SEMI-THERM 33

SEMI-THERM 33rd Annual Symposium & Exhibit
Thermal Measurement, Modeling and Management Symposium
March 13th - March 17th 2017
Thermal Innovations that Make the World's Technology Cool

San Jose, California at the Doubletree by Hilton
For program details, registration, exhibition and hotel information
visit **WWW.SEMI-THERM.ORG** today!

Pre-conference short-courses from world-class thermal experts
Networking opportunities with industry leaders & innovators
Over 50 expert-reviewed papers presented by the brightest thermal professionals and educators

Technical Sessions

Auto/Aerospace/Outdoor (2)
Simulation (2)
Data Center (2)
2Phase
Heat Sinks
Measurement
TIM
LED

SEMI-THERM 33 will feature a Data Center Track, an entire track dedicated to addressing the impact of thermal design of IT equipment on the performance of the modern data center.

Dialog Session

App Development Challenge

Free "How-to" courses developed to introduce practical knowledge of thermal issues to technical and marketing personnel

Program includes evening events and luncheon speakers

THERMI, Harvey Rosten and Thermal Hall of Fame Award presentations

Two-day SEMI-THERM exhibition with over 40 vendors and vendor workshops presenting the most recent technical information

Complimentary receptions Monday and Wednesday evenings.
Take advantage of these opportunities to network with thermal experts

Platinum Sponsors: Mentor Graphics and Future Facilities

SEMI-THERM 33

SEMI-THERM®

KEYNOTE Tuesday March 14, 2017

Ultimately Dense and Efficient Future Computers

Liquid cooling enables an unprecedented density in future computers to a level similar to a human brain. This is mediated by a dense 3D architecture for interconnects, fluid cooling, and power delivery of energetic chemical compounds transported in the same fluid. Vertical integration improves memory proximity and electrochemical power delivery creating valuable space for communication. This strongly improves large system efficiency thereby allowing computers to grow beyond exa-scale. A dense and efficient µServer has been demonstrated as a first milestone along this roadmap. A universal concept is presented showing that volumetric density drives efficiency in information processing irrespective of switch technology and architecture, and can replace the currently slowing Moore's law. By adopting some of the characteristics of the human brain, computers have the potential to become far more compact, efficient, and powerful. And this, in turn, will allow us to take full advantage of cognitive computing – providing our real brains with new sources of support, stimulus, and inspiration.

Bruno Michel received a Ph.D. degree in biochemistry/biophysics from the University of Zurich. He subsequently joined IBM Research to work on scanning probe microscopy and later on the development of accurate large-area soft lithography. Dr. Michel started the Advanced Micro Integration group to improve thermal interfaces and minaturized convective cooling for processors and concentrated photovoltaic systems. Main current research topics of the Zurich group are microtechnology/microfluidics for nature-inspired minaturized tree-like hierarchical supply networks, 3D packaging, and thermophysics for improved understanding of heat transfer in nanomaterials and structures. Dr. Michel started the energy aware computing initiative at IBM and triggered the Aquasar project to promote improved efficiency and energy re-use in future green datacenters and photovoltaic thermal solar concentrators.

DATA CENTER KEYNOTE Wednesday, March 15, 2017

A Holistic View of a Fragmented Data Center Industry

SEMI-THERM and AFCOM are excited to have Dr. Sammakia provide the keynote speech for the Data Center Track at SEMI-THERM 33. Dr. Sammakia's experience spans the full physical scale of IT systems (chip to chiller) and the evolution of the data center from mainframe rooms to today's distributed and cloud computing facilities. Please join us for Dr. Sammakia's unique perspective on how data centers and IT systems have evolved over the decades, the impact of this history on engineering practices and computing performance (with a focus on the gap between IT and facilities) and where the industry is likely to head into the future.

Dr. Bahgat Sammakia is a Distinguished SUNY Professor and the vice president for research at Binghamton University. Dr. Sammakia has spent much of his research career working to improve thermal management strategies in electronic systems at multiple scales ranging from devices to entire Data Centers. Dr. Sammakia joined the faculty of the Watson School for Engineering and Applied Science in 1998 following a fourteen-year career at IBM where he worked in the area of research and development of organic electronic systems. He has contributed to several books on natural convection heat transfer and is also the principal investigator or co-principal investigator on several cross-disciplinary research projects. Dr. Sammakia received his PhD degree in mechanical engineering from the State University of New York at Buffalo. He was a post doctoral fellow at the University of Pennsylvania from 1982 to 1984. Dr. Sammakia is a Fellow of the IEEE, the ASME and of the National Academy of Inventors. Dr. Sammakia has over 250 publications in refereed journals and conference proceedings as well as several books and book chapters related to electronic systems thermal management.

Luncheon Speaker Tuesday, March 14, 2017

Multi-Scale Optimization Strategies for Electronics Thermal Management & Energy Harvesting
Ercan M. Dede

The compact and power-dense nature of advanced electronics is expected to push the limits of traditional thermal management techniques. At the same time, low-grade waste heat represents a tangible source of inefficiency for future electrified systems. Exploiting effective design optimization strategies in the research and development of new cooling and material technologies enables opportunities for increased system performance. Accordingly, gradient-based structural optimization methodologies and their implementation at multiple scales is the focus of this talk. Specifically, electronics thermal management and waste heat recovery are explored as end applications. At the component level, several case studies are presented to illustrate the technical approach for air, single-phase liquid, and two-phase cooling of automotive power electronics. At the material level, thermal composite printed circuit board design for informed heat flow control and energy harvesting is outlined. Through these various examples, multi-scale optimization is revealed to be an essential element in the drive towards novel high performance thermal energy management technologies.

