SEMI-THERM®

SEMI-THERM® 36
The 36th Annual Thermal Measurement, Modeling and Management Symposium
March 16th - 20th, 2020
36
Thermal Innovations that Make the World's Technology Cool

San Jose, California at the Doubletree by Hilton

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Thermal Interface Materials
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Welcome to SEMI-THERM 36!

Pablo Hidalgo, AMD

Dear Colleagues,

It is my pleasure to welcome you to SEMI-THERM 36 annual symposium. The entire organizing team and I want to thank you for your presence in this year's event and we hope you find the symposium extremely helpful and beneficial for your career and your business. The SEMI-THERM organization is dedicated to providing a platform for discussion on the latest advancements in thermal management for both industry professionals as well as members of academia so during the thermal week, all participants can share their knowledge and promote collaboration between entities.

In this edition, the Program Chair, Dr. Marcelo del Valle, the Program Vice-Chair, Prof. Joshua Gess and the entire program committee has assembled a superb list of presentations and papers with a particular emphasis on thermal management from die level to infrastructure level for data centers, as well as measurement techniques of semiconductors and components. The program consists of seven short courses on Monday that will span from the morning till the afternoon. Technical presentations will be given every morning from Tuesday through Thursday. This year's Keynote speaker is Dr. Andy Delano from Microsoft and he will be talking about "Innovations in Thermal Management of Electronic Devices". The symposium will also have two luncheon speakers, one on Tuesday and one on Wednesday, a panel session on data center cooling technologies, one embedded tutorial and one evening tutorial. Tuesday and Wednesday afternoon, you will have the opportunity to enjoy the exhibits and vendor workshops, that you can use for networking with other fellow engineers and attend product presentations provided by vendors.

During the symposium, we will also have several awards and I would like to take this opportunity to congratulate every single one of the recipients for their achievements. The THERMI award, which this year is sponsored by The University of Texas in Arlington, recognizes the recipient's contributions to thermal issues and overcome the challenges presented in electronics cooling. I am very pleased to announce that the 2020 THERMI award recipient is for Dr. Ross Wilcoxon from Collins Aerospace. SEMI-THERM also instituted the Thermal Hall of Fame Lifetime Achievement Award, which this year is sponsored by Celsia, recognizes an individual in the thermal management field that has made significant contributions to the development and commercialization of thermal management technologies during their career. I am also very honored to announce that this distinguished award will be given

Continued

to Prof. Dereje Agonafer from the University of Texas in Arlington. Last but not least, the 2019 Harvey Rosten Award, which is sponsored by Mentor a Siemens business, for outstanding work recently published or in the public domain, for advances in analysis or modeling of thermal effects in electronic equipment or components, will be given to Baver Ozceylan, Prof. Boudenwijn R. Haverkort, Dr. Maurits de Graaf and Dr. Marco E.T. Gerards.

SEMI-THERM wouldn't be as successful as it is without all the individuals that devote their own personal time to help in the preparation and organization of this symposium. From reviewers to session chairs, organizing, steering and technical committee members, the unconditional guidance and support from Bonnie Crystall, Denise Rael and Robert Schuch and I cannot leave behind the continuous mentorship and influence by George Meyer and SEMI-THERM's co-founder Bernie Siegal. I would like to take this opportunity to acknowledge them and give thanks for all your support during the last year.

I hope that SEMI-THERM 36 leaves a positive impact on everyone that participates this year and that everyone takes away the main reason of the symposium existence, education on the best and newest thermal technologies and the ability to build new connections with leaders in the thermal management community.

Please join me in congratulating the Program Chair, Dr. Marcelo del Valle, the Program Vice-Chair, Prof. Joshua Gess for putting together such an exceptional program and I will be looking forward to enjoy with everyone of you a wonderful thermal week.

Sincerely,

Pablo Hidalgo
Symposium General Chair

SEMI-THERM 36

SEMI-THERM 36 SYMPOSIUM PERSONNEL

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SEMI-THERM 36 Chair Persons

General Chair

Pablo Hidalgo, AMD

Dr. Pablo Hidalgo is an MTS Product Development Engineer in the thermal group of the Client Compute Business Unit at AMD. Currently Pablo is working on the development and launch of new Ryzen products for ultra-thin mobile applications. Previously he held positions at Aavid working on the development of new products for consumer applications, military and aerospace industries, data centers and medical. Prior to Aavid, Pablo was a research engineer at the Georgia Institute of Technology, where he spent eight years in the department of mechanical engineering. During his tenure at Georgia Tech, he worked in thermal management of high power electronics using flow control and aerodynamic techniques. His professional experience and interests are single and two-phase cooling, heat pipes, vapor chambers, R&D, conjugate heat transfer modeling, experimental methods, flow control and fluid/structure interactions. Pablo holds a Ph.D. degree in Aerospace Engineering from The University of Alabama and M.S. and B.S in Aerospace Engineering from Saint Louis University.

Program Chair

Marcelo del Valle, Intel

Dr. Marcelo del Valle is a Thermal/Mechanical Engineer at Intel Corporation. He received his B.S.M.E from Universidad de Santiago, Chile, M.S.M.E. from University of Nevada, Reno and his Ph.D. in Mechanical Engineering from Villanova University. Dr. del Valle has worked extensively in experimental measurements in the thermal sciences for more than 7 years. His doctoral research involved detailed experimental characterization and modeling of air to liquid heat exchangers in data center applications. He has published and presented extensively in problems arising from thermal management of electronics, spanning from the chip/module to the facility level, single and two-phase liquid cooling, and thermal management in energy systems. He is part of the program committee of the SEMI-THERM Symposium.

Program Vice Chair

Dr. Joshua Gess, OSU

Dr. Joshua Gess is an Assistant Professor at Oregon State University (OSU) in Thermal Fluid Sciences. He is the coach of the OSU Rolling Beavers Wheelchair Basketball Team and a former MVP of the Auburn University Wheelchair Basketball Team. Dr. Gess is also the co-Founder of the Leading and Enabling Adolescent Futures in STEM (LEAFS) program which adapts engaging scientific activities to maximize the educational impact to young people with disabilities. For four years, he has been a Christopher Reeve Foundation Peer Mentor, a program designed to help people with disabilities acclimate to life after a spinal cord injury (SCI). He has been a strong advocate for inclusion of those with disabilities in STEM fields, particularly given the significant improvement in quality of life these careers can have for those with limited lower or upper limb mobility impairments.

