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	NUVIA
Madhusudan Iyengar	Google
Yogendra K. Joshi	Georgia Institute of Technology
Gary B. Kromann	Motorola
Tom Lee	Xilinx
Michael Ohadi	University of Maryland
Alfonso Ortega	Villanova University
Koneru Ramakrishna	Thermal Consultant
Bahgat Sammakia	State University of New York at Binghamton
Jeffrey Suhling	Auburn University
Sandeep Tonapi	Anveshak

Collage of Previous Art-in-Science Entries



KEYNOTES

Jon Koomey
Koomey Analytics

Theodore (Tod) Sizer
Nokia Bell Labs

Jayathi Murthy
UCLA

K-1: THAT DOES NOT COMPUTE: FACTS AND FICTION ABOUT COMPUTING AND THE ENVIRONMENT

Presenter: Jonathan Koomey, Koomey Analytics

Tuesday, June 1, 10:30 AM – 11:30 AM EDT

Abstract: Information technology (IT) is critically important for modern society, which is why wild claims about IT engender endless public fascination. Researchers and reporters overestimate IT's electricity use and environmental impact, often by orders of magnitude, and these fake facts ("factoids") then spread wildly as people share them and the media report them. Big mistakes result when people's inherent curiosity about an important area of knowledge collides with a pervasive lack of accurate and up-to-date information. Information technology changes so quickly that most data are obsolete as soon as they are created, and people's inability to grasp the power of exponential change makes things even worse. The fact that the most accurate data are closely held proprietary secrets compounds these problems. Unfortunately, honest research to create accurate information will always trail misinformation, because it's harder and takes longer to get the numbers right. This talk will present well-documented examples of misinformation about IT and the environment and summarize time-honored techniques you can use to avoid being misled in the future.

Jonathan Koomey is a researcher, author, lecturer, and entrepreneur who is one of the leading international experts on the economics of climate solutions and the energy and environmental effects of information technology. Dr. Koomey was a lecturer in Earth Systems, School of Earth, Energy, & Environmental Sciences at Stanford University from November 2016 through June 2018. For more than two decades, he worked at Lawrence Berkeley National Laboratory, and has been a visiting professor at Stanford (2003-4 and Fall 2008), Yale University (Fall 2009), and UC Berkeley's Energy and Resources Group (Fall 2011). He was a lecturer in management at Stanford's Graduate School of Business in Spring 2013 and was a Consulting Professor at Stanford from June 2004 to August 2012. Dr. Koomey holds M.S. and Ph.D. degrees from the Energy and Resources Group at UC Berkeley, and an A.B. in History and Science from Harvard University. He is the author or coauthor of nine books and more than 200 articles and reports. He is the author of *Turning Numbers into Knowledge: Mastering the Art of Problem Solving* (which has been translated into Chinese and Italian and is now in its 3rd edition) and *Cold Cash, Cool Climate: Science-Based Advice for Ecological Entrepreneurs* (both from Analytics Press).

K-2: COVID-19 AND 5G: THE LASTING IMPACT AND NEW CHALLENGES FOR OUR COMMUNICATION NETWORKS

Presenter: Theodore (Tod) Sizer, Nokia Bell Labs

Wednesday, June 2, 10:30 AM – 11:30 AM EDT

Abstract: During the COVID-19 pandemic communication networks have provided an essential lifeline for work, school, our health, information, and entertainment during this challenging time at a level which has no historical precedent. Work from home and learn from home is likely to play a larger role in the way we live even after the virus threat has subsided. At the same time, industry is evolving to exploit the benefit of being "Always Connected" in new ways driven by increased demand, new opportunities, and the benefits of cloud-based processing. This benefit was formerly only provided to consumers but now, through the adoption of 5G, is extended to machines and brings with it new and severe requirements which challenge the new applications, the networks that serve them, the data centers which host them, and the devices throughout which enable them. In this talk I will outline the challenges of both the continuing growth in communication demand and the new ones posed by the coming 5G Industrial Revolution.

Dr. Theodore (Tod) Sizer is Executive Vice President of Smart Optical Fabric and Device Research in Nokia Bell Labs, leading teams innovating in all aspects of optical systems and devices for core, submarine, and data center communications. Prior to his current role, Tod lead Wireless Research in Nokia Bell Labs for eight years driving the vision and research of 5G. Tod graduated from Amherst College, and received his Masters and Doctorate in Optics from the Institute of Optics at the University of Rochester. In 2012 he received the Popular Science Breakthrough Innovation award for the lightRadio invention. Tod is a Fellow of Bell Labs, WWRF, and IEEE. He is the author of 54 US patents and a member of the IEEE and OSA.

K-3: ENGINEERING IN THE TIME OF CORONA: SOME LESSONS FOR THE FUTURE

Presenter: Jayathi Murthy, UCLA

Thursday, June 3, 10:30 AM – 11:30 AM EDT

Abstract: During the last year, we have learned many lessons, intended and unintended, that have profound implications for engineering education and research, the nature of engineering work, and issues of access and equity in engineering. In this talk I examine what we have learned and what remains to be learned on all these dimensions and discuss both pitfalls and possibilities. The remote delivery of engineering education, for example, offers tantalizing economies of scale, the potential to draw in hitherto underserved communities, the possibility of lifelong education, and the potential for vastly expanded international connections. At the same time, there are indications that important dimensions of learning are social and that much of it occurs outside the classroom. Can remote learning be enhanced to enable these social dimensions? Similar questions remain to be answered regarding the efficacy of remote engineering employment. Can creativity and teamwork be built and sustained through largely remote interactions? And finally, there are the enormous inequities that the pandemic has laid bare: access to remote learning infrastructure and disparities in the assumption of household responsibilities are but two examples. In examining this last tumultuous year, I hope we can learn what works and does not work, what we need to learn more about, and engineer creatively a better future for us all.

Jayathi Y. Murthy is Ronald and Valerie Sugar Dean at the UCLA Henry Samueli School of Engineering and Applied Science, with 190 faculty members, and more than 6,000 undergraduate and graduate students. Murthy is also a distinguished professor in the Mechanical and Aerospace Department. Murthy's research interests include

nanoscale heat transfer, computational fluid dynamics, and simulations of fluid flow and heat transfer for industrial applications. Recently, her focus is on sub-micron thermal transport, multiscale multi-physics simulations of micro- and nano-electromechanical systems (MEMS and NEMS), and the uncertainty quantifications involved in those systems. Before joining UCLA Engineering as dean in January 2016, Murthy was chair of the Department of Mechanical Engineering at the University of Texas at Austin and held the Ernest Cockrell Jr. Memorial Chair in Engineering. From 2008 to 2014, Murthy served as the director of the Center for Prediction of Reliability, Integrity and Survivability of Microsystems (PRISM), a center of excellence supported by the National Nuclear Security Administration (NNSA). Murthy was an early employee of New Hampshire-based Fluent Inc., a developer and vendor of the world's most widely used computational fluid dynamics software. She led the development of algorithms and software that still form the core the company's products. Murthy received a Ph.D. in mechanical engineering from the University of Minnesota, an M.S. from Washington State University and a B. Tech from the Indian Institute of Technology, Kanpur, where she was named a distinguished alumna in 2012. She is a fellow of the American Society of Mechanical Engineers (ASME) and the author of more than 300 technical publications. She is the recipient of many honors, including the ASME Heat Transfer Memorial Award in 2016 and the ASME Electronics and Photonics Packaging Division Clock Award. She is a member of the National Academy of Engineering and a Foreign Fellow of the Indian National Academy of Engineering.

Follow ITherm on LinkedIn

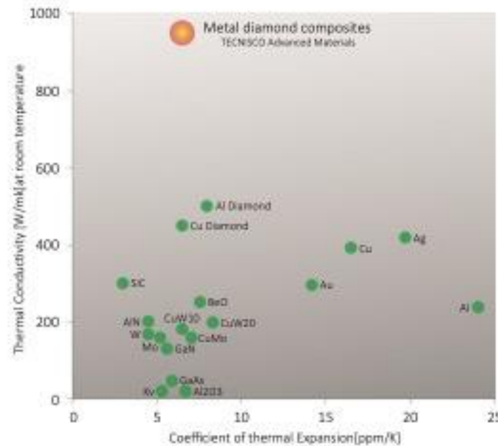
Metal diamond composites

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

Excellent thermal conductivity

CTE well adapted to packaging materials

Easy integration of components



Material Properties

Thermal conductivity	900	W/mK
CTE	6.5~8.0	ppm/K
Density	5.5	g/cm3
Specific Heat	0.39	J/gK
Specific Electrical Resistivity	8.75	μΩcm
Young's Modulus	275	GPa
Flexural Strength	350	MPa

*At Room Temp

tecnisco diamond

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RICHARD CHU ITHERM AWARD FOR EXCELLENCE

THERMAL MANAGEMENT OF LITHIUM-ION BATTERIES FOR ELECTRIC VEHICLES: A MULTISCALE CELL-TO-VEHICLE HIERARCHICAL PERSPECTIVE

Presented by the 2021 Awardee Cristina Amon

Friday June 4, 10:30 AM – 11:30 AM EDT

Alumni Distinguished Professor in Bioengineering
Advanced Thermofluid Optimization, Modeling, and Simulation (ATOMS) Laboratory
Mechanical and Industrial Engineering, University of Toronto

Abstract: Electric Vehicles are expanding at a rapid pace, enabled by technological advances in lithium-ion batteries, fast chargers, and charging infrastructures. Further advances in lithium-ion battery (LIB) performance and lifetime relies on enhanced thermal management strategies and packaging architectures, realized as intelligent battery thermal management systems, which can optimally control the thermo-electrochemical phenomena occurring inside the batteries to maximize LIB performance, minimize degradation, enable fast-charging protocols, and permit a seamless transition of degraded electric vehicle (EV) batteries into less-demanding second-life stationary systems. This presentation will describe current engineering challenges and opportunities on EV thermal management, with a focus on our research on multiscale hierarchical design, modelling, and optimization approaches to overcome cooling and heating challenges across multiple physical domains and length scales; from battery electrodes, to battery cells, modules, and packs, to vehicle-level thermal management systems. We will provide a scale-bridging perspective across the following subjects: (i) sub-continuum modelling and thermal engineering of electrode materials for metal-ion batteries, (ii) characterization of anisotropic thermophysical properties and spatially distributed heat generation rates in battery cells, (iii) high-fidelity thermo-electrochemical modelling and simulations of battery cells and modules, (iv) reduced-order thermal models, scalable to different battery sizes and cooling architectures at the battery pack level, (iv) performance-degradation models of LIB packs, (v) vehicle-level model validated with experiments in a concept EV, and (vi) thermal management systems to enable thermally-safe fast charging and temperature-modulated battery life extension.