Ercan M. Dede received his B.S. and Ph.D. degrees in mechanical engineering from the University of Michigan and an M.S. degree in mechanical engineering from Stanford University. Currently, he is a manager in the Electronics Research Department at the Toyota Research Institute of North America. His group conducts research on advanced vehicle electronics systems including power semiconductors, advanced circuits, packaging, and thermal management technology. He has over 30 issued patents and has published more than 40 articles in archival journals and conference proceedings on topics related to design and structural optimization of thermal, mechanical, and electromagnetic systems.

Luncheon Speaker Wednesday, March 15, 2017
Reducing Earthquake Hazards at Manufacturing Facilities
Guna Selvaduray, Ph.D.

Since the Loma Prieta Earthquake of October 17, 1989 the San Francisco Bay Area has not experienced a major earthquake. This presentation will begin with a brief description of the earthquake threat faced by the urbanized SF Bay Area, with a focus on the fault lines that run through this region. The major part of this presentation will focus on the damage that the industries in the Kansai Region in Japan experienced during the Kobe Earthquake of Jan 17, 1995, and the lessons that were learned from that unfortunate experience. Examples (slides) of damage to buildings and equipment, a summary of the research findings intended to reduce damage and accelerate recovery, and mitigation measures that can be taken ahead of time to reduce damage, especially for production and laboratory equipment will constitute a major part of this presentation.

Dr. Guna Selvaduray earned his M.S. and Ph.D. degrees from Stanford University and his B. Eng. degree from Tokyo Institute of Technology. His research has focused on nonstructural hazard mitigation, hazardous materials problems caused by earthquakes, and protection of building contents and plant equipment from earthquake damage. He has been the recipient of research grants from the National Science Foundation, the Department of the Interior and the California State Government. At San Jose State University, Dr. Selvaduray created the Collaborative for Disaster Mitigation (CDM), a public-private-academic partnership that has focused on implementing hazard mitigation in order to achieve loss reduction.

SEMI-THERM 33

SEMI-THERM®

Short Courses Monday, March 13, 2017

Short Courses Included with SEMI-THERM 33 Full Symposium Registration.

Short Course 1 **Morning**

A History of Commercial CFD from Bernoulli to Spalding and Beyond, with a Focus on Electronics Cooling Simulation

Robin Bornoff, Mentor Graphics **John Parry, Mentor Graphics**

Since the early 1980s, commercially available CFD tools have evolved to play a central role in engineering design today. Limited by available compute power, CFD technologies were devised that offered usefully accurate results but required a high level of both fluid dynamics and programming skills. The last 3 decades have seen a revolution in the industrial adoption of commercial CFD, and widespread adoption for electronics cooling, due to compute power limits being relaxed, novel techniques developed, and usability enhanced.

This review format short course tracks the rise of commercial CFD, in terms of technological capability, the impact of an ever-evolving hardware compute roadmap, integration into a wider design environment, and changing user persona. The course will review the lessons learnt during this period, from compact modelling of complex and IP-restricted electronic parts, through to pragmatic approaches that bring the power of simulation to bear on the initial architectural phase of product design. Results of illustrative examples will be used to show how CFD has impacted different aspects of thermal design across packaging levels and stages in the development process.

By appreciating the current state-of-the-art in the context of its history, the course will help both current and future practitioners apply CFD to their electronic thermal management design work, and better prepare for how CFD and its evolution can assist with future challenges. The course will also be of value to people managing the thermal design activity within their organization.

Robin Bornoff attained a Mechanical Engineering Degree from Brunel University in 1992 followed by a PhD in 1995 for CFD research. He then joined Mentor Graphics Corporation, Mechanical Analysis Division (formerly Flomerics Ltd) as an application and support engineer, specializing in the application of CFD to electronics cooling and the design of the built environment. Having been the Product Marketing Manager responsible for the FloTHERM and FloVENT products, he is now Market Development Manager for the Physical Design of Electronics in the Mechanical Analysis Division.

John Parry attained a Chemical Engineering Degree from Leeds University in 1982, and a PhD in 1988. He joined Mentor Graphics Corporation's Mechanical Analysis Division, when it was founded as Flomerics in 1989 to manage its customer services operation, and later head its research activities. John has coordinated several collaborative research and knowledge transfer projects, and oversaw the technical integration of MicReD into Flomerics' business. He has experience in compact modeling of fans, IC & LED packages, heatsinks, DoE & optimization methods, and thermal characterization, with over 75 published technical articles. He is a member of JC15 and past chair of SEMI-THERM and has 4 patents pending.

Short Course 2 **Morning** **Monday, March 13, 2017**

Fundamentals of Liquid Cooling: From Fluid Selection to Phase Change

Timothy Shedd, Ebullient Inc.

This short course will provide attendees with the tools they need to design liquid-cooled thermal management systems for virtually any challenge they may face. The course will begin with a review of the engineering fundamentals that form the basis for design and prediction of convective heat transfer on simple and complex surfaces. Next, we will apply these fundamentals to develop an objective, thermodynamic criterion for comparing arbitrary fluids on their merits. Proceeding to single-phase flows, we will compare the tradeoffs of different surface enhancements as well as employing more advanced techniques, including spray and jet impingement. We will look at practical examples of natural convection and how to estimate the performance of immersion cooling, which can be quite effective without active pumps. The final section of the course will cover an introduction to boiling and how to employ phase change in electronics cooling. Every topic in the course will be accompanied by practical examples and solutions methods that can be implemented, where possible, in common spreadsheet software.