Short Courses Monday, March 16, 2020

Short Course 1 Morning **8:00 a.m. – 12:00 p.m.**
Introduction to Electronics Cooling
Patrick Loney, Northrop Grumman Mission Systems

As electronic packages get smaller and the power dissipations increase, performing robust thermal analyses is an increasingly important step in the electronics packaging design process. This course will focus on the component level of the electronics assembly. Thermal management, proper cooling techniques, component attachment, and analytical modeling methods will be presented. How to decipher vendor datasheets will be discussed as well as the basics of how to model custom components. Best practices for steady state and transient operational modes are included. Process development will also be presented along with discussions on requirements compliance. Students will finish the course with an understanding of how to determine the limits and requirements of an electronics component, assess the thermal performance, how to integrate the performance model into a Next Higher Assembly (NHA) thermal model, and most importantly, how to communicate this information to their internal and external customers who are dependent on this data.

Patrick Loney recently celebrated his 30th anniversary with Northrop Grumman Corporation. He has over 35 years of experience in the thermal engineering/electronics cooling industry. He received his Batchelor of Sciences degree in Nuclear Engineering from the University of Illinois and his Masters of Sciences degree in Mechanical Engineering from Cleveland State University. He holds several US Patents and Trade Secrets, mostly dealing with thermal management and electronics cooling techniques. He has presented similar courses to internal customers as well as the 2019 IPC AMEX Expo.

Short Course 2 Morning **8:00 a.m. – 12:00 p.m.**
Introduction to Thermal Modeling with OpenFOAM
John F. Maddox, University of Kentucky

OpenFOAM is the leading free, open source software for computational fluid dynamics (CFD). This course is an introduction to thermal modeling using OpenFOAM for users familiar with CFD and heat transfer, however, no prior experience with OpenFOAM is required. Attendees will be introduced to the OpenFOAM environment through hands-on tutorials covering meshing, solving, and post-processing with a focus on conjugate heat transfer. Attendees wishing to participate in the hands-on tutorials will need to bring a laptop with a 64-bit operating system (Window, Mac, or Linux) and Oracle VM VirtualBox installed. All the software required for this course will be free and open source.

Dr. John F. Maddox is an Assistant Professor of Mechanical Engineering at the University of Kentucky, Paducah Campus. He received his Ph.D. in Mechanical Engineering from Auburn University in 2015. His primary research areas are thermal management of high power electronics through jet impingement and thermal characterization of advanced materials used in aerospace and electronics cooling applications.

Short Courses Monday, March 16, 2020

Short Course 3 Morning **8:00 a.m. – 12:00 p.m.**
Design and Optimization of Heat Sinks
Marc Hodes and Georgios Karamanis, Transport Phenomena Technologies, LLC

This course provides the audience with an understanding of heat sink design and optimization in the context of the thermal management of electronics. The course has two parts. The first part begins with an overview of common methods to manufacture heat sinks such as extrusion, die casting and forging, and discusses their advantages and disadvantages with respect to cost and fin geometry. Attention then shifts to the theory of spreading resistance and how it can be calculated in order to properly size the thicknesses of the bases of heat sinks. Next, the theory of the operation of heat pipes in tubular and flat (vapor chamber) configurations is presented along with their roles in smoothing out temperature gradients in the fins and bases of heat sinks. In the second part of the course, single-phase conjugate heat transfer, where conduction in the heat sink is coupled to convection in the coolant, i.e., air or water, flowing through the heat sink is highlighted. We discuss why the constant heat transfer coefficient assumption tends to be an invalid one in real heat sinks by using specific examples. Then, the use of computational fluid dynamics (CFD) to compute conjugate Nusselt numbers is considered. The course concludes with a discussion of how to embed pre-computed results for conjugate Nusselt numbers and dimensionless flow resistances for heat sinks in flow network models (FNMs) of circuit packs such as blade servers. Finally, how to use a multi-variable optimization scheme to optimize the geometry (fin thickness, spacing, height, length) of an array of heat sinks in a circuit pack represented by an FNM model with embedded tabulations of CFD results is discussed.

Marc Hodes is a Professor of Mechanical Engineering at Tufts University and the CTO of Transport Phenomena Technologies, LLC. He received his B.S., M.S. and Ph.D. degrees in Mechanical Engineering, the latter from MIT in 1998. He held a succession of appointments at Alcatel-Lucent's (now Nokia's) Bell Laboratories from Postdoctoral Scientist to Manager of a Thermal Management Research Group between 1998 and 2008, when he joined Tufts University.

Georgios (George) Karamanis is a Co-Founder and Senior Engineer in Transport Phenomena Technologies, LLC. He received his Ph.D. and M.S. in Mechanical Engineering from Tufts University. He has expertise in analytical, numerical and experimental techniques relevant to convective transport. He is the PI in a NSF Phase I SBIR awarded to Transport Phenomena Technologies, LLC, to develop specialized thermal modeling software and hardware for Data/Telco centers.

Short Courses Monday, March 16, 2020

Short Course 4 Morning **8:00 a.m. – 12:00 p.m.**

Thermal Management of Li-Ion Battery Packs

Azita Soleymani Ph.D., Electronic Cooling Solutions, Inc.

The thermal management of li-ion battery packs is crucial, as the cooling is directly related to the safety, reliability, performance and durability of battery packs. In this course, the specific thermal requirements of li-ion battery cells and battery packs will be discussed. The empirical tests necessary to characterize the thermal performance of cells will be presented; and it will be shown how the test results can be utilized to estimate real-time heat generation rates of cells at different state-of-charge, current and temperature.

Practical considerations in the design of thermal management system of battery packs will be provided in detail. The course will cover comprehensively the use of different simulation approaches such as Computational Fluid Dynamics, 1-D system level simulations, and Digital Twin. The Digital Twin models of battery packs can be developed in order to perform what-if scenarios, to conduct in-depth root cause analyses, to further optimize the cooling system, to make life-time predictions and to optimize operating parameters for thermal management.

Dr. Azita Soleymani is currently holding the director position at ECS Inc. She graduated from Lappeenranta Univ. of Tech., with PhD degree in advanced simulation and modeling of transport phenomena. After graduation, she worked as a manager in a Danaher company and Byton Inc.

Short Course 5 Afternoon **1:30 p.m. – 5:30 p.m.**

Air Movers and Aeroacoustics for Electronics Cooling

Mark MacDonald, Intel Corporation

This course will survey performance characteristics of various relevant fan types, including axial fans, blowers, crossflow or tangential blowers, volumetric resistance blowers, and other emerging technologies including electronhydrodynamic blowers, synthetic jets, piezo flappers, and micropumps. Emphasis will be placed on understanding the physical mechanisms of operation, best practices for characterization, implementation considerations, and applicable scaling laws (including acoustic scaling laws). The course will also cover aeroacoustics and psychoacoustics (sound quality and ergonomics) for consumer electronics in detail.

Mark MacDonald holds a Ph.D. from Cornell University. Formerly an Adjunct Professor at Portland State University, he is the holder of 45 U.S. patents, 17 of them specific to Air Movers. Dr. MacDonald is a winner of the Martin Hirschorn Prize from the International Acoustics Congress for work on notebook blower acoustics.