Cristina Amon is Alumni Distinguished Professor and Dean Emerita of the Faculty of Applied Science and Engineering at the University of Toronto. Prior to joining U of T in 2006, she was the Raymond J. Lane Distinguished Professor and Director of the Institute for Complex Engineered at Carnegie Mellon University. She has pioneered the development of computational fluids dynamics, multidisciplinary multiscale hierarchical modelling, concurrent design and optimization methodologies for thermo-fluid transport phenomena, with applications to thermal management of electronics and electric vehicles, renewable energy and biomedical devices.

Professor Amon is a fellow of ASEE, ASME, IEEE and other major professional societies in her field and has contributed over 400 refereed articles to the education and research literature. She was appointed to the Order of Canada and inducted into the Canadian Academy of Engineering, Hispanic Engineer Hall of Fame, Royal Society of Canada, Spanish Royal Academy and US National Academy of Engineering. Among her many accolades, she received the ASEE Westinghouse Medal, ASEE Ralph Coats Roe Award, ASME Heat Transfer Memorial Award, ASME InterPACK

Achievement Award, EIC Sir John Kennedy Medal, and CSME Robert W. Angus Medal. She was recognized as one of Canada's Most Influential Women in 2012, the Powerful Women Trailblazers & Trendsetters in 2019, and received the highest honor for Engineers in Canada (2020 Engineers Canada Gold Medal) and in Ontario (2015 PEO Gold Medal) for outstanding engineering public service, technical excellence and professional leadership. Cristina Amon is the founding chair of the Global Engineering Deans Council and has served on numerous advisory and review boards in North America and abroad, editorial and technical conference roles, including ITherm General Chair in 2002. She received her Mechanical Engineering degree from Simon Bolivar University in Venezuela, and her M.S. and Sc.D. from the Massachusetts Institute of Technology.

TECHNOLOGY TALK SESSIONS

TECH TALK SESSION 1: RELIABILITY CHALLENGES IN EMERGING TECHNOLOGIES AND APPLICATIONS

Session Chair: Emre Armagan (Intel)

Tuesday, June 1, 1:00 PM – 2:00 PM EDT

Diganta Das
University of Maryland

Lei Jiang
Intel

EFFECTS OF TEMPERATURE ON ELECTRONICS RELIABILITY: FUTILE ATTEMPTS TO OVERSIMPLIFY

Effects of Temperature on Electronics Reliability: Futile Attempts to Oversimplify

Speaker: Diganta Das (University of Maryland)

Abstract: The reliability assessment process for electronics is often isolated from the science of how products are impacted by thermal stress and the fundamental driving factors. Ignoring these fundamentals, assuming that they are not tractable, leads to an oversimplified reliability assessment process that takes a limited view of temperature factors and overlooks the interactions with other stress factors and the influences of materials, geometry, and architecture. This presentation will critically review the separation of failure processes from reliability assessment and the negative consequences. It will explore how the electronics component manufacturers can assist the product manufacturers in assessing component reliability in their applications.

Diganta Das (Ph.D., Mechanical Engineering, University of Maryland, College Park, B.Tech, Manufacturing Science and Engineering, Indian Institute of Technology) is an Associate Research Scientist at the Center for Advanced Life Cycle Engineering in University of Maryland. His expertise is in reliability, environmental and operational ratings of electronic parts, uprating, electronic part reprocessing, counterfeit electronics, technology trends in the electronic parts, and parts selection and management methodologies. His current research interests include the electronic parts supply chain, counterfeit electronics avoidance, and detection, and power electronics reliability. Dr. Das has published more than 75 articles on these subjects. He is vice-chair of the standards group of the IEEE Reliability Society and chair of the IEEE Reliability Prediction Working group. He had been an Associate Editor of the journal Microelectronics Reliability. He is a Six Sigma Black Belt and a member of IEEE, IMAPS, and SMTA.

THERMAL METHODOLOGIES ON SCALES IMPACTING DEVICE RELIABILITY

Speaker: Lei Jiang (Intel)

Abstract: Rising power densities at chip-level and device-level pose challenges to reliability and thermal management that spans over 12 orders of length scale and 6 orders of temporal scale. At the transistor device level, there is currently no industry-wide standard model for phonon scattering and heat removal impact to reliability of electromigration and aging for example. We present here some of the first principles and compact modeling efforts to capture the local thermal effect at circuit scale in advanced technologies and how it can be leveraged effectively to optimize the design for reliability. Modeling also plays key role in estimating chip-level self-heat impact on advanced integration schemes such as 3D die stacking. We will present modeling and validation methodologies to bridge these length scales to enable robust and high-performance processor design.

Lei Jiang received his B.S. degree in Engineering Mechanics from Dalian University of Technology, China in 1992; M.S. degree in Civil Engineering from University of Houston, USA, in 1994; and his Ph.D. in Mechanical Engineering and Applied Mechanics from University of Michigan at Ann Arbor, USA, in 1997. From 1997 to 1998, he was a Research Fellow at Engineering and Applied Mathematics Department at Northwestern University and at Department of Naval Architecture and Marine Engineering at University of Michigan. Since 1998, he has been with Intel Corporation, Hillsboro, Oregon, as a member of the TCAD group in the Technology and Manufacturing organization and most recently as a Principal Engineer focusing in thermal mechanical analysis. His professional interest includes the development of thin-film process modeling tools, software for advanced device modeling and reliability verification, and power-thermal validation on integrated circuits. He is author of more than 30 publications, 7 patents and has participated in IEEE conferences as tutorial speaker.

TECH TALK SESSION 2: HETEROGENEOUS INTEGRATION

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

Wednesday, June 2, 1:00 PM – 2:00 PM EDT

Yogendra K. Joshi
Georgia Institute of Technology

Rajiv Mongia
Intel

TWO-PHASE COOLING OPPORTUNITIES AND CHALLENGES FOR HETEROGENEOUS MICROSYSTEMS

Speaker: Yogendra K. Joshi (Georgia Institute of Technology)

Abstract: Heterogeneously packaged microsystems incorporating digital, radio-frequency, opto-electronic, and power devices will require embedded cooling, where the coolant is brought in close proximity, and often in direct contact with the active die. Dielectric coolants can be utilized for such applications, with a saturation temperature selected depending on the application. Due to the poor heat transfer properties of these coolants, phase change offers the ability to improve their performance. Evaporative closed loop cooling offers significantly higher heat transfer coefficients and lower coolant circulation rates than single phase cooling. Evaporative cooling can also be effectively utilized in passive devices such as vapor chambers, and thermosyphons. This talk will focus on three topics with applications to two-phase cooling of heterogeneous microsystems: (i) computational simulations of flow boiling in micro-passages, (ii) use of surface modification in flow boiling enhancement, and (iii) passive two-phase thermal management using vapor chambers.

Yogendra Joshi is Professor and John M. McKenney and Warren D. Shiver Distinguished Chair at the G.W. Woodruff School of Mechanical Engineering at the Georgia Institute of Technology. His research interests are in multi-scale thermal management. He is the author or co-author of over four hundred publications in this area, including over two hundred journal articles. He received his B. Tech. in Mechanical Engineering from the Indian Institute of Technology (Kanpur) in 1979, M.S. in Mechanical Engineering from the State University of New York at Buffalo in 1981, and Ph.D. in Mechanical Engineering and Applied Mechanics, from the University of Pennsylvania in 1984. He has served as the Principal Investigator for multiple Defense Advanced Research Projects Agency (DARPA) programs, and Office of Naval Research Consortium for Resource-Secure Outposts (CORSO). He was Site Director for the National Science Foundation Industry/University Cooperative Research Center on Energy Efficient Electronic Systems. He has held visiting faculty appointments at Stanford University, Katholieke Universiteit Leuven, and Xi'an Jiaotong University. He is an elected Fellow of the ASME, the American Association for the Advancement of Science, and IEEE. He was a co-recipient of ASME Curriculum Innovation Award (1999), Inventor Recognition Award from the Semiconductor Research Corporation (2001), the ASME Electronic and Photonic Packaging Division Outstanding Contribution Award in Thermal Management (2006), ASME J. of Electronics Packaging Best Paper of the Year Award (2008), IBM Faculty Award (2008), IEEE SemiTherm Significant Contributor Award (2009), IIT Kanpur Distinguished Alumnus Award (2011), ASME InterPack Achievement Award (2011), ITherm Achievement Award (2012), ASME Heat Transfer Memorial Award (2013), and AIChE Donald Q. Kern Award (2018).

THERMAL CHALLENGES AND INNOVATION FOR HETEROGENEOUSLY INTEGRATED PACKAGES

Speaker: Rajiv Mongia (Intel)

Abstract: In the last 15 years, both process and packaging technology has advanced to the point that "true" systems on a package are now possible. We can now integrate dies from multiple process nodes and vendors at the package level to achieve heterogeneous computing at the product level. For example, Intel's Stratix 10 product line contains both 2.5D and 3D elements to integrate silicon from up to 3 process nodes in a single product package. This approach has obvious advantages in both product cost, time-to-market and product flexibility; however, it creates unique challenges for the thermal designer and architect. Specifically, with a heterogeneous approach, the conventional approaches of thermal resistance no longer hold sufficient accuracy for thermal solution design.

Rajiv Mongia is Senior Principal Engineer in the Data Platforms Group. He is the Lead Thermal Architect in the Programmable Solutions Group where he is responsible for FPGA Thermal Architecture (from the die level to platform level). He also holds a role as Innovation Lead in the Thermal-Mechanical Solutions (TMS) group within Data Center Group (DCG) focusing on the Xeon product line. Prior to DPG, Rajiv has had several positions at Intel including leading Experience and Maker Outreach in the Modular Innovation Group; SW Product Management and User Experience for Intel® RealSense™ products; Program Director for the Social Computing Intel Science and Technology Center and the Sustainable and Connected Cities Intel Collaborative Research Institute; and leading an international thermal technology development team focused on pathfinding to technology enabling in the PC Client Group. Prior to joining Intel, Rajiv was an engineering consultant where he led fire and explosion investigations including the WTC attack on 9/11. He was also the lead engineer of a start-up developing gas turbines for distributed power generation. Rajiv has been awarded 47 United States patents in the areas of combustion, thermals, mechanicals, platform engineering and human-computer interface design. He also received a number of awards including co-recipient of the 2015 Intel Achievement Award *For developing and bringing to market the first Intel RealSense products*. He received his undergraduate in Mechanical Engineering from Purdue University and his Masters and Ph.D. specializing in Combustion from the University of California, Berkeley.