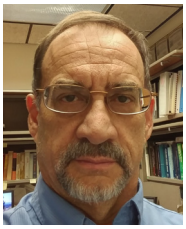
Dr. Timothy Shedd had an early passion for technology and sustainable energy which led him to obtain a B.S. in Electrical Engineering from Purdue University in 1992. He began working with the Semiconductor Engineering Group at Digital Equipment Corporation (now part of Intel), and was a designer of the world's fastest commercial CPUs from 1988 through 1995. At DEC, Dr. Shedd first learned how computing power was limited by heat produced at the chips, and he helped to design one of the first commercial CPUs with active power control. Dr. Shedd completed M.S. and Ph.D. degrees in Mechanical Engineering from the University of Illinois at Urbana-Champaign. He became a professor of Mechanical Engineering at the University of Wisconsin-Madison in 2001, publishing over 45 peer-reviewed journal articles and many more conference and symposia publications. Dr. Shedd founded Ebullient in 2012. He is now full time with Ebullient as its CEO and CTO.

Short Course 3 **Morning** **Monday, March 13, 2017**

Transient Thermal Analysis Using Linear Superposition

Roger Stout, ON Semiconductor

The mathematical principle of linear superposition is a powerful and useful method of analyzing many thermal problems. This course will show how it may be applied to semiconductor and more general electronics packaging and system situations, in particular for time-varying power inputs to single and multiple heat-source applications. The "method of images" will be demonstrated for creating transient simulations of certain classes of non-symmetric thermal problems from simpler solutions. The use and significance and implications of Foster and Cauer thermal RC networks for transient analysis will be covered. Various features of Microsoft Excel as a tool for performing thermal analysis will be presented, including the use of Visual Basic. Multiple heat-source steady-state thermal problems, are, of course, a special case of transient analysis and will also be considered. Limitations of linear superposition will be discussed.



Roger Stout received his BSE in Mechanical Engineering at Arizona State University in 1977, and as a Hughes Fellow earned his MSME at the California Institute of Technology in 1979. His full-time career then began at Motorola, which in 1999 launched its first spin-off, ON Semiconductor, where today Roger manages the Thermal and Mechanical Characterization Lab, which is part of the Packaging Technology Development organization within ON's Corporate Research and Development division in Phoenix, AZ. Roger has authored and coauthored more than 70 technical papers and presentations. He has been a peer reviewer for the IEEE TCPT Journal (and others). Roger holds six patents, and has been a registered Professional Engineer (Mechanical) in the state of Arizona since 1983.

SEMI-THERM 33

SEMI-THERM®

Short Course 4 **Afternoon** **Monday, March 13, 2017**

Spreadsheet Based Thermal Analysis Method
Ross Wilcoxon, Rockwell Collins

This course will show the attendees methods for using spreadsheets to do a variety of typical thermal analyses. It will begin with a brief overview of spreadsheet functions on cells and arrays as well as methods for more easily controlling the input and output of spreadsheet tools. This will be followed by discussions on the analysis of situations such as a thermal resistance network, flow within a chassis, uncertainty analysis of a thermal test stand and transient thermal behavior. Students will be provided with example spreadsheets that can be adapted for their own analysis needs.

Ross Wilcoxon is a Principal Mechanical Engineer in the Rockwell Collins Advanced Technology Center. He conducts research and supports product development related to component reliability, electronics packaging and thermal management. He has contributed to the development of multiple systems for communication, processing, displays and radars for commercial and military avionics applications. His research areas have included rapid test methods for evaluating component reliability, heat pipes, liquid metal cooling, advanced composites and tin whisker mitigation. He is a past chair of the SEMI-THERM conference, has dozens of conference and journal publications and holds 29 US patents. Prior to joining Rockwell Collins in 1998, he was an assistant professor at South Dakota State University. He received B.S. and M.S. degrees in mechanical engineering from South Dakota State University and a Ph.D. in mechanical engineering from the University of Minnesota.

Short Course 5 **Afternoon** **Monday, March 13, 2017**

Design of Experiments for Thermal Engineering
James Petroski, Design By Analysis

This course is intended to introduce people to the concept of Design of Experiments (DOE) and how it can be applied to engineering for effective design and experimentation. Beginning with a discussion of effective experimentation, the class will progress through different types of experimentation used today, the role of statistics in planning experiments and the product designs they influence, to an overview of various types of DOE's. In depth presentation of certain DOE types will be given and the reason why the DOE type is chosen for a particular situation. The course will then show the process of setting up a "typical" DOE and follow with two examples, one from an analytical design using a DOE and a second of an experimental DOE of a system.

James Petroski is the founder and Principal Consultant of Design by Analysis Technical Consulting. Mr. Petroski has been involved in thermal, shock and vibration management of electronics systems for DOD, NASA and commercial applications with over 35 years' experience in the field of electronics packaging and LED thermal management. He received his Bachelor's in Engineering Science and Mechanics from Georgia Tech and a MS degree in Engineering Mechanics from Cleveland State University. He has authored numerous papers related to LED and electronics packaging, has thirty patents pertaining to solid-state lighting, and is currently a member of the ASME K-16 Subcommittee on Heat Transfer in Electronics.

Short Course 6 **Afternoon** **Monday, March 13, 2017**

Fundamentals of Power in the Data Center
Brian Zahnstecher, PowerRox

Accurate modelling of power electronics in data center hardware is a fundamental determinant of successful implementation. A common industry practice is to use simplified assumptions for loading and power conversion efficiency to provide approximate calculations of power utilization. Unfortunately, implementers find huge errors and variability between predicted and actual power consumption, which yield very costly (in CAPEX, OPEX, and time) headaches for many stakeholders. This is due to oversimplification of the highly convoluted and transient nature of power loading in the data center.