Short Courses Monday, March 16, 2020

Short Course 6 Afternoon **1:30 p.m. – 5:30 p.m.**

Micro-Two-Phase Electronics Cooling…Getting it on its Way

John R. Thome, EPFL

Two-phase flow and flow boiling heat transfer can reliably cool heat fluxes in excess of 500 W/cm2 with heat transfer coefficients nearing 100 kW/m2K with respect to the cold plate's base area. Yet, industry is hesitant to accept this technology on a large scale. Most of the reservations about this approach are easily mitigated with proper design/planning, and the benefits are substantial. In general, a micro-thermosyphon that works passively with gravity-driven flow is used with heat dissipation to a compact air coil. Due to the new "form factor" and huge surface area of the coil compared to an air-cooled heat sink, energy consumption by the fans is greatly reduced. Furthermore, a thermosyphon (no electrical driver or flow controllers) provides high reliability that is commonplace with packages which use two-phase thermal management. This lecture will recount the history and background of two-phase cooling, noting lessons learned along the way. Several case studies will be presented where a design flaw was mitigated and the resulting improvements in performance will be highlighted. At the end of this course, you will be able to successfully design a two-phase cold plate cooled system which improves the reliability, cost of operation, and longevity of your devices.

John R. Thome is Professor-Emeritus of Heat and Mass Transfer at the Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland since 1998. He obtained his PhD at Oxford University in 1978. Having retired in July 2018 at the EPFL, he co-owns the consulting/thermal engineering software company, JJ Cooling Innovation Sàrl in Lausanne. He is also a Visiting professor at Brunel University in London and an Honorary professor at the University of Edinburgh… to keep his "feet" in research while still supervising MS student theses at the EPFL. He recently received the 2019 IEEE Richard Chu ITHERM Award for Excellence in Thermal and Thermo-Mechanic Management of Electronics and the 2019 ASME Allan Krause Thermal Management Medal at InterPack. He is the author of five books on two-phase heat transfer and flow and has over 245 journal papers on macroscale and mircoscale two-phase flow, flow visualization, boiling/condensation heat transfer, flow pattern-based models, and micro-two-phase cooling systems for electronics cooling. He has done numerous sponsored projects with IBM, ABB, Nokia Bell Labs, Carl Zeiss, CERN, etc. He is editor-in-chief of the 16-volume series Encyclopedia of Two-Phase Heat Transfer and Flow (2016-2018). He founded the Virtual International Research Institute of Two-Phase Flow and Heat Transfer in 2014, now with 25 participating universities to promote research collaboration, sharing of experimental and numerical data, and education.

Short Course 7 Afternoon **1:30 p.m. – 5:30 p.m.**

Let's Work Together: How Co-Design Leads to Better Solutions in Thermal Management

Lauren Boteler, Army Research

Laboratory Optimization studies are generally done intradisciplinary rather than interdisciplinary, and this leads to conflict as different fields have different values when it comes to what they want in a packaged solution. Heat sinks in energy dense power electronics are an excellent example of where better communication and co-design models can yield significant improvements to fielded performance with just a small amount of preparation during the design phase. Parameterization and Figure of Merit (FOM) definitions that encapsulate electrical/ thermal/mechanical properties pare down the solution space to a set that represents what all fields want rather than cyclically proposing "optimal" solutions that one or more fields can't possibly accommodate. This course will examine how fielded solutions were truly optimized using novel co-design tools and optimization techniques which span multiple disciplines. The case studies examined will show marked improvement beyond what single-track minded approaches yield, and lessons learned from this course will translate directly to better solutions in your workplace.

Dr. Lauren Boteler leads the thermal and packaging research programs as part of the Advanced Power Electronics group at the U.S. Army Research Laboratory (ARL). She received her Ph.D. degree in mechanical engineering from the University of Maryland. Her work at ARL, beginning in 2005, has focused on electronics packaging and thermal management solutions for a wide range of Army applications. She designs thermal and packaging solutions including 3D chip stacking, power electronics, laser diodes, RF HEMT devices, top side cooling, phase change materials, and additive manufacturing. More recently, she has initiated a research program in Advanced Power Electronics Packaging and Thermal Management which focuses on four main challenges of power electronics packaging: transient thermal mitigation, additive manufacturing, coengineering/codesign, and high-voltage packaging. She was also awarded the 2018 ASME EPPD Woman Engineer of the Year award for her contributions to the electronics packaging community.

Schedule of Events Monday March 18, 2020

8:00 a.m. – 12:00 p.m. — **San Jose, San Juan, Santa Clara, Carmel, Monterey**

Morning Short Courses
Session Chair: Joshua Gess, Oregon State University

Short Course 1: Introduction to Electronics Cooling
Patrick Loney, Northrop Grumman Mission Systems

Short Course 2: Introduction to Thermal Modeling with OpenFOAM
John F. Maddox, University of Kentucky

Short Course 3: Design and Optimization of Heat Sinks
Marc Hodes and Georgios Karamanis, Transport Phenomena Technologies, LLC

Short Course 4: Thermal Management of Li-Ion Battery Packs
Azita Soleymani Ph.D., Electronic Cooling Solutions, Inc.

1:30 p.m. – 5:30 p.m. — **San Jose, Santa Clara, Carmel, Monterey**

Afternoon Short Courses
Session Chair: Joshua Gess, Oregon State University

Short Course 5: Air Movers and Aeroacoustics for Electronics Cooling
Mark MacDonald, Intel Corporation

Short Course 6: Micro-Two-Phase Electronics Cooling…Getting It On Its Way
John R. Thome, EPFL

Short Course 7: Let's Work Together: How Co-Design Leads to Better Solutions in Thermal Management
Lauren Boteler, Army Research

3:30 p.m. – 6:30 p.m. — **Bayshore Ballroom Foyer**

Attendee Registration

5:30 p.m. – 6:30 p.m. — **Bayshore Ballroom Foyer**

Welcome Reception

6:30 p.m. – 7:45 p.m. — **San Carlos**

SEMI-THERM Program Committee Meeting

Schedule of Events Tuesday, March 17, 2020

7:00 a.m. – 7:45 a.m. — **San Jose**
Speakers' Breakfast (March 17 Speakers, Session Chairs and Co-Chairs only)

8:00 a.m. – 8:10 a.m. — **Oak and Fir**
Welcome Message – General Chair, Pablo Hidalgo, AMD

8:10 a.m. – 9:10 a.m. — **Oak and Fir**
Session 1: Liquid Cooling
Session Chair: Timothy Shedd, ZutaCore

8:10 a.m. – 8:30 a.m. — **Oak and Fir**
Direct Micro–Pin Jet Impingement Cooling for High Heat Flux Applications
Vahideh Radmard, Yaser Hadad, Arad Azizi, Srikanth Rangarajan, C. Hiep Hoang, Charles Arvin, Kamal Sikka, Scott N. Schiffres, Bahgat Sammakia, Binghamton University

8:30 a.m. – 8:50 a.m. — **Oak and Fir**
Shape Optimization of a Pin Fin Heat Sink
Thomas Menrath, A. Rosskopf, F. B. Simon, M. Groccia, S. Schuster, Fraunhofer IISB

8:50 a.m. – 9:10 a.m. — **Oak and Fir**
Wicking Performance Enhancement By Laser Induced Roughness
Sougata Hazra, Farid Soroush, Tanya Liu, Mehdi Asheghi, Kenneth E. Goodson, Stanford University

9:10 a.m. – 10:10 a.m. — **Oak and Fir**
Keynote: Innovations in Thermal Management of Electronic Devices
Andy Delano, Microsoft

10:10 a.m. – 10:30 a.m. — **Gateway Foyer**
Networking Break

10:30 a.m. – 12:30 p.m. — **Oak and Fir**
Parallel Session 2: Data Center
Session Chair Kourosh Nemati, Future Facilities Ltd.