TECH TALK SESSION 3: BATTERY THERMAL MANAGEMENT

Session Chair: Naveenan Thiagarajan (GE)

Thursday, June 3, 1:00 – 2:00 PM EDT

Ahmad Pesaran
NREL

Ankur Jain
University of Texas at Arlington

LITHIUM-ION BATTERY THERMAL MANAGEMENT AND SAFETY NEEDS FOR PLUG-IN ELECTRIC VEHICLES

Speaker: Ahmad Pesaran (NREL)

Abstract: The demand for plug-in hybrid and battery electric vehicles (PEVs) are rising as communities move toward cleaner transportation. Lithium-ion batteries are the dominant technology for these PEVs due to their higher energy and power. The cost of these batteries has been coming down and their performance has been getting better. However, their life can be limited under uncontrolled thermal excursions due to use or climate. As the lithium-ion battery temperature increases its life decreases, so thermal management is needed to keep the battery temperature within desired range. The cooling systems could be air, direct liquid or indirect liquid. In this presentation we will review the latest approach to thermal management and tools needed to design battery thermal management systems. Another aspect of the state of the art of lithium-ion batteries is that they use organic flammable liquids that under abuse conditions could ignite and cause fire in a vehicle. We will discuss how these batteries could go

into thermal runaway and what are the tools and approaches that designers use to mitigate the thermal runaway in vehicles.

Ahmad Pesaran received his Ph.D. from UCLA and has been working at NREL for the last 35 years. Until 2017, he was the Manager of Energy Storage Group with research activities on high energy anodes, electrode coatings, battery thermal management, 3D electrochemical-thermal modeling, safety modeling, battery second use, techno-economic analysis of batteries for Evs; he led the Computer-Aided Engineering for Electric Drive Vehicle Batteries for DOE. Ahmad has co-authored more than 150 papers and conference presentations on energy storage and electric drive vehicles. He is an active member of US Advanced Batteries Consortium. Ahmad was elected to SAE Fellow in 2018 for his contributions to electric mobility. Ahmad was on off-site assignment with Department of Energy in 2017-2018 as battery technical advisor. Currently, Ahmad is supporting DOE's Vehicle Technologies Office with various industry projects.

MULTISCALE HEAT TRANSFER AND THERMAL MANAGEMENT IN LI-ION BATTERIES: CHALLENGES AND OPPORTUNITIES

Speaker: Ankur Jain (University of Texas at Arlington)

Abstract: Li-ion batteries are widely used for energy conversion and storage in electric vehicles, aircraft, consumer electronics and renewable energy storage. While offering excellent energy conversion and storage characteristics, however, these batteries suffer from several safety related problems, as evidenced by recent product recalls and incidents of fires in electric cars and aircraft. A fundamental understanding of heat transfer in Li-ion materials, cells and battery packs is critically needed. Such problems are often multiscale and multi-disciplinary in nature, offering opportunities for novel scientific research as well as engineering development. This Tech Talk will provide an introduction to Li-ion battery technology and the nature of heat transfer across multiple scales, ranging from battery materials all the way to large battery packs. The nature of heat generation and thermal conduction will be discussed and correlated with electrochemical processes that occur within a cell. Key thermal management challenges and approaches will be discussed. The problem of thermal runaway, including key mitigation techniques will be discussed in detail. The emphasis will be both on the fundamental physics underlying these problems, as well as practical engineering approaches that have been proposed for solving such problems. It is expected that this talk will be of interest to students and scientists/engineers with an interest in learning about heat transfer and thermal management in a novel multiscale system.

Ankur Jain is an Associate Professor in the Mechanical and Aerospace Engineering Department at the University of Texas, Arlington. His research interests include heat transfer in Li-ion batteries, microscale thermal transport, additive manufacturing and applied mathematics. He has published 88 journal papers, and given 51 invited talks, seminars and tutorials. He received the UT Arlington College of Engineering Lockheed Martin Excellence in Teaching Award (2018), UT Arlington College of Engineering Outstanding Early Career Award (2017), NSF CAREER Award (2016) and the ASME EPP Division Young Engineer of the Year Award (2013). In 2017, he was invited by the US National Academy of Sciences to participate in the 5th Arab-American Frontiers of Science, Engineering, and Medicine Symposium in Rabat, Morocco. He received his Ph.D. (2007) and M.S. (2003) in Mechanical Engineering from Stanford University, and B.Tech. (2001) in Mechanical Engineering from Indian Institute of Technology, Delhi with top honors.

PANEL SESSIONS

PANEL SESSION 1: THERMO/MECHANICAL MANAGEMENT OF ADVANCED MOBILE/TELECOM, WIRELESS, AND COMPUTING DEVICES

Moderator: Victor A. Chiriac (Global Cooling Technology Group, LLC)

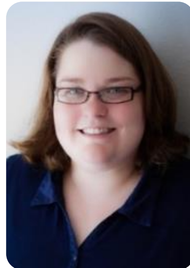
Tuesday, June 1, 11:45 AM – 12:45 PM EDT

Raj Pendse
Facebook

Y.C. Lee
Kelvin Thermal Technologies, Inc.

Ravi Mahajan
Intel

John R. Thome
GCTG, LLC


Amy Marconnet
Purdue University

Hiroyuki Ryoson
Dexerials Corp.

Ali Heydari
NVIDIA

Abstract: We are at the crossroads of the fourth industrial revolution, with the emergence of several technologies, including hyper-connectivity, advanced telecommunication avenues, Artificial Intelligence (AI), Internet of Things (IoT), cloud computing and big data. The society is changing at a fast pace, with connectivity and mobility driving every aspect of it: there were approximately 14 billion connected devices in 2015, and that number is expected to double by 2025. Everything requires higher performance, more data, 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 will help power a 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 many other. 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 challenges and solutions of the future.

PANEL SESSION 2: MODEL-BASED DESIGN OF NOVEL ELECTRONIC COMPONENTS AND SYSTEMS – CHALLENGES AND OPPORTUNITIES

Moderator: Przemyslaw Gromala (Bosch GmBH, Germany)

Wednesday, June 2, 11:45 AM – 12:45 PM EDT

Pradeep Lall
Auburn University

Milena Vujosevic
TDK

Kashi Vishwanath Machani
Globalfoundries

Paola Altieri-Weimar
Infineon Technologies AG

Saket Karajgikar
Facebook

Abstract: Model based design is a powerful methodology that allows accelerating design and development process of novel advanced packaging and electronic systems. Numerical tools allow combination of different domain as well as scale. Structure on integrated circuitry level as low as in (nm) scale, while at the same time novel communication or transportation system are measured in (cm) or (m). This panel will discuss challenges and opportunities that are ahead of us. We will share our experience and expertise from both industry (across entire supply chain) and academia.

P-3: TWO-PHASE LIQUID COOLING SYSTEMS FOR HIGH POWER ELECTRONICS

Moderator: John Thome (JJ Cooling Innovation)

Thursday, June 3, 11:45 AM – 12:45 PM EDT

Filippo Cataldo
Metalmeccanica

Luca Amalfi
Nokia Bell Labs

Corey Wilson
ThermAvant Technologies

Mark Schultz
IBM

Matteo Bucci
MIT

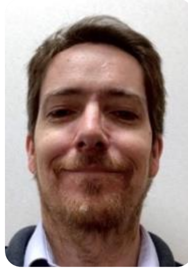
Abstract: Thermosyphon and pulsating heat pipe cooling continues to gain traction in the cooling of electronics. The panel will address new developments on the industrialization of two-phase cooling systems. Panelists from diverse industrial sectors will cover the status of existing and pending applications for the designing of two-phase cold plates and their cooling systems (thermosyphon and PHP systems). Recent tests results from prototypes will also be presented.

P-4: THERMAL CHALLENGES IN NEXT-GENERATION OPTO-ELECTRONIC SYSTEMS

Moderators: Luca Amalfi (Nokia Bell Labs), Amy Marconnet (Purdue)

Thursday, June 3, 2:15 PM – 3:15 PM EDT

Amr Helmy
University of Toronto



Mark Earnshaw
Nokia Bell Labs

Nitin Karwa
Honeywell

Yogendra Joshi
Georgia Institute of Technology

Peter de Bock
ARPA-E

Ying Sun
NSF

Abstract: Data transport, processing and storage are following an exponentially increasing trend, driven by higher demands in mobile broadband, video/gaming, cloud, 5G network and Internet of Things. Such escalating trends are directly linked to the next-generation "digital" transformation, which is dominated by intelligent machine-to-machine and human-to-machine communications, automating "everything everywhere". This has profound implications in terms of overall system design with the associated general trend towards achieving greater device functionality per unit volume. Optical fibers and photonic components are the preferred solution for both short-reach and long-haul communications. In order to meet next-generation bandwidth, latency and energy efficiency requirements, there is an ever-increasing need of closer integration and co-packing of optical and electronic components. Thermal management will be the key to enable these densification challenges by coupling novel passive cooling technologies with accurate temperature stabilization techniques. A panel of experts from industry, academia and government agencies will share their vision and discuss the importance of thermal management solutions for opto-electronic systems and beyond.

STUDENT HEAT SINK DESIGN CHALLENGE

Session Chairs: Amy Marconnet (Purdue University), Joshua Gess (Oregon State University)

Tuesday, June 1, 2:15 PM – 3:15 PM EDT

The ITherm organizing committee is delighted to again host the joint ASME K-16 / IEEE EPS Student Design Challenge during ITherm 2021 Virtual. 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 natural convection. Designs were submitted by teams from around the world and evaluated by a team of experts based on a series of design and manufacturing criteria. For the 2021 competition, the top 8 most effective and creative designs were printed using additive manufacturing facilities at GE and tested using state-of-the-art test equipment at Oregon State University. Of the following semi-finalists, four teams, selected as finalists, will present their work at the 2021 ITherm Virtual Conference:

Sponsored by:

STUDENT POSTER AND NETWORKING SESSION

Session Chairs: Mahsa Ebrahim (Loyola Marymount University), Arjang Shahriari (Qualcomm), Joseph Hanson Vázquez (Intel)

Wednesday, June 2, 2:15 PM – 4:15 PM EDT

This student poster presentation and networking event will feature a live and interactive session via the Gather platform which allows multiple attendees to hold separate conversations in parallel. In this virtual and live poster session, students will stand next to their poster stands and conference attendees can navigate around the virtual environment and interact with each student separately, as well as other attendees in the poster rooms, common area lounge and private rooms, resembling a real in-person experience. The poster session committee will share the resumes of those student presenters who are seeking jobs and internships upon their request with the professional attendees to connect the students to potential employers.