This entry- to intermediate-level short course will provide an in-depth investigation into what drives power requirements in data center equipment. The first part will focus on key attributes of data center hardware system power budgets including major loads and their power profiles, correlation between such attributes and how they impact overall power demand (i.e. – how redundancy impacts budget), and specific examples (i.e. – blade server, white-box, high-end network switch). The second part will focus on rolling-up what was learned about power budgets at the system-level into the rack, aisle, and complete data center levels to provide the full picture of the data center power solution all the way from the load to the building inputs. This will include many application-specific examples (i.e. – virtualization, dynamic power allocation, etc.) representative of solutions for today and tomorrow (i.e. – IoT, Cloud Computing, etc.).

Brian Zahnstecher is a Sr. Member of the IEEE, Chair of the IEEE SF Bay Area Power Electronics Society (PELS), and the Principal of PowerRox, where he focuses on power design, integration, system applications, and OEM market penetration, and private seminars for power electronics. He previously held positions in power electronics with industry leaders Emerson Network Power, Cisco, and Hewlett-Packard, where he advised on best practices, oversaw product development, managed international teams, created/enhanced optimal workflows and test procedures, and designed and optimized voltage regulators. He holds Master of Engineering and Bachelor of Science degrees from Worcester Polytechnic Institute.

VENDOR WORKSHOPS Afternoons Tuesday March 14 and Wednesday March 15

calyos KULR Mentor Graphics Mechanical Analysis NETZSCH Cradle MSC Software Company 6SigmaET by Future Facilities ANSYS

SEMI-THERM 33

SEMI-THERM®

Evening Presentation **Tuesday, March 14, 2017**

A Decade of Data Center Efficiency: What's Past is Prologue!

Presenter: Jonathan G. Koomey, PHD

In 2006, the EPA's ENERGY STAR group brought the information technology industry together twice to discuss energy efficiency in data centers. Electricity use of these facilities had doubled in the preceding 5 years, and most folks in the industry knew something had to be done.

Since then, server manufacturers have redesigned their devices to reduce power use when idle, highly efficient data center modules have become commonplace, virtualization of workloads is routine, efficiency metrics are in widespread use, cloud computing is a well known term, and the most sophisticated owner-operators use engineering simulation to better manage design and operation of their facilities.

The results have been dramatic. Total electricity used by data centers in the US has grown little since 2007, even as delivery of computing services continues to explode. The shift to scaleable and modular facilities has enabled substantial improvements in infrastructure efficiency even as servers have become much more sophisticated in monitoring and controlling energy use.

This success is remarkable, but much more remains to be done. Most enterprise data centers operate at far lower efficiencies than their cloud computing counterparts, which makes them much more expensive to own and operate. Surprisingly, the solutions are now impeded primarily by management problems, not technology. Senior management routinely fails to understand the tight link between better energy performance and better business performance. Once that changes, the pace of efficiency improvements can proceed even more rapidly.

This talk will review these historical developments and describe how industry can do even better in coming years.

Dr. Jonathan G. Koomey is a researcher, author, lecturer, and entrepreneur whose work spans climate solutions, critical thinking skills, and the energy and environmental effects of information technology.

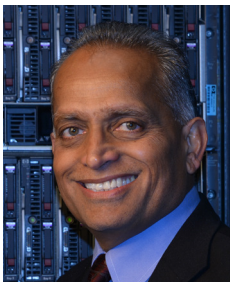
(Date/Time subject to change)

For program details, registration, exhibition and hotel information visit WWW.SEMI-THERM.ORG today!

SEMI-THERM®

THERMI Award

Each year, SEMI-THERM honors a person as a Significant Contributor to the field of semiconductor thermal management. The THERMI award is intended to recognize a recipient's history of contributions to crucial thermal issues affecting the performance of semiconductor devices and systems. The voting body of past THERMI winners and the current year General Chair are pleased to present the 2017 THERMI Award to:



Chandrakant Patel

Chandrakant Patel is currently Chief Engineer and Senior Fellow of HP Inc.
Dr. Patel has led HP Labs in delivering innovations in chips, systems, data centers, storage, networking, print engines and software platforms. He is a pioneer in thermal and energy management in data centers, and in the application of information technology for available energy management at the scale of cities.
An ASME and an IEEE Fellow, Patel has been granted 148 patents and published more than 150 papers. An advocate of a return to fundamentals, he has served as an adjunct faculty member in engineering at Chabot College, U.C. Berkeley Extension, San Jose State University and Santa Clara University.
In 2014, Chandrakant was elected to the Silicon Valley Engineering Hall of Fame.

Chips, Data Centers to 3D Printing:
An Exciting Road Ahead Paved on the Fundamentals of Thermal Sciences

The 19th and the early 20th centuries were largely about the industrialization of electro-mechanical (physical) systems like the steam engine and the utility grid. The latter half of the 20th century has been about information (cyber) systems and the internet. The 21st century will be about the integration of these two, namely cyber-physical systems (CPS). Advancement in thermal sciences has tracked these technology trends. During the cyber age, early thermal management advancements were driven by the growth of chip technologies. In the latter part of the 20th century, by the rise of internet data centers.