10:30 a.m. – 10:50 a.m. — **Oak**
Determination of Cost Savings Using Variable Speed Fans for Cooling Servers
Minh Tran[1], Nicole Okamoto[2], Hussammedine Kabbani[2], Saeid Bashash[2],
[1]Velodyne Lidar, [2]San Jose State University

10:50 a.m. – 11:10 a.m. — **Oak**
On Economic Cooling of Contained Server Racks Using an Indirect Adiabatic Air Handler
Riccardo Lucchese[1], Michele Lionello[2], Mirco Rampazzo[2], Andreas Johansson[1], Wolfgang Birk[1],
[1]Lulea University of Technology, [2]Università degli Studi di Padova

Keynote
Tuesday, March 17, 9:10 a.m. - 10:10 a.m.

Innovations in Thermal Management of Electronic Devices

Presenter: Andy Delano
Microsoft

Andy plans to highlight innovations from across the industry and over the last ~ 5-7 years and also talk about what he has found to be effective techniques for innovating over the course of his career.

Andy Delano leads the Microsoft Surface team's thermal architectural and technology efforts. Prior to joining Microsoft in 2012, Andy managed the thermal R&D team within Honeywell's electronic materials division developing and launching highly successful products for the electronics packaging industry. Andy started his career in 1998 as a thermal engineer at Hewlett-Packard designing server and workstation thermal systems. While at HP, Andy was also an adjunct professor at CU and taught heat transfer, thermodynamics, and thermal systems design between 1999 and 2005.

Prior to his career, Andy obtained his Ph.D. in mechanical engineering from Georgia tech in 1998, and his thesis was on a single pressure absorption refrigerator originally patented by Albert Einstein. During the first part of his graduate studies, Andy also worked on the design and production of the 1996 Olympic Torch and spent 6 weeks traveling with the torch relay.

Schedule of Events Tuesday, March 17, 2020

11:10 a.m. – 11:30 a.m. **Oak**

An Experimental Apparatus for Two Phase Cooling of High Heat Flux Application Using an Impinging Cold Plate and Dielectric Fluid

Cong Hiep Hoang, Sadegh Khalili, Bharath Ramakrisnan, Srikanth Rangarajan, Yaser Hadad, Vahideh Radmard, Kamal Sikka, Scott Schiffres, Bahgat Sammakia, Binghamton University

11:30 a.m. – 11:50 a.m. **Oak**

CFD Investigation of Dispersion of Airborne Particulate Contaminants in a Raised Floor Data Center

Satyam Saini, Pardeep Shahi, Pratik Bansode, Ashwin Siddarth, Dereje Agonafer, University of Texas at Arlington

Continued

Schedule of Events Tuesday, March 17, 2020, Continued

11:50 a.m. – 12:10 p.m. **Oak**

Experimental Validation of a Numerically-Optimized Array of Heat Sinks

Georgios Karamanis and Marc Hodes, Transport Phenomena Technologies, LLC

12:10 p.m – 12:30 p.m. **Oak**

General Guidelines for Commercialization of a Small–Scale In–Row Cooled Data Center (Current Status and Future Plans)

Yaman Manaserh[1], Mohammad. I. Tradat[1], Ghazal Mohsenian[1], Bahgat G. Sammakia[1], Mark J. Seymour[2], [1]Binghamton University, [2]Future Facilities

Continued

Luncheon Speaker
Tuesday March 17

Another day at the office: combining AI, CFD, and Belgian beer

Presenter: Lieven Vervecken
Diabatix

The majority of people do not really know what it is and the word highly overstates the technology, but Artificial Intelligence (AI) has made its entry and it is here to stay. Logically, it was only a matter of time before AI found its way into the field of Computational Fluid Dynamics (CFD). The possibilities with this combination seem endless, but are they really? Which challenges are we facing and how can we overcome them? In this talk I share some of our experiences when working with some of the largest companies in the world with one of the newest technologies in the world.

Lieven Vervecken is co-founder and CEO of Diabatix nv where he is responsible for the general management and the overall vision and strategy of the company. Diabatix is a Belgian technology scale-up specialized in generative design for cooling components that helps multinationals all over the world to push the boundaries in thermal design. Before devoting his work full-time to Diabatix, Lieven completed two master's degrees in engineering and a PhD in the field of Computational Fluid Dynamics from the University of Leuven. Lieven is an experienced speaker at national and international conferences, and former lecturer at the University of Leuven. He is passionate about the limitless possibilities of combining engineering with artificial intelligence technology and takes every opportunity to expand his knowledge in this field.

Continued

Schedule of Events Tuesday March 17, Continued

10:30 a.m. – 12:30 p.m. **Oak and Fir**

Parallel Session 3: Consumer Electronics I

Session Chair: Alex Ockfen, Facebook

10:30 a.m. – 10:50 a.m. **Fir**

Self–Heating Investigation in SOI MOSFET Structures with High Thermal Conductivity Buried Insulator Layers

Konstantin Petrosyants and Dmitry Popov, Moscow Institute of Electronics and Mathematics

Continued

How-To Presentation

Tuesday, March 17 5:00 p.m. - 6:00p.m.

A Tile: A Look at Acoustic Fundamentals and Designs as Applied to Air-Cooled Electronics

Presenter: Herman Chu

As air-cooling design continues to increase in airflow requirement without much relief in the overall equipment form factor, acoustic design considerations need to be actively engaged at the start of the product development cycle in order to clearly define expectations and deliver the best achievable sound quality.

In this how-to session, the speaker will present acoustic design fundamentals, review logarithmic arithmetic used in calculating sound levels, and review pertinent industry standards in performing acoustic testing for product evaluation.

Herman Chu is classically trained in thermal fluid systems and has over 30 years of industry experience spanning from military aerospace applications to electronic cooling of consumer products, computers and computer servers, mainframes and NEBS compliant networking equipment. His career has taken him to deploy all different kinds of cooling technologies from air cooling to various forms of liquid cooling.