All student first authors with accepted papers were eligible to apply for the poster session. Each E-poster was submitted in advance of the event and judged offline by industry and academic professionals. Additionally, the oral presentation of each poster will be evaluated during the live virtual poster session. The judgment process will be based on technical merit, clarity and self-sufficiency of the content, the novelty of the work, and the overall impact of the poster display.

Outstanding posters will be selected for awards based on the evaluation scores. Poster awards will be announced during the ITherm 2021 Awards Ceremony on Friday, June 4. Awards certificates will be mailed to the awardees. The poster awards are independent of the paper awards, and the same work is eligible for winning both awards based on the specific judging criteria for each award.

LIST OF STUDENT POSTERS

EMERGING TECHNOLOGIES

Student Name	School	Poster ID	Poster Title
Pranay Nagrani	Purdue University	p115	Two-Fluid Modeling of Dense Particulate Suspensions for Electronics Cooling
ALPER SAYGIN	Ozyegin University	p172	A Numerical Investigation Into Frost Formation Over A Vertical Plate In An Impinging Flow Stream
Rajath Kantharaj	Purdue University	p192	Impact of Squeezing on the Microstructure of Thermal Interface Materials
Saeel Shrivallabh Pai	Purdue University	P201	A Machine-Learning-Based Surrogate Model for Internal Flow Nusselt Number and Friction Factor in Various Channel Cross Sections
Alison Hoe	Texas A&M University	p262	Dynamic characterization of phase change materials under harmonic heating

COMPONENT-LEVEL THERMAL MANAGEMENT

Student Name	School	Poster ID	Poster Title
Ceren Cengiz	Ozyegin University	P108	Thermal and Optical Characterization of White and Blue Multi-Chip LED Light Engines
Brian Kelly	Georgia Institute of Technology	p132	Dielectric Fluids for the Direct Cooling of Power Electronics
Meghavin Bhatasana	Purdue University	p147	Optimization of an Embedded Phase Change Material Cooling Strategy Using Machine Learning
Ji Yong Kim	Ulsan National Institute of Science and Technology	p162	Preliminary study on the boiling heat transfer performance of R-123 refrigerant with nano-porous aluminum oxide membrane
Soumya Bandyopadhyay	Purdue University	P279	Experimental Characterization of Cascaded Vapor Chambers for Spreading of Non-Uniform Heat Loads
Venu Madhav Hanumanthugari	Indian Institute of Science, Bangalore	P296	Resistance network model for a PCM coupled heat pipe

Karthekeyan Sridhar	Auburn University	p317	Development of microgravity boiling experiments aboard the ISS from terrestrial adverse gravity outcomes for a ratcheted microstructure with engineered nucleation sites
Samuel Kim	Georgia Institute of Technology	P345	An Experimental study of the effectiveness of heat extraction by the drain ohmic contact of β-Ga2O3 MOSFETs

SYSTEM-LEVEL THERMAL MANAGEMENT

Student Name	School	Poster ID	Poster Title
Adeel Arshad	University of Nottingham	P116	A numerical study of HNCPCM filled metal-foam strips based heat sink for passive cooling.
Ujash Shah	UCLA	P266	Segmented Thermal Management with Flash Cooling for Heterogeneous Wafer-Scale Systems
Achutha Tamraparni	Texas A&M university	p335	Experimental validation of composite phase change material optimized for thermal energy storage
Eliel Marcelino	UFABC - Federal University of ABC	P371	Review on some Viscosity Models for CuO-water Nanofluid and their effects on Thermal Enhancement for Automotive Applications

MECHANICS AND RELIABILITY

Student Name	School	Poster ID	Poster Title
AATHI RAJA RAM PANDURANGAN	Auburn University	P227	Non-Perpendicular High-G Shock on Potted Fine Pitch Electronic Under Sustained High Temperature Exposure
Jinesh Narangaparambil	Auburn University	P229	Printed flexible LC filter using the micro-dispensing technique using silver conductive pasted and ECA for component attachment
Venkatesh Avula	Georgia Institute of Technology	p232	Augmented finite element method (AFEM) for steady-state thermal and thermomechanical modeling of heterogeneous integration architectures
Kartik Goyal	Auburn University	P235	Electrically Conductive Adhesive Interconnections on Additively Printed Substrates
Mrinmoy Saha	Auburn University	P238	Evolution of High-Temperature and Low-Temperature High Strain Rate Properties for SAC-R after Sustained Exposure to 50°C
Padmanava Choudhury	Auburn University	p240	Effect of Thermal Aging on the Interface-Fracture Toughness od the PCB-UF Interface

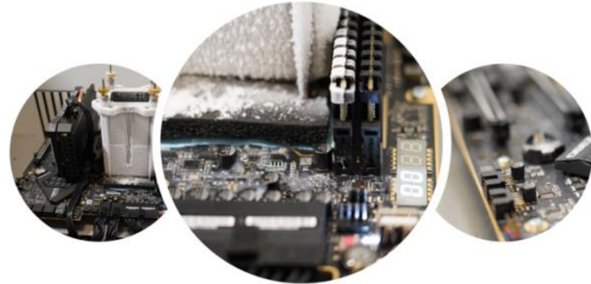
Ved Soni	Auburn University	P243	SOH and RUL Modelling of Li-Ion Coin Cells Subjected to Varying C-Rates, Depths of Charge, Operating Temperatures and Custom Charge Profiles
Vikas Yadav	Auburn University	P247	Low-Temperature High Strain Rate Constitutive Behavior of SnAgCu Solder Alloys after Prolonged Storage at High Temperature
Vishal Arvindbhai Mehta	Auburn University	P250	High Strain Rate Properties of SAC305 Alloy at Cold Temperatures Subsequent to 100°C Storage for Periods up to 120 Days
Tony Thomas	Auburn University	P255	Prognostic and RUL Estimations of SAC305, SAC105,and Sn/Tg Solders under Different Drop and Shock Loads using Long Short-Term Memory (LSTM) Deep Learning Technique
Madhu Kasturi	Auburn University	P257	Microstructural Characterization of Viscoelastic Properties of Underfills Exposed to High Temperature
Sungmo Jung	Auburn University	P259	Cu-Al WB Reliability under Sustained High Temperature and High Voltage Bias Application
Hyesoo Jang	Auburn Univeristy	P260	Twist Reliability Assessment of Flexible Battery in Wearable Applications
Mohammad Al Ahsan	Auburn University	p372	Evolution of Mechanical Properties of SAC+Bi Lead Free Solder Materials Subjected to Different Thermal Cycling Profiles
Abdullah Fahim	Auburn University	P373	Prediction of Stress-Strain Behavior of Thermally Cycled SAC305 Solder Joints by Finite Element Modeling and Nanoindentation Characterization
Mohammad Haq	Auburn University	P375	Anand Parameters of Eutectic Tin-Bismuth Solder
KM Rafidh Hassan	Auburn University	p376	The Effect of Bismuth Content on Mechanical Properties of SAC+Bi Lead Free Solder Materials and Determination of Anand Parameters
Mohd Aminul Hoque	Auburn University	P377	Microstructural Study of Lead Free Solder Alloys Subjected to Mechanical Cyclic Loading Under Various Conditions
S M Hasan	Auburn University	P378	Comparison of Thermal Cycling Induced Mechanical Properties Evolutions of Bulk Solder Bars and Solder Balls
Debabrata Mondal	Auburn University	p379	Micromechanical Modeling of Lead-Free Solders to Determine Effective Material Properties Using the Method of Homogenization
Jing Wu	Auburn University	p380	Investigation and Comparison of Aging Effects in SAC+Bi Solders Exposed to High Temperatures

STUDENT OVERCLOCKING COMPETITION

Session Chairs: Joshua Gess (Oregon State University), Justin Weibel (Purdue University)

Friday, June 4, 11:45 AM – 12: 15 PM EDT

The IEEE EPS Student Overclocking Competition is a new event for ITherm 2021 where student teams design, build, and test a thermal management solution to enable the overclocking of a processor. The student teams will be given the opportunity to describe their designs and report the overclocking performance using competition-standard benchmarks. Teams will describe the engineering aspect necessary to perform the overclocking through short presentations.



Purdue University Overclocking Team Setup (Photos Courtesy of Jared Pike, Purdue University)

ECTC/ITHERM JOINT DIVERSITY PANEL

ITherm Chairs: Cristina Amon (University of Toronto), Amy Fleischer (Cal Poly)

ECTC Chairs: Allyson Hartzell (Philips), Kitty Pearsall (Boss Precision)

Available On-Demand from June 1 – July 6

DIVERSITY DOES MATTER AND CAN DRIVE ENHANCED BUSINESS PERFORMANCE

The 2021 ECTC / ITherm Joint Diversity Panel will focus on:

- Diversity and programs enabling diversity
- Gender, ethnic and cultural diversity bring different perspectives to the table is known. How does this work?
- Companies in top quartile for ethnic and cultural diversity were 36% more likely to outperform on profitability (“Delivering through diversity”, McKinsey and Company, January 2018)

A live feedback and Q&A session are scheduled for Wednesday, June 9 at 11:00 AM EDT.

Panelists

Joyce Wu
Analog Devices

Victor Tymchenko
Intel

Alexandra Gualdino
PMD Technologies

Adeel Bajwa
Kulicke and Soffa Industries

HIR VIRTUAL WORKSHOP

Session Chair: Bill Chen (ASE) and Bill Bottoms (3MTS)

Available On-Demand from June 1 – July 6

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. During this workshop, 23 technical workgroups will present on their areas of expertise. All ITherm 2021 Virtual registrants will have access to the recording of the HIR Workshop held as part of the 71st ECTC Virtual Event.

In addition to the pre-recorded workshop, a live feedback and Q&A session is being scheduled.