In the 21st century, an entirely new crop of challenges is upon us. The 21st century cyber-physical solutions – such as those associated with autonomous physical systems - will require novel computing architectures and topologies for real time analysis and action. These cyber-physical systems will necessitate novel chip scale thermal management solutions. With respect to internet data centers, the promise of the 20th century has not been realized as 60% of the people in the world are yet to be connected. The total cost of ownership of the next generation of data centers will have to be driven down by a factor of ten with innovations in thermal and energy management. Finally, a new area will emerge as resource constraints will accelerate on-demand high throughput 3d printing of least lifetime energy structural parts. Thermal management will become one of the key pillars of these 3d print engines.

In this session, we will explore these opportunities that promise an exciting road ahead for the thermal sciences community. For future contributors, success will require multi-disciplinary breadth with depth in the fundamentals of thermal sciences.

SEMI-THERM 33

SEMI-THERM®

How-To Courses
Evening concurrent sessions — Wednesday March 15, 2017

If you've ever wanted some practical guidelines on how to 'Choose Between Heat Pipes & Vapor Chambers', for instance, or 'Select the Best Air Mover', you won't want to miss these 50 minute presentations. Join our thermal industry veterans as they offer concise insight into their field of specialty, while leaving 10 minutes for some Q&A. Attendees can choose from four presentations on Wednesday, the third evening of the symposium.

Thermocouple Theory and Practice — **Presenter: Bob Moffatt**

Conceptually, thermocouples are very simple: two wires joined together at one end and connected to an instrument at the other. Put the junction on a device, read the signal and learn ---- the temperature of the thermocouple! The problem is that you generally don't care what the thermocouple temperature is, you want to know the temperature of the device to which it is attached. To get the job done, you need to know about thermocouple theory, but also about radiation error and conduction error and, in some cases, velocity error. In this hour, we will cover the physics of TCs, apply that theory to circuits with connectors, and introduce you to the environmental errors you will face.

Dr. Robert J. Moffatt Professor Robert J. Moffat received his Ph.D. at Stanford University and was a Professor of Mechanical Engineering at Stanford for 31 years. His research in the area of experimental heat transfer in turbulent boundary layers led to turbulence intensity based heat transfer correlations that are standard in the gas turbine industry. His work in convective cooling of electronic components in both forced and natural convection brought physics based understanding to a field that lacked methodical approaches. He is a world renowned expert in experimental methods in the thermosciences, in experimental measurements in electronics cooling, and in the use of uncertainty analysis as a tool for planning experimental programs of provable accuracy. He is a Fellow of both ASME and ISA. He retired from teaching in 1993 but remains active in research, consulting and teaching engineers how to be better engineers.

Design of Liquid Cooled Systems — **Presenter: Pablo Hidalgo, Thermacore, Inc.**

The increase in computing capabilities and larger heat dissipation is approaching the limits of air cooled systems in certain applications. Technology is advancing towards an increasing number of liquid cooled systems due to its cost-effective performance for high-power, high-heat flux electronics such as microprocessors, IGBTs or power modules. Since liquid forced convection has at least an order of magnitude higher heat transfer coefficients than forced air convection, at the expense of higher overall pressure drop, the heat transfer mechanism is significantly more effective. In this presentation, comprehensive design steps and guidelines for designing any kind of liquid cooled system will be addressed.

Pablo Hidalgo is a senior thermal engineer in the R&D group at Thermacore working on the development of new products for military, aerospace, data centers and medical applications. Previously he has spent eight years in the department of mechanical engineering at the Georgia Institute of Technology working as a research engineer. During his tenure at Georgia Tech, he worked in thermal management of high power electronics using diverse flow control techniques and aerodynamics.

How-To Courses
Evening concurrent sessions

Wednesday March 15, 2017

Design Consideration for Heat Sink Mounting Solution

Presenters: Dr. Milena Vujosevic, Intel
Juan L. Cruz, Light

As systems are becoming more densely packed with more components added on the board and/or with boards becoming smaller, the heat sink attachment designs need to become more innovative. This requires engineers to become more aware of the impact that heat sink mount design choice can have on the performance and reliability of electronic components. In this course we will discuss the multitude of challenges that need to be taken into the account when designing heatsink mounting solutions. Special focus will be on explaining why successful heat sink mounting solutions need to account for both heat transfer and mechanical considerations.

Dr. Milena Vujosevic is a Principal Engineer and Senior Manager in Intel's Quality and Reliability Organization. She leads strategic developments in package certification, multiphysics predictive modeling methodologies and co-optimization of customers' board assembly solutions. She has more than 20 years of experience in engineering and management of multidisciplinary teams includingincluding: technology development, product design, quality and reliability, research and teaching. Prior to joining Intel in 2005, she worked for Motorola in the area of MEMS. Milena has a PhD in Mechanical Engineering. She has more than 60 technical publications.

Juan L Cruz is Thermal Mechanical Engineer at Light. Juan has worked in the thermal management field for over 15 years solving a multitude of thermal challenges. He was the lead Thermal Architect at Ericsson where he developed innovative thermal solutions for high end routers that used up to 80KW per rack.

Practical Guidelines for Using Heat Pipes and Vapor Chambers in Heat Sinks

Presenter: George Meyer

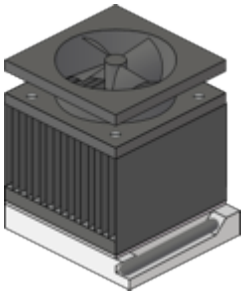
Heat pipes, and increasingly vapor chambers, are common devices used to improve heat sink thermal performance by over 30% when compared to solid metal alternatives. This course will cover two-phase device similarities, differences, misconceptions, best uses, sizing and performance modeling through the presentation of numerous examples.