Basic Pumped Refrigerant Cycle Calculations for Cooling IT Loads

Presenter: Joe Marsala
Durbin Group LLC

There is a growing interest in using pumped refrigerant to cool IT loads across various hardware platforms. This how-to session will examine some of the basic first order engineering considerations necessary when evaluating pumped refrigerant as an option. The speaker will present how pumped refrigerant thermodynamic cycles are represented on pressure-enthalpy diagrams, how to calculate refrigerant circulation rates and discuss choice of refrigerant. The four basic components of a pumped refrigerant cycle: refrigerant pump, cold plate, condenser and reservoir will be presented.

Schedule of Events Tuesday March 17, 2020 Continued

10:50 a.m. – 11:10 a.m. **Fir**
Testing and Analysis of Improved Thermal Solutions for a Home Wireless Router
Raul Vargas, Justin Dixon, MD Malekkul Islam, Electronic Cooling Solutions

11:10 a.m. – 11:30 a.m. **Fir**
Thermal Acceptability Limits for Wearable Electronic Devices
Mark Andrew Hepokoski[1], Allen Curran[1], Timothy Viola[1], and Alex Ockfen[2]
[1]ThermoAnalytics, Inc., [2]Facebook Reality Labs

11:30 a.m. – 11:50 a.m. **Fir**
Transient Thermal Model for Wearable Device in Contact with Human Skin
Bruce Guenin, Consultant

11:50 a.m. – 12:10 p.m. **Fir**
DNN–Based Fast Static On–Chip Thermal Solver
Jimin Wen, Stephen Pan, Norman Chang, Wen–Tze Chuang, Wenbo Xia, Deqi Zhu, Akhilesh Kumar, En–Cih Yang, Karthik Srinivasan, Ying–Shun Li, ANSYS, Inc.

12:10 p.m – 12:30 p.m. **Fir**
Microencapsulated Phase Change Materials as Heat Transfer Media in Electronics
John D. Rasberry, Keysight Technologies

12:40 p.m. – 2:00 p.m. **Pine and Cedar**
Luncheon and Presentation:
Another day at the office: Combining AI, CFD, and Belgian beer
Presenter: Lieven Vervecken, Diabatix

1:30 p.m. – 6:00 p.m. **Bayshore Ballroom**
Exhibits Open

2:00 p.m. – 5:00 p.m. **Oak and Fir**
Vendor Workshops Parallel Sessions

5:00 p.m. – 6:00 p.m **Oak**
How–To Presentation I
A Look at Acoustic Fundamentals and Designs as Applied to Air–Cooled Electronics
Presenter: Herman Chu

5:00 p.m. – 6:00p.m **Fir**
How–To Presentation II
Basic Pumped Refrigerant Cycle Calculations for Cooling IT Loads
Presenter: Joe Marsala, Durbin Group LLC

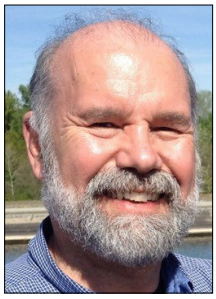
6:00 p.m. – 7:15 p.m. **Pine and Cedar**
Dinner

7:30 p.m – 9:30 p.m. **Oak and Fir**
Evening Tutorial: Realistic Thermal Model for Human Skin in Contact with a Wearable Electronic Device
Bruce Guenin, Consultant

Evening Tutorial

Tuesday, March 17, 7:30 p.m. - 9:00 p.m.

Realistic Thermal Model for Human Skin in Contact with a Wearable Electronic Device



Presenter: Bruce Guenin, Ph.D.

Makers of electronic devices try to provide as much performance and functionality in them as possible, consistent with certain limits for internal chip temperatures. For wearables, the external temperatures of these devices are also critical for user comfort and safety. For accuracy in a thermal model for the wearable device, it is necessary to accurately account for the transfer of heat into human skin. The commonly used ad-hoc assumption of an isothermal boundary condition representing the region of contact between a wearable device and human skin is no longer adequate.

In the medical and biological fields, modeling the transfer of heat into or out of living tissue is a mature area of study. The dominant methodology in this regard is referred to as the Pennes biothermal model, named after its creator. It is a conduction model supplemented by a mechanism for cooling the tissue by blood flow, which Pennes called "perfusion." The application of the Pennes model requires that certain specified material properties be measured for each of the different tissue types involved in the heat flow, namely: thickness, thermal conductivity, specific heat, and perfusion rate. In the case of human skin all three layers (epidermis, dermis, and hypodermis) are separately represented.

Despite its wide use in the life sciences, the Pennes biothermal model is virtually unknown in the electronics cooling sector. It's the intent of this presentation to provide sufficient background information and details in its implementation that the attendees will be able to apply it immediately to their work.

Dr. Bruce Guenin has spent many years in the electronics and computer industries, which has given him a broad perspective on macro trends in these fields. His previous affiliations include Oracle, Sun Microsystems, and Amkor. He is a past chairman of the JEDEC JC-15 Thermal Standards Committee and the Semi-Therm Conference. He has been an editor of Electronics Cooling since 1997. His contributions to the thermal sciences have been recognized by receiving the Harvey Rosten Award in 2004 and the Thermi Award in 2010. He received a B.S. degree in Physics from Loyola University, New Orleans, and a Ph.D. in Physics from the University of Virginia. He has authored and co-authored over 90 papers and articles in the areas of thermal and stress characterization of microelectronic packages, electrical connectors, solid state physics, and fluid dynamics and has been awarded 18 patents in these areas.

From the Creators of *Electronics Cooling*

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Schedule of Events Wednesday, March 18, 2020

7:00 a.m. – 7:45 a.m. — **San Jose**
Speakers' Breakfast (March 18 Speakers, Session Chairs and Co-Chairs only)

8:00 a.m. – 8:10 a.m. — **Oak and Fir**
Welcome Message
General Chair, Pablo Hidalgo, AMD

8:10 a.m. – 8:50 a.m. — **Oak and Fir**
THERMI Award Presentation: Dr. Ross Wilcoxon, Collins Aerospace
Apollo – The Beginning of Semiconductor Thermal Management

8:50 a.m. – 9:10 a.m. — **Gateway Foyer**
Networking Break

9:10 a.m. – 10:10 a.m. — **Oak and Fir**
Parallel Session 4: Air Movers
Session Chair: Robin Bornoff, Mentor, a Siemens Business

9:10 a.m. – 9:30 a.m. — **Oak**
Principles and Advantages of Diaforce Airmover Technology for Upcoming IT Infrastructure Cooling Demand
Wolfgang Laufer, ebm-papst, St. Georgen, Germany

9:30 a.m. – 9:50 a.m. — **Oak**
Inclination Angle Effects on Dual Synthetic Jet Heat Transfer
Sophia Brodish, Matthew Harrison, Ali Haider, Ted Brekken, Peter DeBock, Joshua Gess, Oregon State University

9:50 a.m. – 10:10 a.m. — **Oak**
Application of Fan Blade Serration to Reduce Fan Noise
Prathamesh M Ghankutkar, Bart Manufacturing, Inc.