- **Overview:** Heterogenous Integration is the Future
- **Session 1 (Moderator: Bill Bottoms, 3MTS):** High performance computing and data centers; 2D-3D and interconnect; Thermal management; Integrated Photonics; Test; Cyber Security
- **Session 2 (Moderator: Tom Salmon, SEMI):** Automotive; MEMS & Sensor Integration; SiP and Module; Supply Chain; Integrated Power Electronics
- **Session 3 (Moderator: Ravi Mahajan, Intel):** 5G & Future Communications; WLP (Fan-in & Fan Out); Aerospace & Defense; Mobile; Materials & Emerging Research Materials; IoT
- **Session 4 (Moderator: Amr Helmy, University of Toronto):** Medical, Health & Wearables; Emerging Research Devices; Single Chip and Multi Chip Integration; Co-Design; Modeling & Simulation; Reliability

Bill Chen

Bill Bottoms

Amr Helmy

Ravi Mahajan

Tom Salmon

PROFESSIONAL DEVELOPMENT COURSES

A set of 14 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. Each course will be 2.5 hours long and will occur within the 1st two weeks of the conference. After the initial presentation, all PDCs will be available for the duration of the conference. New for 2021, attendees can register for more than two PDCs. A separate registration fee is required to attend these courses, and the PDC course registration can be performed at the ECTC registration website.

2021 PROFESSIONAL DEVELOPMENT COURSES

Achieving High Reliability of Lead-Free Solder Joints – Materials Considerations
Live Presentation: Tuesday, June 1, 10:00 AM – 1:00 PM EDT

Live Q&A: Monday, June 21, 12:00 PM – 1:00 PM EDT

Course Leader: Ning-Cheng Lee (Indium Corporation)

Fundamentals of Glass Technology and Applications for Advanced Semiconductor Packaging
Live Presentation: Wednesday, June 2, 7:00 PM – 10:00 PM EDT

Live Q&A: Tuesday, June 22, 12:00 PM – 1:00 PM EDT

Course Leaders: Prakash Gajendra and Joseph Canale (Corning, Inc.)

Fundamentals of RF Design and Fabrication Processes of Fan-Out Wafer/Panel Level Packaged and Interposers
Live Presentation: Monday, June 14, 10:00 AM – 1:00 PM EDT

Live Q&A: Monday, June 21, 10:00 AM – 11:00 AM EDT

Course Leaders: Ivan Ndip and Markus Wöhrmann (Fraunhofer IZM)

Eliminating Package Failure Mechanisms for Improved Reliability
Live Presentation: Thursday, June 3, 7:00 PM – 10:00 PM EDT

Live Q&A: Wednesday, June 23, 12:00 PM – 1:00 PM EDT

Course Leader: Darvin Edwards (Edwards Enterprises)

Characterization of Advanced EMCs for FO-WLP, Heterogeneous Integration, and Automotive Electronics
Live Presentation: Thursday, June 3, 10:00 AM – 1:00 PM EDT

Live Q&A: Tuesday, June 22, 10:00 AM – 11:00 AM EDT

Course Leaders: Przemyslaw Gromala (Robert Bosch GmbH)

Reliable Integrated Thermal Packaging for Power Electronics
Live Presentation: Friday, June 4, 10:00 AM – 1:00 PM EDT

Live Q&A: Wednesday, June 23, 10:00 AM – 11:00 AM EDT

Course Leader: Patrick McCluskey (University of Maryland)

Flip Chip Technologies
Live Presentation: Monday, June 7, 10:00 AM – 1:00 PM EDT

Live Q&A: Thursday, July 1, 10:00 AM – 11:00 AM EDT

Course Leaders: Eric Perfecto (GLOBALFOUNDRIES) and Shengmin Wen (Synaptics Inc.)

Wafer-Level Chip-Scale Packaging (WCSP) Fundamentals
Live Presentation: Tuesday, June 8, 10:00 AM – 1:00 PM EDT

Live Q&A: Thursday, June 24, 12:00 PM – 1:00 PM EDT

Course Leader: Patrick Thompson (Texas Instruments, Inc.)

Additive Flexible Hybrid Electronics – Manufacturing and Reliability
Live Presentation: Tuesday, June 8, 7:00 PM – 10:00 PM EDT

Live Q&A: Friday, June 25, 12:00 PM – 1:00 PM EDT

Course Leader: Pradeep Lall (Auburn University)

Fan-Out Wafer/Panel Level Packaging and 3D Chiplet Heterogeneous Integration
Live Presentation: Wednesday, June 9, 7:00 PM – 10:00 PM EDT

Live Q&A: Friday, June 25, 8:00 PM – 9:00 PM EDT

Course Leader: John Lau (Unimicron Technology Corporation)

Polymers in Wafer Level Packaging
Live Presentation: Wednesday, June 9, 10:00 AM – 1:00 PM EDT

Live Q&A: Friday, June 25, 10:00 AM – 11:00 AM EDT

Course Leader: Jeffrey Gotro (InnoCentrix, LLC)

Reliability Mechanics and Modeling for IC Packaging
Live Presentation: Thursday, June 10, 7:00 PM – 10:00 PM EDT

Live Q&A: Monday, June 28, 10:00 PM – 11 PM EDT

Course Leaders: Ricky Lee (HKUST) and Xuejun Fan (Lamar University)

From Wafer to Panel Level Packaging
Live Presentation: Thursday, June 10, 10:00 AM – 1:00 PM EDT

Live Q&A: Monday, June 28, 10:00 AM – 11:00 AM EDT

Course Leaders: Tanja Braun and Michael Töpper (Fraunhofer IZM)

Thermal Management of Electronics
Live Presentation: Friday, June 11, 10:00 AM – 1:00 PM EDT

Live Q&A: Monday, June 28, 12:00 PM – 1:00 PM EDT

Course Leader: Jaime Sanchez (Intel Corporation)

CONFERENCE TECHNICAL PROGRAM

TRACKS & SESSIONS

COMPONENT-LEVEL THERMAL MANAGEMENT

- TI-1: Heat Sinks
- TI-2: Cold Plates
- TI-3: Thermosyphons
- TI-4: Two Phase Cooling
- TI-5: Thermal Analysis and Modeling I
- TI-6: Thermal Analysis and Modeling II
- TI-7: Thermal Analysis and Modeling III
- TI-8: Data Center Cooling
- TI-9: Equipment Cooling
- TI-10: Jet Impingement
- TI-11: Vapor Chambers and Heat Pipes I
- TI-12: Vapor Chambers and Heat Pipes II
- TI-13: TIMs, LEDs, and Discrete Devices
- TI-14: Power Electronics

SYSTEM-LEVEL THERMAL MANAGEMENT

- TII-1: Air Cooling Techniques and Heat Exchangers
- TII-2: Air Cooling Techniques and Heat Exchangers II
- TII-3: Liquid Cooling
- TII-4: Liquid Cooling II
- TII-5: Advanced Modeling of Thermal Systems
- TII-6: Thermal Management in Electric Aircraft
- TII-7: Mobile Thermal Management and IoT
- TII-8: Data Center Thermal Management
- TII-9: Phase Change Thermal Systems
- TII-10: Batteries and Thermal Storage
- TII-11: Next-Gen Electronics Systems Co-Design

EMERGING TECHNOLOGIES & FUNDAMENTALS

- E-1: Machine Learning and Data Science
- E-2: Additive Manufacturing
- E-3: Boiling, Condensation, And Two-Phase
- E-4: Measurement and Diagnostic Techniques
- E-5: Convection in Microchannels, Jets, And Porous Materials
- E-6: Micro and Nanoscale Thermal Transport

MECHANICS & RELIABILITY

- M-1: Characterization of Polymers
- M-2: Prognostics and Health Management of Electronics
- M-3: Thermo-Mechanical Assessment
- M-4: Mechanical Shock and Vibration
- M-5: Power Electronics
- M-6: Flexible Electronics
- M-7: Automotive Electronics
- M-8: Material Characterization
- M-9: Compact Modeling
- M-10: Solder Joint Fatigue

TRACKS, SESSIONS, AND PRESENTATIONS

TRACK TI: COMPONENT-LEVEL THERMAL MANAGEMENT

SESSION TI-1: HEAT SINKS

Session Chairs: Brian Donovan (Unites States Naval Academy), K. Matsumoto (IBM)

Compact modeling of the pin-fin heat sink with variable fin density cooled by natural convection (p157)
Young Jin Lee, Sung Jin Kim (KAIST)

Twisted Offset Strip Fin Heat Sink for Power Electronics Cooling (p203)
Ahmed Elkholy, Omar Khaled, Roger Kempers (York University)

Package-Level Integration of Liquid Cooling Technology with Microchannel IHS for High Power Cooling (p211)
Je-Young Chang, Devdatta Kulkarni, Ravi Mahajan, Michael Jorgensen, Nick Neal, Rich Dischler,
Aravind Dasu, Sandeep Ahuja, Rajiv Mongia (Intel Corporation)

Revisiting the optimal thickness profile of cooling fins: A one-dimensional analytical study using optimality conditions (p384)
Joe Alexandersen (University of Southern Denmark), Ole Sigmund (Technical University of Denmark)

SESSION TI-2: COLD PLATES

Session Chairs: Jonathan Felts (TAMU), Franklin Robinson (NASA Goddard Space Flight Center)

Thermal Performance Characterization of Stacked Silicon Microcoolers for Spatially Non-Uniform Power Dissipation (p186)
Aakrati Jain, Risa Miyazawa, Dishit Parekh, Marc Bergendahl, Kamal Sikka (IBM Research)

Effect of Channel Aspect Ratio and Fin Geometry on Fluid Flow and Heat Transfer Performance of Sectional Oblique Fin Microchannels (p194)
Vaibhav Rudragoudar, Harish Chhatija, Sanskar Panse, Srinath Ekkad (North Carolina State University)

Integrated Stacked Silicon Microcoolers (p270)
Marc Bergendahl, Aakrati Jain, Dishit Parekh, Iqbal Saraf, Ravi Bonam, Kamal Sikka, Dario Goldfarb, Hongqing Zhang, Ed Cropp, Risa Miyazawa, Keiji Matsumoto, Takashi Hisada, Hiroyuki Mori (IBM Research)

SESSION TI-3: THERMOSYPHONS

Session Chairs: Michael Fish (US Army Research Laboratory)

Air cooled loop thermosyphon cooling system for high heat load CPUs: design and performance simulation (p125)
Jackson Marcinichen (JJ Cooling Innovation SARL), Guilherme Armas (Instituto Superior Tecnico Universidade De Lisboa), Gautier Rouaze, John Thome (JJ Cooling Innovation SARL), L Winston Zhang (Novark Technologies Inc)

Experimental evaluation and simulation validation of an air cooled loop thermosyphon designed for high heat load CPUs (p126)
Guilherme Armas (Instituto Superior Tecnico Universidade De Lisboa), Gautier Rouaze, Jackson Marcinichen, John Thome (JJ Cooling Innovation SARL), L Winston Zhang (Novark Technologies Inc)