Who Should Attend: Engineers interested in learning about how to best incorporate heat pipes and/or vapor chambers into their next heat sink design.

George Meyer is a thermal industry veteran with over three decades of experience in electronics thermal management. He currently serves as the CEO of Celsia Inc., a design and manufacturing company specializing in custom heat sink assemblies using heat pipes and vapor chambers. Previously, Mr. Meyer spent twenty-eight years with Thermacore in various executive roles including Chairman of the company's Taiwan operations. He holds over 70 patents in heat sink and heat pipe technologies and serves as a chairperson for both SEMI-THERM and IMAPS thermal conferences in the San Francisco area.

SEMI-THERM®

SEMI-THERM Electronics Cooling App Development Challenge



Tuesday March 14, 5:00pm-5:45pm Bayshore Ballroom Lobby

Presenter: Ross Wilcoxon Rockwell Collins.

This year, SEMI-THERM is introducing a new activity for the 2018 Symposium, SEMI-THERM 34. We are challenging our participants to develop their own mobile apps that can be used to analyze thermal systems, evaluate design options, provide useful information for analysts, teach important concepts in the field of electronics cooling, etc. Apps submitted for the App Challenge will be reviewed by members of the SEMI-THERM Program and Technical Committees and winners in various categories will be announced. These winners will be given prizes and a reduced registration fee for SEMI-THERM 34, which will be held in March of 2018 in San Jose, CA. ST34 will include a special session in which authors will give demonstrations of their winning apps.

The 2017 SEMI-THERM Symposium will have an afternoon session that includes an overview of the App Developement Challenge. This will describe how the challenge will be conducted and provide a timeline for events included in the challenge. The session at SEMI-THERM 33 will also include a brief overview of tools can be used by individuals with no prior experience in app development to create sophisticated and useful tools for engineering analysis.

SEMI-THERM®

Market Trends of the Semiconductor Industry

March 16, Thursday afternoon 2:00p.m. - 5:30p.m.

CHAIR: Rahima Mohammed, Intel Corporation

1. Cloud Computing
2. Artificial Intelligence, Deep Learning and Machine Learning
3. Virtual Reality
4. Advanced Driver Assistance Systems (ADAS)
5. Redefinition of Client Computing

SEMI-THERM®

MAE

Mechanical & Aerospace Engineering
The University of Texas at Arlington

ES2 | Center for Energy-Smart Electronic Systems

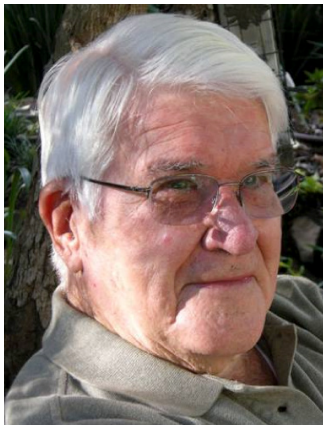
VILLANOVA UNIVERSITY

We are proud to sponsor:

The SEMI-THERM Educational Foundation
Thermal Hall of Fame

Lifetime Achievement Award

Presented To



Dr. Robert J. Moffat

In Recognition of Significant Contributions to the Field of Electronics Thermal Management

Professor Robert J. Moffat received his Ph.D. at Stanford University and was a Professor of Mechanical Engineering at Stanford for 31 years. His research in the area of experimental heat transfer in turbulent boundary layers led to turbulence intensity based heat transfer correlations that are standard in the gas turbine industry. His work in convective cooling of electronic components in both forced and natural convection, in particular in developing the concept of the adiabatic heat transfer coefficient, brought physics based understanding to a field that lacked methodical approaches. He is a world renowned expert in experimental methods in the thermosciences, in experimental measurements in electronics cooling, and in the use of uncertainty analysis as a tool for planning experimental programs of provable accuracy. His short courses at SEMI-THERM and at many other venues are legendary and have been hugely influential in training generations of engineers on proper experimental characterization and testing of electronic systems. He is a Fellow of both ASME and ISA. He retired from teaching in 1993 but remains active in research, consulting and teaching engineers how to be better engineers.

SEMI-THERM 33

SEMI-THERM®

The 2016 Harvey Rosten Award Recipients



Subtractive Design: A Novel Approach to Heatsink Improvement

Robin Bornoff, John Wilson, John Parry
Mentor Graphics, Mechanical Analysis Division

Robin Bornoff attained a Mechanical Engineering Degree from Brunel University in 1992 followed by a PhD in 1995 for CFD research. He then joined Mentor Graphics Corporation, Mechanical Analysis Division (formerly Flomerics Ltd) as an application and support engineer, specializing in the application of CFD to electronics cooling and the design of the built environment. Having been the Product Marketing Manager responsible for the FloTHERM and FloVENT products, he is now Market Development Manager for the Physical Design of Electronics in the Mechanical Analysis Division.

John Wilson joined Mentor Graphics Corporation, Mechanical Analysis Division in 1999, after receiving his BS and MS in Mechanical Engineering from the University of Colorado at Denver. Previously John managed the engineering design services business, ranging from IC component level to Data Centers, heat sink optimization and compact model development. John has extensive experience in IC package level test and analysis correlation through his work at Mentor Graphics' Fremont-based Thermal Test Facility. He is currently the Electronics Product Specialist for the Mechanical Analysis Division.