Continued

Wednesday, March 18, 2020
THERMI Award Presentation:

Apollo - The Dawn of Semiconductor Thermal Management

Ross Wilcoxon

Over fifty years ago, the majority of the world's production of integrated circuits were used by a single project: the Apollo program that led to the first humans on the moon. Effective thermal management of the electronics used in Apollo played a critical role its ultimate success. This presentation provides a brief overview of the state of technology for electronics design and testing at the time of Apollo, describes electronic packaging and thermal management approaches used in Apollo systems, and talks about ways that the field of electronics cooling has changed, and not changed, over the past five decades.

Parallel Session 5: Consumer Electronics II
Session Chair: Alex Ockfen, Facebook

9:10 a.m. – 9:30 a.m. **Fir**
Reduction of Surface Touch (Skin) Temperatures using Composites of Graphite with Ultra–High Spreading Capacity and Insulation with Ultra–Low Thermal Conductivity
Mitchell Warren[1], Julian Norley[2], John Allen[1], Jonathan Taylor[2], Lindsey Keen[1],
[1]WL Gore & Associates, [2]NeoGraf Solutions, LLC

9:30 a.m. – 9:50 a.m. **Fir**
An Analysis of Temperature Variation Effect on Response and Performance of Capacitive Microaccelerometer Inertial Sensors
Jacek Nazdrowicz and Andrzej Napieralski, Lodz University of Technology

9:50 a.m. – 10:10 a.m. **Fir**
Measurement of Performance Parameters of Ultra–Thin Vapor Chamber Under Microgravity
Wei–Keng Lin, Wen–Hua Zhang, Chien Huang, Ching–Huang Tsai, Kenny Hsaio, T–Global Technology Co., Ltd

10:10 a.m. – 10:30 a.m. **Gateway Foyer**
Networking Break

10:30 a.m. – 12:30 p.m. **Oak and Fir**
Parallel Session 6: Two Phase
Session Chair: Devin Pellicone, ACT

10:30 a.m. – 10:50 a.m. **Oak**
Numerical Investigation of Coolants for Chip–Embedded Two–Phase Cooling
Pritish R. Parida and Timothy Chainer, IBM Research

10:50 a.m. – 11:10 a.m. **Oak**
Numerical Investigation of Two–Phase Immersion Cooling using FC–72 Dielectric Fluid
Amirreza Niazmand, University of Texas at Arlington

11:10 a.m. – 11:30 a.m. **Oak**
Empirical Study of Oscillating Heat Pipe Heat Spreaders for High Heat Flux Applications
Joe Boswell, ThermAvant Technologies

11:30 a.m. – 11:50 a.m. **Oak**
Experimental Characterization of Refrigerant-Based Two–Phase Cold Plates to 1000 W: Thermal Metrology and Metrics
Felipe Valenzuela, Villanova University

11:50 a.m. – 12:10 p.m. **Oak**
Design and Optimization of Micropillar Structures for Enhanced Evaporative Cooling of High–Powered Electronics
Mun Mun Nahar[1], Haotian Wu[1], Zhikai Yang[1], Alexander Austin[1], Jorge Padilla[2], Madhusudan Iyengar[2], Damena Agonafer[1]
[1]Washington University in Saint Louis, [2]Google Inc

Continued

SEMI-THERM® 35 THERMA

Monday, March 16, 2020

8:00 a.m. – 12:00 p.m.
San Jose, San Juan, Santa Clara, Carmel, Monterey
Morning Short Courses
Session Chair: Joshua Gess, Oregon State University

Short Course 1
Introduction to Electronics Cooling
Patrick Loney, Northrop Grumman Mission Systems

Short Course 2
Introduction to Thermal Modeling with OpenFOAM
John F. Maddox, University of Kentucky

Short Course 3
Design and Optimization of Heat Sin
Marc Hodes and Georgios Karam, Transport Phenomena Technologies, LLC

Short Course 4
Thermal Management of Li-Ion Battery Packs
Azita Soleymani Ph.D., Electronic Cooling Solutions Inc.

1:30 p.m. – 5:30 p.
San Jose, Santa Clara, Carmel, Monterey
Afternoon Short Courses
Session Chair: Joshua Gess, Oregon State University

Short Course 5
Air Movers and Aeroacoustics for Electronics Cooling
Mark MacDonald, Intel Corporation

Short Course 6
Micro-Two-Phase Electronics Cooling…Getting It On Its Way
John R. Thome, EPFL

Short Course 7
Let's Work Together: How Co-Design Leads to Better Solutions in Thermal Management
Lauren Boteler, Army Research

3:30 p.m. – 6:30 p.m. **Bayshore Ballroom Foyer**
Attendee Registration

5:30 p.m. – 6:30 p.m. **Bayshore Ballroom Foyer**
Welcome Reception

6:30 p.m. – 7:45 p.m. **San Carlos**
SEMI-THERM Program Committee Meeting

Tuesday, March 17, 2020

7:00 a.m. – 7:45 a.m. **San Jose**
Speakers' Breakfast
(March 17 Speakers, Session Chairs and Co-Chairs only)

8:00 a.m. – 8:10 a.m. **Oak and Fir**
Welcome Message
General Chair: Pablo Hidalgo, AMD

8:10 a.m. – 9:10 a.m. **Oak and Fir**
Session 1: Liquid Cooling
Session Chair: Timothy Shedd, ZutaCore

10 a.m. – 10:10 a. **Oak and Fir**
Keynote: Innovation in Thermal Management of Electronic Devices
Andy Delano, Microsoft

10:10 a.m. – 10:30 a.m. **Gateway Foyer**
Networking Break

10: m. – 12:30 p. **Oak and Fir**
Session : Parallel Session: Data Center
Session Chair: Kourosh Nemati, Future Facilities Ltd.