Two-Phase Closed-Loop Thermosyphon Filled with a Dielectric Liquid for Electronics Cooling Applications (p199)
Omidreza Ghaffari, Chady Al Sayed, Manuel Vincent, Yaser Nabavi Larimi (Universite de Sherbrooke), Francis Grenier, Simon Jasmin (Systemex Energies Inc), Luc Frechette, Julien Sylvestre (Universite de Sherbrooke)

SESSION TI-4: TWO PHASE COOLING

Session Chairs: Adam Wilson (US Army Research Laboratory)

Preliminary study on the boiling heat transfer performance of R-123 refrigerant with nano-porous aluminum oxide membrane (p162)
Ji Yong Kim, In Cheol Bang (Ulsan National Institute of Science and Technology)

Performance of Two-Phase Cooling Technologies that Use Water as a Working Fluid under Sub-Ambient Pressures (p195)
Paul Diglio, Je-Young Chang, Devdatta Kulkarni, David Shia, Pooya Tadayon (Intel Corp)

Development of microgravity boiling experiments aboard the ISS from terrestrial adverse gravity outcomes for a ratcheted microstructure with engineered nucleation sites (p317)
Karthekeyan Sridhar (Auburn University), Vinod Narayanan (University of California Davis), Sushil Bhavnani (Auburn University)

SESSION TI-5: THERMAL ANALYSIS AND MODELING I

Session Chairs: Herman Oprins (Imec), Bo Dan (Microsoft)

Artificial Neural Networks for Package Thermal Analysis (p127)
Kamal Sikka, Rahul Lall, Tuhin Sinha (IBM)

Analytical Solution for a Chip Temperature Distribution in a Multilayer Chip-Package with Thermal Warpage (p143)
Aakrati Jain, Dishit Parekh, Marc Bergendahl, Kamal Sikka (IBM Research)

Optimization of an Embedded Phase Change Material Cooling Strategy Using Machine Learning (p147)
Meghavin Bhatasana, Amy Marconnet (Purdue University)

SESSION TI-6: THERMAL ANALYSIS AND MODELING II

Session Chairs: Aakrati Jain (IBM), Ankur Miglani (IIT Indore)

Methodology for Accurate Hotspot Prediction by Upscale Spatiotemporal Resolution of Temperature Sensing using Power meter and Resistor-Capacitor Thermal Model (p299)
Taekeun An, Jongkyu Yoo, Yunhyeok Im (Samsung Electronics)

A Bayesian deconvolution application to calibrate multi-port RC network representation of electronic packages (p301)
Quentin Dupuis (Universite Paris Nanterre, Thales Global Services), Valentin Bissuel (Thales Global Services), Najib Laraqi, Jean-Gabriel Bauzin (Universite Paris Nanterre), Oliver Daniel (Thales Global Services)

Thermal analysis for 3D functional partitioning for high-performance systems (p334)
Herman Oprins, Dragomir Milojevic, Geert Van Der Plas, Eric Beyne (Imec)

SESSION TI-7: THERMAL ANALYSIS AND MODELING III

Session Chairs: Scott Schiffres (State University of New York Binghamton), Gilberto Rayas (Intel)

A kind of node number selection method for electrical machine lumped-parameter thermal model based on the systematic bias (p105)
Zhiyu Sheng (Southeast University), Dong Wang (National Key Laboratory of Science and Technology On Vessel Integrated Power System)

Assessing the impact of novel polymers and thermal management in a power electronics module using machine learning approaches (p114)
Palash Acharya, Manojkumar Lokanathan, Abdelhamid Ouroua, Robert Hebner, Shannon Strank, Vaibhav Bahadur (The University of Texas At Austin)

Lumped Parameter Thermal Network Modelling of Power Transformers (p155)
Anshuman Dey (University of British Columbia), Navid Shafiei, Rahul Khandekar (Alpha Technologies Ltd), Wilson Eberle, Ri Li (University of British Columbia)

SESSION TI-8: DATA CENTER COOLING

Session Chairs: Dishit Parekh (IBM), Piyas Chowdhury (Juniper Networks)

FSW manufacturing process of cold plates compared to brazing for data center liquid cooling (p173)
Yuehong Fan, Jin Yan, Jimmy Chuang (Intel)

An Advanced Server System Design with 3-Dimensional Vaper Chamber Heat Sink Solution (p180)
Ruiyu Sun, Qingming Fu, Guofeng Chen, Yongwei Li (JD Technology Group), Jun Zhang, Yingqiong Bu, Jing Liu, Nishi Ahuja, Qing Qiao (Intel)

Low-pressure heat transfer fluids for pumped two-phase cooling (p290)
Nitin Karwa, Samuel Yana Motta (Honeywell International Inc)

SESSION TI-9: EQUIPMENT COOLING

Session Chairs: Marc Bergendahl (IBM)

Study of the Optimal Design of a DC Contactor with an Electromagnetic-Thermal Coupling Analysis Workflow (p171)
Ha Su Kim, Young Kook Kim, Ho Jun Lee, Kilyung Ahn (LS ELECTRIC), Lee Myunghoon, Tomoya Horiuchi (Ansys Korea), Young Geun Kim (LS ELECTRIC)

Thermoelectric Power System Economics-The APEX: New Paradigms in Manufacturing and Interface Performance Relationships Driving System Cost Optimization (p294)
Terry Hendricks (NASA-Jet Propulsion Laboratory)

On cold plate corrosion with propylene glycol/water coolant (p310)
David Shia, Jin Yang, Sean Sivapalan, Rithi Soeung, Christia Amoah-Kusi (Intel Corporation)

SESSION TI-10: JET IMPINGEMENT

Session Chairs: Risa Miyazawa (IBM), Devdatta Kulkarni (Intel)

Performance analysis of impingement chip-attached micro pin fin direct liquid cooling package for hotspot targeted applications (p144)
Vahideh Radmard, Arad Azizi, Srikanth Rangarajan, Najmeh Fallahtfi, Cong Hiep Hoang, Ghazal Mohsenian (Binghamton University), Koursh Nemati (Future Facilities), Scott Schiffres, Bahgat Sammakia (Binghamton University)

Numerical Investigation of Liquid Jet Impingement for Power Electronics Cooling in Electrified Transportation (p154)
Samantha Jones-Jackson, Romina Rodriguez (McMaster University), Manoj Gokhale (Eaton Corporation), Ali Emadi (McMaster University)

Two-phase Impingement Cooling using a Trapezoidal Groove Microchannel Heat Sink and Dielectric Coolant HFE 7000 (p159)
Cong Hiep Hoang, Srikanth Rangarajan, Vahideh Radmard, Mohammad Tradat (Binghamton University), Charles Arvin (IBM Corporation), Scott Schiffres, Bahgat Sammakia (Binghamton University)

SESSION TI-11: VAPOR CHAMBERS AND HEAT PIPES I

Session Chairs: Tuhin Sinha (IBM)

Vapor Chamber Thermal Diode with Laser fabricated Wickless Components (p190)
George Damoulakis (University of Illinois At Chicago), Graham Kaufman, Alfred Tsubaki, George Gogos, Craig Zuhlke (University of Nebraska Lincoln), Constantine Megaridis (University of Illinois At Chicago)

Thermal Resistance-Capacitance Network Model for a PCM Coupled Heat Pipe (p296)
Venu Hanumanthugari, Karthik G M (Indian Institute of Science Bangalore), Venkata Raghavendra (Indian Space Research Organization Bangalore), Pramod Kumar (Indian Institute of Science Bangalore), Amrit Ambirajan (Independent Consultant)

SESSION TI-12: VAPOR CHAMBERS AND HEAT PIPES II

Session Chairs: Jeffrey Didion (NASA), Omidreza Ghaffari (University of Sherbrooke)

Measurement of Variable Conductance Ultrathin Vapor Chambers to Double the Capillary Limit During Transient Startup (p207)
Ryan Lewis (Kelvin Thermal Technologies), YC Lee (University of Colorado)

Experimental investigation of low-profile heat pipe with wickless wettability-patterned condenser (p220)
Mohamad Jafari Gukeh, George Damoulakis, Constantine Megaridis (University of Illinois At Chicago)

Experimental Characterization of Cascaded Vapor Chambers for Spreading of Non-Uniform Heat Loads (p279)
Soumya Bandyopadhyay, Norawish Lohitnavy, Amy Marconnet, Justin Weibel (Purdue University)

SESSION TI-13: TIMS, LEDS, AND DISCRETE DEVICES

Session Chairs: Anil Yuksel (IBM)

Thermal and Optical Characterization of White and Blue Multi-Chip LED Light Engines (p108)
Ceren Cengiz, Mohammad Azarifar, Mehmet Arik (Ozyegin University)

Improving thermally limited burst performance of microprocessors using high conductivity graphite spreaders (p112)
Ravishankar Srikanth, Bhargav Nandigama (Intel Corporation)

Gallium Infiltration of Porous Metal Foams (p364)
Michael Fish, Adam Wilson, Brenden Hanrahan, Claude Pullen (US Army Research Laboratory)

SESSION TI-14: POWER ELECTRONICS

Session Chairs: Yuanchen Hu (IBM), Simon Jasmin (Systemex Energies)

Dielectric Fluids for the Direct Forced Convection Cooling of Power Electronics (p132)
Brian Kelly (Georgia Institute of Technology and National Renewable Energy Laboratory), Gilbert Moreno (National Renewable Energy Laboratory), Steve Meyers (BorgWarner), Sreekant Narumanchi (National Renewable Energy Laboratory), Yogendra Joshi, Samuel Graham (Georgia Institute of Technology)

Heat Spreading and Heat Removal Needs of a Novel Power Electronics Package with Integrated Cooling (p248)
Ahmet Mete Muslu, Ryan Wong, Vanessa Smet, Yogendra Joshi (Georgia Institute of Technology)

The effectiveness of heat extraction by the drain metal contact of β-Ga_2O_3 MOSFETs (p345)
Samuel Kim (Georgia Institute of Technology), Daniel Shoemaker, Bikramjit Chatterjee (Pennsylvania State University), Kelson Chabak, Andrew Green, Kyle Liddy, Gregg Jessen (Air Force Research Laboratory), Samuel Graham (Georgia Institute of Technology), Sukwon Choi (Pennsylvania State University)

TRACK TII: SYSTEM-LEVEL THERMAL MANAGEMENT

SESSION TII-1: AIR COOLING TECHNIQUES AND HEAT EXCHANGERS I

Session Chairs: Nicholas Neal (Intel), Prabhakar Subrahmanyam (Intel), Manjunath C Rajagopal (University of Illinois at Urbana-Champaign)