John Parry attained a Chemical Engineering Degree from Leeds University in 1982, and a PhD in 1988. He joined Mentor Graphics Corporation's Mechanical Analysis Division, when it was founded as Flomerics in 1989 to manage its customer services operation, and later head its research activities. John has coordinated several collaborative research and knowledge transfer projects, and oversaw the technical integration of MicReD into Flomerics' business. He has experience in compact modeling of fans, IC & LED packages, heatsinks, DoE & optimization methods, and thermal characterization, with over 75 published technical articles. He is a member of JC15 and past chair of SEMI-THERM and has 4 patents pending.

The Harvey Rosten Award

The award is for outstanding work, recently published or in the public domain, which advances the analysis or modeling of thermal or thermomechanical effects in electronic equipment or components, including experiments aimed specifically at the validation of numerical models. The award is in the form of a plaque and a $1000 cash prize. The award was established by the family and friends of Harvey Rosten, to commemorate his achievements in the field of thermal analysis of electronics equipment, and the thermal modeling of electronics parts and packages. The Award is made annually to encourage innovation and excellence in these and closely related fields.

The recipient is selected by the Selection Committee, made up of eminent practitioners in the electronics-thermal field. The cirteria for selection are:

- The work represents an advance in thermal analysis or thermal modeling of electronics equipment or components, including experiments aimed specifically at validating numerical models.
- The work demonstrates clear application to practical electronics design.
- The work demonstrates insight into the physical processes affecting the thermal behavior of electronics components, parts and systems.
- The work is innovative in embodying this understanding in either thermal analysis or thermal modeling.
- A pragmatic approach is taken in the application of the work.

Thermal Week™ Programming*
Program Chair: Jesse Galloway, Amkor

*subject to change

Tuesday

#1 Auto/Aerospace/Outdoor Josh Gess, Oregon State University	#2 Simulation Robin Bornoff, Mentor	#3 Simulation Gokul Shankaran, Ansys	#4 Extended Session Dave Saums, DS&A LLC
(P.6) Design of Thermal System Based on Combination of Thermoelectric and Vapor Chamber Technologies Author Alex Gurevich, Double Check Ltd	(P.64) Full-Circuit 3D Electro-Thermal Modeling of an IGBT Power Converter Author Robin Bornoff, Mentor Graphics	(P.55) An Efficient Transient Thermal Simulation Methodology for Power Management IC Designs Author karthik srinivasan, ansys	(P.56) Effects of Anisotropic Nonconductive Film Properties on 3D IC integration Author Mei-Chien Lu, Monte Rosa Technology
(P.22) Study of an Innovative Multiple Fans System with one Piezoelectric Actuator Embedded in a Circular Heat Sink Author Hsiao-Kang Ma, National Taiwan University	(P.9) Efficient Electronic Cooling via Flow-Induced Vibrations Author Aaron Rips, Johns Hopkins University	(P.3) Enabling faster design/performance decisions for 3D-IC package architectures Author Metin Ozen, OZEN ENGINEERING, INC.	(P.38) Thermal Analysis of Hybrid Circuits with Variable Heat Transfer Coefficient Author Marcin Janicki, Lodz University of Technology
(P.26) Development of a passively cooled outdoor telecom power enclosure Author Martin Cermak, Simon Fraser University	(P.24) The Effect of Improper Conformal Coating on SnPb and Pb-free BGA Solder Joints during Thermal Cycling: Experiments and Modeling Author Maxim Serebreni, University of Maryland, Baltimore County	(P.8) QUAD FLAT NO-LEAD PACKAGE ASSEMBLY UNDER POWER AND THERMAL CYCLING Author Unique Rahangdale, The University of Texas at Arlington	(P.29) Organic Direct Bond Copper Author Rajesh Tripathi, DuPont
(P.54) THERMAL MANAGEMENT OF CAMERA-BASED VISION SYSTEMS IN ADVANCED DRIVER ASSISTANCE SYSTEMS Author Arun Raghupathy, Electronic Cooling Solutions Inc	(P.36) Structure-Aware Thermal Model Reduction Author Marcin Janicki, Lodz University of Technology	(P.25) Integrating chip-level microfluidics cooling into sytem level design of digital circuits Author Peter G. Szabo, Budapest University of Technology and Economincs, Department of Electron Devices	(P. 14) Role of Carbon Nanotube Diameter on the Thermal Interfacial Resistance: A Molecular Dynamics Approach Author Ajinkya Sarode, Indian Institute of Technology Gandhinagar
(P.44) Solid Phase, High Flux Cooling of Electronic Equipment Author William David Alexander, ACPI Ltd.	(P.39) Static and Transient System-Level Electro-Thermal Analysis for Power MOSFET Author Rajen Murugan, Texas instruments, Inc.		