10:30 a.m. – 12:30 p.m. **Oak and Fir**
Session 3: Parallel Session: Consumer Electronics I
Session Chair: Alex Ockfen, Facebook

12:40 p.m. – 2:00 p.m. **Pine and Cedar**
Luncheon and Presentation:
Another day at the office: Combining AI, CFD, and Belgian beer
Presenter: Lieven Vervecken, Diabatix

1:30 p.m. – 6:00 p.m. **Bayshore Ballroom**
Exhibits Open

2:00 p.m. – 5:00 p.m. **Oak and Fir**
Vendor Workshops Parallel Sessions

5:00 p.m. – 6:00 p.m **Oak**
How–To Presentation I:
A Look at Acoustic Fundamentals and Designs as Applied to Air–Cooled Electronics
Presenter: Herman Chu

5:00 p.m. – 6:00p.m **Fir**
How–To Presentation II:
Basic Pumped Refrigerant Cycle Calculations for Cooling IT Loads
Presenter: Joe Marsala, Durbin Group LLC

6:00 p.m. – 7:15 p.m. **Pine and Cedar**
Dinner

7:30 p.m – 9:30 p.m. **Oak and Fir**
Evening Tutorial: Realistic Thermal Model for Human Skin in Contact with a Wearable Electronic Device
Bruce Guenin, Consultant

Wednesday, M

7:00 a.m. – 7:45 a.m.
Speakers' Breakfast
(March 18 Speakers, Session

8:00 a.m. – 8:10 a.m.
Welcome Message
General Chair, Pablo Hidalg

8:10 a.m. – 8:50 a.m.
THERMI Award Presentat
Dr. Ross Wilcoxon, Collins A
Apollo – The Beginning of
Management

8:50 a.m. – 9:10 a.m.
Networking Break

9:10 a.m. – 10:10 a.m.
Session 4: Parallel Sessio
Session Chair: Devin Pellicc

9:10 a.m. – 10:10 a.m.
Session 5: Parallel Sessio
Electronics II
Session Chair: Alex Ockfen,

10:10 a.m. – 10:30 a.m.
Networking Break

10:30 a.m. – 12:30 p.m.
Parallel Session 6: Two Ph
Session Chair: Robin Bornoff, M

10:30 a.m. – 12:30 p.m.
Parallel Session 7: Autom
Outdoor/TIM I
Session Chair: Dave Saums,

12:40 p.m. – 1:40 p.m.
Luncheon and Presentati
Bletchley Park: Enigma, U
Colossus
Presenter: Dave Saums DS&

1:30 p.m. – 6:30 p.m.
Exhibits Open

2:00 p.m. – 5:00 p.m.
Vendor Workshops

5:30p.m. – 6:30 p.m.
Exhibitor Reception

AL WEEK

March 16 - March 20, 2019
San Jose, CA

March 18, 2020

San Jose
on Chairs and Co-Chairs only)

Oak and Fir
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Pine and Cedar
tation:
, Ultra, and the Making of
DS&A LLC

Bayshore Ballroom

Oak and Fir

Bayshore Ballroom

Thursday, March 19, 2020

7:00 a.m. – 7:45 a.m. — San Jose
Speakers' Breakfast
(March 19 Speakers, Session Chairs and Co-Chairs only)

8:00 a.m. – 8:10 a.m. — Oak and Fir
Welcome Message
General Chair, Pablo Hidalgo, AMD

8:10 a.m. – 9:10 a.m. — Oak and Fir
Session 8: CFD and Measurement Techniques
Session Chair: Pritish Parida, IBM

9:10 a.m. – 10:10 a.m. — Oak and Fir
Embedded Tutorial: Additive Manufacturing
Ram Ranjan, UTRC

10:10 a.m. – 10:30 a.m. — Gateway Foy
Networking Break

10:30 a.m. – 11:30 a.m. — Oak and Fir
Session 9: Automotive/Ae spac e/Outdoor/ TIM II
Session Chai dria a ngel, isco Systems

11:30 p – 12:30 p.m. — Oak and F
Thermal ll of Fame Lif ime Achievement Aw rd Pres tation:
ereje Agonafe Univ ity of Texas at Arlington

12:30 p.m. – 2:00 p. — Pine and Cedar
Awards Lu heon
arvey B ten Award, The al Hall of Fame Award, a TH RMI Award

2:00 p – 4:00 p.m. — Oak and Fir
Panel Dis sion: Liquid Cooling

4:00 p.m. – 5:15 p.m. — San Jose
Post SEMI-THERM Program Meeting

5:15 p.m. – 6:00 p.m. — San Jose
Technical Advisory Board Meeting

6:00 p.m. – 6:45 p.m. — San Jose
STEF Board Meeting

Friday, March 20, 2020

8:30 a.m. – 12:30 p.m. — Santa Clara
JEDEC JC 15 Meeting

Thermal Characterization Techniques for Semiconductor Packages
Activities within JC-15's scope include the standardization of thermal characterization techniques, both testing and modeling, for electronic packages, components, and materials for semiconductor devices.

The following events are open to all Registered **SEMI-THERM** Attendees:

esday:
- Exhibits
- Vendor Workshops
- Evening Tutorial

Wednesday:
- Exhibits
- Vendor Workshops
- How To Courses

Plan on attending SEMI-THERM 37 at the DoubleTree by Hilton in San Jose, CA, March 16-20, 2020.

Consider submitting an abstract for a paper presentation at ST 37.

The Call for Papers (CFP) will be listed at www.SEMI-THERM.org by April 1, 2020.

SEMI-THERM will be accepting abstracts for both peer and non-peer reviewed papers shortly thereafter, with a final submission deadline on September 15, 2020.

Luncheon Speaker
Wednesday, March 18

Bletchley Park: Enigma, Ultra, and the Making of Colossus

Presenter: Dave Saums

The development of what has become known as "signals intelligence" traces back to crude beginnings during World War I, in the United Kingdom. As the dark clouds of political and military moves began to turn into signs of impending winter storms in the late 1930s, efforts were made in the UK, France, and in Poland to begin to more seriously decipher diplomatic and military codes being used by the German government. Similar code-breaking activities were taking shape in the United States in very crude form, and in Germany and Japan. In Poland, a small team of so-called codebreakers had focused on the Enigma code being used by the German government for both diplomatic and military purposes and that team made a striking decision that had enormous implications for the outcome of World War II. The British government, having set up a rudimentary codebreaking office twenty years earlier, moved very slowly to develop a more focused effort to break these diplomatic codes. As September 1939 turned the world again to war, the need for tools and methods to crack both diplomatic and military codes became absolutely critical. A small staff was assigned and this small team moved into an old Victorian family estate in Bletchley Park, less than an hour from London by train. The "Special Relationship" that still exists today between the United Kingdom and the United States grew directly from these seeds of human activity and cooperation. This presentation will outline the breaking of the German Enigma code (which became a series of different codes, used by different armed forces services), which produced what as titled as top-secret "Ultra" information about German military plans, locations of ships and submarines and battle groups, and how these first mechanized codebreaking machines were devised.

This presentation will focus on the technologies employed and short descriptions of hardware developed, as precursors to the modern age of digital computing – but will also illustrate the human contributions to preventing the destruction of the modern democratic world in the 1940s. The connections to technology in today's world rose from what would otherwise have been the ashes of defeat.

Bletchley Park today is an astounding museum of both technical detail and human achievement – the opening chapters in what has become the computing world that we live in today.

Dave Saums has thirty-nine years of technical marketing, product development, and business development experience with advanced thermal materials, thermal components, and twophase liquid cooling systems. Dave has operated a consulting firm focused on thermal materials and components for fourteen years, in addition to twenty-five years' experience with thermal component and materials manufacturers.