On Characterizing Air-Flow-Through Chassis: An Investigation of Manifold Flow in Rugged Electronics Enclosures (p205)
Brandon Ealy, Jeffrey Van Anda, Dan Gallagher (Orion Technologies), David Vos (Lockheed Martin)

Potential Flow Modeling for Fast Data Center Thermal Simulation (p206)
Wei Tian, James VanGilder, Michael Condor (Schneider Electric)

On the Thermal Efficiencies of Cascading Heat Exchangers: An Experimental Approach - I (p382)
Prabhakar Subrahmanyam, Pooya Tadayon, Ying-Feng Pang, Arun Krishnamoorthy, Amy Xia (Intel Corporation)

On the Thermal Efficiencies of Cascading Heat Exchangers: An Algorithmic Approach - II (p383)
Prabhakar Subrahmanyam, Pooya Tadayon, Victor Polyanko, Paul Diglio, Rahima Mohammed, Mark Bianco (Intel Corporation)

SESSION TII-2: AIR COOLING TECHNIQUES AND HEAT EXCHANGERS II

Session Chairs: Shadi Mahjoob (California State University Northridge), Xiang Zhang (Oregon State University)

Heat Transfer Enhancements at Low-Pressure for Electromechanical Actuators (p333)
Jose Corona, Kamal Kaddoura, John Kizito (North Carolina Agricultural and Technical State University)

AI Assisted Fan Failure Prediction using Workload Fingerprinting (p348)
Derssie Mebratu, Rahul Khanna, Jaiber John (Intel Corporation), Romir Desai (Carnegie Mellon University)

SESSION TII-3: LIQUID COOLING I

Session Chairs: Enakshi Wikramanayake (Exponent), Patrick Shamberger (Texas A & M)

Advances in IBM Z Water Cooling: z13, z14, z15 (p124)
Dustin Demetriou, Milnes David, Cory VanDeventer, Randy Zoodsma (IBM)

Thermosyphon simulation code: transient thermal performance and experimental validation (p286)
Remy Haynau, Jackson Braz Marcinichen (JJ Cooling Innovation), Raffaele Luca Amalfi (Nokia Bell Labs), Filippo Cataldo (Provides Metalmeccanica), John Richard Thome (JJ Cooling Innovation. - EPFL)

SESSION TII-4: LIQUID COOLING II

Session Chairs: Farah Singer (University of Maryland), Martinus Arie (Virgin Galactic)

Two-Phase Immersion Cooling of Microprocessors with Electroplated Porous Heat Spreaders: Thermal Performance and Reliability (p151)
Chady Al Sayed, Omidreza Ghaffari, Seyedyaser Nabavi Larimi (University of Sherbrooke), Francis Grenier, Simon Jasmin (Sytemex Energies Inc), Luc Frechette, Julien Sylvestre (Department Of Mechanical Engineering University Of Sherbrooke)

Advanced Single-phase Passive Immersion Cooling Solution with Natural Convection for Outdoor Edge Servers (p185)
Liwen Guo, Jiahong Wu, I-Min Hsieh, Cheng-Hua Huang, Bo Li, Chiming Jao, Vinson Lin, Robert Yuan (Foxconn), Xianguang Tan, Xiaojin Fan, Zhenghui Wu, Yong Sheng, Yongzhan He, Jiajun Zhang (Baidu), Jun Zhang, Carrie Chen, Yuyang Xia, Wenqing Lv, Min Wu, Chris Du, Candy He, Jonas Zhang, Nishi Ahuja, Qing Qiao (Intel)

Hybrid Two-phase Cooling Technology for Next-generation Servers: Thermal Performance Analysis (p285)
Raffaele Luca Amalfi, Francois Pierre Faraldo, Todd Salamon, Ryan Enright (Nokia Bell Labs), Filippo Cataldo (Provides Metalmeccanica), Jackson Braz Marcinichen (JJ Cooling Innovation), John Richard Thome (JJ Cooling Innovation - EPFL)

Physically-derived Figure of Merit (FOM) Quantifying the Cooling Performance of Fluids in Laminar Free-surface Jet Impingement Cooling of Electrical Components (p322)
Claas Ehrenpreis, Hossein Askarizadeh (RWTH Aachen University Institute of Heat And Mass Transfer), Hakim El Bahi (TOTAL Marketing And Services Research Division), Huihui Xu (RWTH Aachen University Institute For Power Electronics And Electrical Drives), Gregoire Roux, Shimin Zhang (TOTAL Marketing And Services Research Divisionn), Reinhold Kneer, Wilko Rohlfs (RWTH Aachen University Institute Of Heat And Mass Transfer)

SESSION TII-5: ADVANCED MODELING OF THERMAL SYSTEMS

Session Chairs: Neera Jain (Purdue University), Taravat Khadivi (University of Texas At Arlington)

Thermal-Fluid Structural Interaction Modeling of Outdoor Digital Displays (p212)
Luis Diego Monge Jimenez (Georgia Institute of Technology), J Michael Brown (Manufacturing Resources International), Yogendra Joshi (Georgia Institute of Technology)

Compute at the Edge: Mechanical & Thermal Design Considerations (p222)
Joseph Hanson Vazquez, Stephen Langanke, Erich Ewy, Keith Swesey, Jared Shipman (Intel Corporation)

Optimization of PCM based Thermal Management Device for Power Electronics using an Effective Thermal Conductivity Model for Architected Enhancers (p265)
Romain Hubert, Olivier Bou Matar (University Lille), Jerome Foncin (Thales), Philippe Coquet (University Lille), Dunlin Tan (Thales), Hongling Li (Nanyang Technological University), Jong Jen Yu (Thales), Edwin Teo (Nanyang Technological University), Thomas Merlet (Thales), Philippe Pernod (Nanyang Technological University), Edwin Teo (Nanyang Technological University), Philippe Pernod (Centrale Lille)

SESSION TII-6: THERMAL MANAGEMENT IN ELECTRIC AIRCRAFT

Session Chairs: Harish Ganapathy (Intel Corporation), Krishna Vasanth Valavala (Intel), Amir Shooshtari (University of Maryland)

Development of Solid-State Waste Heat Delivery System for Electric Aircraft (p131)
Jeffrey Diebold, Kuan-Lin Lee, Calin Tarau, William Anderson (Advanced Cooling Technologies)

Hybrid Electric Aircraft Thermal Management: Now, New Visions and Future Concepts and Formulation (p344)
Terry Hendricks (NASA Jet Propulsion Laboratory), Calin Tarau (Advanced Cooling Technologies Inc), Rodger Dyson (NASA Glenn Research Center)

SESSION TII-7: MOBILE THERMAL MANAGEMENT AND INTERNET OF THINGS

Session Chairs: Ajit Vallabhaneni (Qualcomm Technologies Inc), Priyanka Tunuguntla (Intel)

DLAG-TA: Deep Learning-Based Adaptive Grid Builder for System-Level Thermal Analysis (p160)
Wen-Sheng Lo, Hong-Wen Chiou, Shih-Chieh Hsu, Yu-Min Lee (National Chiao Tung University)

Optimization of hotspot location on multi stacked board of mobile phone (p168)
Youngsang Cho, Jongkyu Yoo, Yunhyeok Im, Taekeun An, Heeseok Lee, Yun Heo (Samsung Electronics)

Characterizing the On-chip Temperature of an Off-the-shelf TSV-based 3D Stacked CPU (p264)
Ji Hun Kwon, Seung Hun Choi, Sung Woo Chung (Korea University)

SESSION TII-8: DATA CENTER THERMAL MANAGEMENT

Session Chairs: Prabhakar Subrahmanyam (Intel Corporation), Mahdi Nabil (Qualcomm Inc.)

Investigation of aisle containment solutions using detailed server simulation models in data centers (p120)
Yuanchen Hu (IBM), Dustin Demetriou (IBM Systems)

Thermal Design of Portable Modular High Performance Computing Data Centers (p189)
Anil Yuksel, Dustin Demetriou, Yuanchen Hu, Vic Mahaney (IBM)

A New Tile Model for Air Flow Distribution in a Full-Featured Data Center with Raised Floor Plenum (p217)
Cheng-Xian Lin, Beichao Hu (Florida International University), Dhaval Patel, Yogendra Joshi (Georgia Institute of Technology), Jim VanGilder (Schneider Electric), Mark Seymour (Future Facilities)

Novel pulsating heat pipe for high density power data centers: performance and flow regime analysis (p287)
Filippo Cataldo, Yuri Crea (Provides Metalmeccanica), Raffaele Luca Amalfi (Nokia Bell Labs), Jackson Braz Marcinichen (JJ Cooling Innovation), John Richard Thome (JJ Cooling Innovation - EPFL)

SESSION TII-9: PHASE CHANGE THERMAL SYSTEMS

Session Chairs: Alison Hoe (Texas A&M University), Patrick Shamberger (Texas A and M University)

A numerical study of HNCPCM filled metal-foam strips based heat sink for passive cooling (p116)
Adeel Arshad (University of Nottingham), Hamza Faraji (Hassan II University), Mark Jabbal, Yuying Yan (University of Nottingham)

Thermal cooling of electronics using hybrid nanoparticles dispersed PCM based finned heat sink (p117)
Adeel Arshad (University of Nottingham UK), Mohammed Ibrahim Alabdullatif (Islamic University of Madinah Saudi Arabia), Mark Jabbal, Yuying Yan (University of Nottingham UK)

Automated Parameterized CFD Simulations of Phase-Change Material Embedded Heat Exchangers (p200)
Daniel Bacellar, Tanjebul Alam, Jiazhen Ling, Vikrant Aute (University of Maryland)

Numerical Validation of Effective Specific Heat Functions for Simulating Melting Dynamics in Latent Heat Thermal Energy Storage Modules (p221)
Brendan Gillis (Purdue University), Neera Jain (Purdue University)

Experimental validation of composite phase change material optimized for thermal energy storage (p335)
Achutha Tamraparni, Alison Hoe, Michael Deckard, Chen Zhang, Alaa Elwany, Patrick Shamberger, Jonathan Felts (Texas A&M University)

SESSION TII-10: BATTERIES AND THERMAL STORAGE

Session Chairs: Raffaele Luca Amalfi (Nokia Bell Labs), Ratnesh Tiwari (University of Maryland)