SEMI-THERM 33

SEMI-THERM®

Thermal Week™ Programming*
Program Chair: Jesse Galloway, Amkor

*subject to change

Wednesday

#5 Data Center Chris Aldham, Future Facilities	#6 2Phase Pablo Hidalgo	#7 Data Center Veerendra Mulay, Facebook	#8 Heat Sinks George Meyer, Celsia, Inc.
(P.43) VHTX: A CODE FOR SIMULATION OF STEADY STATE AND DYNAMIC RESPONSE OF SINGLE OR MULTIPLE NETWORKED CROSS FLOW HEAT EXCHANGERS IN DATA CENTER THERMAL MANAGEMENT SYSTEMSthor Alfonso Ortega, Villanova University	(P.53) Cooling 11.6 TFlops (1500 Watts) in an Office Environment Author Timothy A. Shedd, Ebullient, Inc.	(P.18) Using Power Trend Predicator to Improve Datacenter Thermal Management Efficiency Author Song,Chuan, Intel Asia-Pacific Research & Development Ltd.	(P.31) A New Hybrid Heat Sink With Impinging Micro-Jet Arrays and Microchannels Fabricated Using High Volume Additive Manufacturing Author R. Chen, Microfabrica Inc., U.S.A.
(P.46) Thermal Power Envelope for IoT Modules Author Jared Shipman, Intel Corporation	(P.65) Oscillating flow in a heat sink with parallel micro channels Author Yiwu KUANG, Institute of Refrigeration and Cryogenics, School of Mechanical Engineering	(P.17) Rack-level study of hybrid cooled servers using warm water cooling for distributed vs. centralized pumping systems Author Manasa Sahini, University of Texas at Arlington	(P.5) Radially Varying Air Gap for Near-Ideal Low Cost Passive Heat Spreaders Author Evan A Chenelly, Intel Corporation, CCG (Client Computing Group)
(P.47) An Experimental and Theoretical Investigation of the Effects of Supply Air Conditions on Computational Efficiency in Data Centers Employing Aisle Containment Author Morgan Tatchell-Evans, University of Leeds	(P.35) Modeling Embedded Two-phase Liquid Cooled High Power 3D Compatible Electronic Devices Author Pritish R. Parida, IBM	(P.32) Experimental Methods to Characterize the Impact of Cross Flow Orientation on Jet of Air after a Perforated Tile Author Sadegh Khalili, State University of New York at Binghamton	(P. 16) Analytical and Experimental Verification of Interleaved Trapezoidal Heat Sink Hong-Long Chen, Chi-Chuan Wang Department of Mechanical Engineering National Chiao Tung University
(P.52) Impact of Elevated Temperature on Data Center Operation Based on Internal and External IT Instrumentation Author Mohammad Ibrahim Hamad Tradat, State University of New York at Binghamton	(P.10) Experimental Study on Flow Boiling in a Hierarchical Manifold Microchannel Heat Sink Array Author Justin A Weibel, Purdue University	(P.37) Performance of a Mixed Mode Air Handling Unit for Direct Liquid Cooled Servers Author Mustafa Kadhim, University of Leeds	(P.30) Experimental Characterization of a Cold Plate used in Warm Water Cooling of Data Centers Author Bharath Ramakrishnan, Binghamton University
(P.60) CooLMUC-2: A Supercomputing Cluster with Heat Recovery for Adsorption Cooling Author Torsten Wilde, Leibniz Supercomputing Centre	(P.21) Integration of a Multiple Piezoelectric Fans System with a Vapor Chamber Author Hsiao-Kang Ma, National Taiwan University		(P. 62) Analytical and Experimental Verification of Interleaved Trapezoidal Heat Sink Hong-Long Chen, Chi-Chuan Wang Department of Mechanical Engineering National Chiao Tung University

Thermal Week™ Programming*
Program Chair: Jesse Galloway, Amkor

*subject to change

Thursday

#9 Measurement Kaz Yazawa, Microsanj	#10 TIM Jason Strader, Laird	#11 LED Genevieve Martin, Philips	#12 Auto/Aerospace/Outdoor Ross Wilcoxon, Rockwell Collins
(P.7) Hyperspectral Thermoreflectance Imaging for Power Devices Author Kazuaki Yazawa, Microsanj LLC.	(P.51) Variability in Theta JC Measurements Due to Secondary Effects Author Tom Nordstog, Amkor Technology	(P.2) Analysis on LED Street Lamp Cooling Using Electromagnetic Fans Author Hsienchin Su, Notus cooling	(P.49) Electro-Thermal Analysis for Automotive High Power MOSFETs Author Asantha Kempitiya , Infineon Technologies Americas Corp.
(P.13) Rapid test method for thermal characteristics of semiconductor devices Author Shiwei Feng, Beijing University of Technology	(P.20) The interface in molybdenum-copper-composites used for thermal management applications Author Martin Seiss, Plansee SE	(P.61) Thermal Structure Function Analysis and Thermal Compact Model Development for a Mid-Power LED Author Anton Alexeev, Eindhoven University of Technology	(P.66) Novel Expand-to-Shape Latent Heat Storage Systems based on Carbon Foams Author Sandra Reisinger, Schunk Hoffmann Carbon Technology AG
(P.41) Title High Performance Computing 3 Dimensional Integrated Thermal Test Vehicle Author Stephen Charles Polzer, Mayo Clinic	(P.42) EXPERIMENTS ON THE THERMAL RESISTANCE OF DEFORMABLE THERMAL INTERFACE MATERIALS UNDER MECHANICAL LOADING Author Richard Kenney, Villanova University	(P.40) A Method of Characterising the Thermal Resistance of High Power LEDs Author John Ellis, Plessey Semiconductors Ltd	(P.27) Natural-graphite-sheet based heat sinks Author Martin Cermak, Simon Fraser University
(P.63) High Temperature Submicron SOI CMOS Technology Characterization for Analog and Digital Applications up to 300°C Author Konstantin Petrosyants, National Research University Higher School of Economics (Moscow Institute of Electronics and Mathematics)	(P.50) Thermal Performance of TIMs during Compressive and Tensile Loading Author Cameron Nelson, Amkor Technology	(P.4) Transient Light Emission Microscopy for Detecting the Non-Uniform Junction Temperature in Flip-Chip Light-Emitting Diodes Author Mian, TAO and S. W. Ricky LEE, The Hong Kong University of Science and Technology	(P.48) Numerical Modeling and Optimization of a V-groove Warm Water Cold-plate Author Yaser Hadad, Binghamton University
	(P.58) Evaluation of characterization methods for thermal interface materials Author Dirk Schweitzer, Infineon Technologies AG		