Experimental Study on the Thermal Interactions in Novel Intelligent Lithium-Ion Modules for Electric Vehicles (p198)
Jan Kleiner, Alexander Heider, Lidiya Komsiyska, Christian Endisch, Gordon Elger (TH Ingolstadt)

An Advanced Distributed Backup Power Design with Lithium Iron Phosphate Battery for Data Center Energy Efficiency (p272)
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Jiangcheng Cao, Yufeng Jin (Peking University Shenzhen Graduate School), Wei Wang (Institute of Microelectronics Peking University)

Segmented Thermal Management with Flash Cooling for Heterogeneous Wafer-Scale Systems (p266)
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Pradeep Lall, Padmanava Choudhury (Auburn University), Jaimal Williamson (Texas Instruments)

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Session Chairs: Junichiro Shiomi (University of Tokyo), Matteo Bucci (MIT)

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Session Chairs: Joe Alexandersen (University of Southern Denmark), Eric Dede (Toyota)

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Pradeep Lall, Jinesh Narangaparambil, Kyle Schulze (Auburn University), Curtis Hill (Jacobs Space Exploration Group Quantitech NASA MSFC)

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Toward high-throughput thermal characterization of combinatorial thin-film solid state phase change materials (p309)
Adam Wilson, Darin Sharar, Jay Maddux, Michael Fish (US Army Research Laboratory), Iain Kierzewski (General Technical Services)

Finding the minimum quantity and the optimum placement of on-die temperature sensor in SOC design based on analyzing rank analysis (p350)
Heeseok Lee, Yunhyeok Im, Yunhyeok Im, Taekeun An, Young-Sang Cho, Jongkyu Yoo (Samsung Electronics)

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Session Chairs: Bladimir Ramos-Alvarado (Penn State University), Hyoungsoon Lee (Chung-Ang University)

Two-Fluid Modeling of Dense Particulate Suspensions for Electronics Cooling (p115)
Pranay Nagrani, Ivan Christov, Amy Marconnet (Purdue University)

A comparison between frictional and accelerational components of two-phase flow pressure drop in PEM fuel cell flow channels (p181)
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Uday Manda, Yoav Peles, Shawn Putnam (University of Central Florida)

Spatiotemporal wicking dynamics: The effects of pillar height, density, and anisotropic geometries (p277)
John Bal, Krishnan Siva Rama Manoharan, Shawn Putnam (University of Central Florida)

Numerical Study of Thermal Transport in Channel Flows Enhanced with Single and Multi Air Jet Impingement Cooling and Structured Target Surfaces (p280)
Arturo Garcia, Shadi Mahjoob (California State University Northridge)

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Session Chairs: Zhe Cheng (HUST), Ronald Warzoha (United States Naval Academy)

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Rajath Kantharaj, Carl Wassgren, Aaron Morris, Amy Marconnet (Purdue University)

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Mohammad Motalab, Md Faiyaz Jamil, Md Sagir Jony, Pritom Bose (Bangladesh University of Engineering and Technology), Jeffrey Suhling (Auburn University)

Effect of Lamination Parameters and Mechanical Folding on Li-Ion Battery Capacity Deterioration and SOH Degradation Rate (p242)
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Two-dimensional actuation of liquid-metal droplets for hot-spot cooling (p312)
Saige Dacuycuy, Wayne Shiroma, Aaron Ohta (University of Hawaii at Manoa)

ITherm 2020 PAPER AWARDS

The following papers received awards during last year's ITherm 2020 Virtual conference.

COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

BEST PAPER

Embedded Microchannel Cooling for High Power-Density GaN-on-Si Power Integrated Circuits

Remco Van Erp, Georgios Kampitsis, Luca Nela, Reza Soleimanzadeh Ardebili, Elison Matioli

OUTSTANDING PAPER

Heat Transfer and Two-Phase Flow Regimes in Manifold Microgaps: Performance Comparison Between R245fa and FC-27

David C. Deisenroth, Michael Ohadi, Avram Bar-Cohen

SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

BEST PAPER

General Thermosyphon Simulation Code for Electronics Cooling Applications

Jackson B. Marcinichen, Raffaele L. Amalfi, Filippo Cataldo, John R. Thome

OUTSTANDING PAPER

A Compact Rack Model for Data Center CFD Modeling

James VanGilder, Yatharth Vaishnani, Wei Tian, Michael Condor

EMERGING TECHNOLOGIES AND FUNDAMENTALS TRACK

BEST PAPER

Additively Manufactured Nitinol as a Solid-State Phase Change Material

Darin J. Sharar, Adam A. Wilson, Asher Leff, Andrew Smith, K. Can Atil, Alaa Elwany, Raymundo Arroyave, Ibrahim Karaman

OUTSTANDING PAPER

Mechanical Design and Reliability of Gold-Tin Eutectic Bonding for Silico-based Thermal Management Devices

Farid Soroush, Ki Wook Jung, Mehdi Asheghi, Madhusudan Iyengar, Chris Malone

MECHANICS AND RELIABILITY TRACK

BEST PAPER

Modelling Indium Interconnects for Ultra Fine-Pitch Focal Plane Arrays

Stoyan Stoyanov, Chris Bailey, Rhys Waite, Christopher Hicks, Terry Golding

OUTSTANDING PAPER

RUL Estimations of SAC305 Solder PCB's under Different Conditions of Temperature and Vibration

Pradeep Lall, Tony Thomas, Ken Blecker

ITHERM 2020 POSTER AWARDS

The following student posters received awards during last year's ITherm 2020 Virtual conference.

BEST OVERALL POSTER

Modeling Deformation Behavior of SAC305 Solder Joints with Multiple Grains
Debabrata Mondal, Auburn University

COMPONENT-LEVEL THERMAL MANAGEMENT TRACK

BEST POSTER

Phase change cooling of spacecraft electronics: Terrestrial reference experiments prior to ISS microgravity experiments

Karthekeyan Sridhar, Auburn University

OUTSTANDING POSTER

Coupled Electro-Thermal Analysis of Permanent Magnet Synchronous Motor for Electric Vehicles

Amitav Tikadar, Georgia Institute of Technology

SYSTEM-LEVEL THERMAL MANAGEMENT TRACK

BEST POSTER

Confined Immersion Cooling in Microscale Gaps

Albraa Alsaati, Purdue University

OUTSTANDING POSTER

Corrosion in liquid cooling systems with water based coolant - Part 1: Flow loop design for reliability tests

Girish Anant Kini, Georgia Institute of Technology

EMERGING TECHNOLOGIES AND FUNDAMENTALS TRACK

BEST POSTER

Fabrication of compliant interconnects using additive manufacturing

Khan Md. Rabbi, University of Central Florida

OUTSTANDING POSTER

Effect of Dynamic Folding with Varying Fold Orientations and C-rates on Flexible Power Source Capacity Degradation

Ved Soni, Auburn University

MECHANICS AND RELIABILITY TRACK

BEST POSTER

Fabrication of compliant interconnects using additive manufacturing

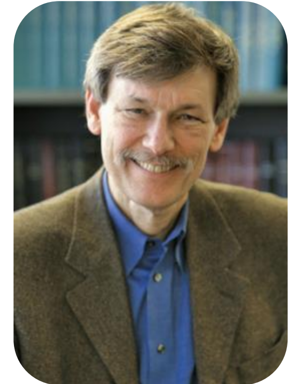
Tumininu Olatunji, University of Arkansas

OUTSTANDING POSTER

Compatibility Analysis of Liquid Gallium and Common Packaging Metals for Applications in Electronic Component Thermal Management

Rachel McAfee, Oregon State University

PROFESSOR AVRAM BAR-COHEN ITherm BEST PAPER AWARDS



The IEEE ITherm Conference (sponsored by IEEE Electronic Packaging Society) is honored to announce the establishment of the **Professor Avram Bar-Cohen Best Papers** of the conference beginning with the 2021 conference year. There will be four such Awards, one for each Track of the conference:

1. Prof. Avram Bar-Cohen Best Paper in Component-Level Thermal Management
2. Prof. Avram Bar-Cohen Best Paper in System-Level Thermal Management
3. Prof. Avram Bar-Cohen Best Paper in Mechanics and Reliability
4. Prof. Avram Bar-Cohen Best Paper in Emerging Technologies and Fundamentals

Prof. Avram Bar-Cohen, Distinguished University Professor in the A. James Clark School of Engineering, Department of Mechanical Engineering, University of Maryland, College Park, passed away on October 10, 2020. He was 74. Avi, as he is fondly known to all of us, was an eminent researcher in the science and art of heat transfer, particularly as it is applied to the cooling of electronic devices and systems. He was a guiding force in the emergence of thermal management of electronic devices and systems as a critical engineering domain. Since his passing, a lot has been written highlighting his accomplishments and contributions.

In collaboration with his colleagues, Avi showed a great vision in starting the ITherm Conference series in 1988 as a companion conference to the broader IEEE Electronic Packaging Society's (at that time CHMT, later CPMT) flagship packaging conference, ECTC, by focusing ITherm on thermal and thermo-mechanical aspects of the electronic devices and systems. He envisioned ITherm as a stand-alone conference to better serve the needs of researchers and engineers in these areas. By co-locating with ECTC, the relevance and interconnectedness of the ITherm goals to the future of packaging technologies have been demonstrated over the years. In the early years of ITherm, he and his colleagues guided ITherm to become what it is today, a premier conference to exchange ideas, and report on the latest advances in thermal management and thermo-mechanical aspects of electronic devices. He served twice as its General Chair, setting high goals and standards for the papers presented. He encouraged ITherm leadership over the years to reach out to a wide range of audiences, from first year graduate students to senior researchers, and to participants from all over the globe. Over the years, he mentored the conference leadership to adapt to continuous changes in technology so that the conference remains relevant and current. He made sure that there was a continuous leadership chain for successive conferences well into the future. He and his colleagues who started ITherm planted a sapling in 1988, which has emerged into a big tree that provides a forum to discuss and disseminate the latest in the field.

We recall him joking at the 10th ITherm or so, with several of us present, with his ever-present mischievous smile, that all of us would be attending the 25th ITherm with a walking stick, bent backs, with eye-glasses at the edge of our noses and asking "say what" with our hand cupped around our ear. In those days, ITherm was held once every two years and he was looking to ITherm 2030 and beyond. Naming the Best Papers of ITherm in his honor is a small token of the ITherm Community's appreciation of what Avi created in 1988 with his colleagues and sustained over the years with his vision and leadership. We are all enjoying the fruits of it today and we are sure the Community will do the same for many years to come. Thank you, Avi.

ITherm 2021 PAPER AWARDS SELECTION COMMITTEE

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