Schedule of Events Wednesday March 20, 2020 Continued

12:10 p.m – 12:30 p.m. **Oak**
Actively Cooled Two–Phase Cold Plate for High Heat Flux Electronics
Michael Ellis, Advanced Cooling Technologies, Inc.

Parallel Session 7: Automotive/Aerospace/Outdoor/TIM I
Session Chair: Dave Saums, DS&A LLC

10:30 a.m. – 10:50 a.m. **Fir**
Validated Model Calibration for Simulation Aided Thermal Design
Raul Catalin Cioban[1,2] Sz. Szőke[1], Z. Kórádi[1], D. Zaharie–B. [1], C. Leordean[1],
[1]Robert Bosch, [1]Babes–Bolyai University

10:50 a.m. – 11:10 a.m. **Fir**
Innovations in Liquid Metal Thermal Interface Materials
Tim Jensen, Indium Corporation

11:10 a.m. – 11:30 a.m. **Fir**
Thermal and EMI Performance of Natural Graphite Sheet Heat Sinks with Embedded Heat Pipes
Xavier Faure[1], Martin Cermak[1], Ali Saket[2], Martin Ordonez[2], and Majid Bahrami[1], John Kenna[3],
[1]Simon Fraser University, [2]University of British Columbia, [3]Terrela Energy Systems Ltd.

11:30 a.m. – 11:50 a.m. **Fir**
Developing a Proper Mission Profile to Extend Thermal Margin
Brian Philofsky, Xilinx

11:50 a.m. – 12:10 p.m. **Fir**
Effects of Solder Voiding on the Reliability and Thermal Characteristics of Quad Flatpack No–lead (QFN) Components
Ross Wilcoxon, Dave Hillman and Tim Pearson, Collins Aerospace

12:10 p.m. – 12:30 p.m. **Fir**
Calibration of a Detailed FDA Thermal Model to Test Data
Patrick Loney, Northrop Grumman

12:40 p.m. – 1:40 p.m. **Pine and Cedar**
Luncheon and Presentation:
Bletchley Park: Enigma, Ultra, and the Making of Colossus
Presenter: Dave Saums DS&A LLC

1:30 p.m. – 6:30 p.m. **Bayshore Ballroom**
Exhibits Open

2:00 p.m. – 5:00 p.m. **Oak and Fir**
Vendor Workshops Parallel Sessions

5:30p.m. – 6:30 p.m. **Bayshore Ballroom**
Exhibitor Reception

Schedule of Events Thursday March 19, 2020

7:00 a.m. – 7:45 a.m. **San Jose**
Speakers' Breakfast (March 19 Speakers, Session Chairs and Co-Chairs only)

8:00 a.m. – 8:10 a.m. **Oak and Fir**
Welcome Message
General Chair, Pablo Hidalgo, AMD

8:10 a.m. – 9:10 a.m. **Oak and Fir**
Session 8: CFD and Measurement Techniques
Session Chair: Pritish Parida, IBM

8:10 a.m. – 8:30 a.m. **Oak and Fir**
Monte Carlo Prediction of PPM Failure Rate Using a Parametric Reduced Order Model
Robin Bornoff[1] and Wendy Luiten[2]
[1]Mentor, a Siemens business, [2]WLC

8:30 a.m. – 8:50 a.m. **Oak and Fir**
Thermal Characterization of a Virtual Reality Headset during Transient and Resting Operation
Rachel C McAfee, Cole Haxton, Matthew Harrison, Joshua Gess, Oregon State University

8:50 a.m. – 9:10 a.m. **Oak and Fir**
Cross Correlation Method for Images Alignment: Application to 4 Buckets Calculation in Thermoreflectance
Metayrek Youssef[1], Kociniewski Thierry[2], Khatir Zoubir[1]
[1]IFSTTAR, [2]University of Versailles St Quentin

9:10 a.m. – 10:10 a.m. **Oak and Fir**
Embedded Tutorial: Additive Manufacturing
Ram Ranjan, UTRC

10:10 a.m. – 10:30 a.m. **Gateway Foyer**
Networking Break

10:30 a.m. – 11:30 a.m. **Oak and Fir**
Session 9: Automotive/Aerospace/Outdoor/TIM II
Session Chair: Adriana Rangel, Cisco Systems

10:30 a.m. – 10:50 a.m. **Oak and Fir**
Smart Pole Active Electronics Thermal Solution
Walter Mark Hendrix, SRC Design Solutions, LLC

10:50 a.m. – 11:10 a.m. **Oak and Fir**
Experimental Measurement and Finite Element Analysis of Thermal Conductivity of Alumina / Silicone Polymer Composites
Masakazu Hattori[1], Kazuaki Sanada[2], Yasushi Kajita[3]
[1]Fuji Polymer Industries Co., Ltd., [2]Toyama Prefectural University, [3]Nagoya Municipal Industrial Research Institute

Continued

Embedded Tutorial

Thursday March 19, 9:10 a.m. - 10:10 a.m.

Additive Manufacturing

Presenter: Ram Ranjan
UTRC

Additive Manufacturing (AM) is an emerging field that enables cost efficient manufacturing of complex design features and reduce the number of parts in component assemblies. For thermal management applications, AM can make structures that optimally reduce pressure drop and reform thermal boundary layers in the coolant flow field, reducing the package's overall thermal resistance to incredibly low levels. Emerging design methods such as topology optimization enable physics-led optimization of thermal components. These structures that were once "academic" are now producible. However, there are rules and guidelines that must be followed to ensure that a part is consistently producible. In this tutorial, topology optimization methods will be introduced as a tool for novel conceptual design of components such as heat sinks and heat exchangers. "Rules of thumb" will be presented which will arm attendees with the information they need to make AM work for them in the most efficient way, i.e. building parts right on the first try with no failures, lower surface roughness, reduced overhang requirements, etc. Attendees will learn about the new possibilities of AM and how best to use this technique to exceed performance over conventional manufacturing methods.

Schedule of Events Thursday March 19, 2020 Continued

11:10 a.m. – 11:30 a.m. **Oak and Fir**
CVD Polycrystalline Diamond for Laser Diode Applications
Firooz Faili, Element Six Technologies

11:10 a.m. – 11:30 a.m. **Oak and Fir**
CVD Polycrystalline Diamond for Laser Diode Applications
Firooz Faili, Element Six Technologies

11:30 p.m. – 11:50 p.m. **Oak and Fir**
Paper TBD
Presenter: TBD

11:50 p.m. – 12:30 p.m. **Oak and Fir**
Thermal Hall of Fame Lifetime Achievement Award Presentation:
Dereje Agonafer, University of Texas at Arlington

Continued

Panel Discussion: Liquid Cooling

Thursday March 19, 2020 2:00p.m – 4:00p.m.

David Grant graduated from the University of Tennessee in 2003 with a B.S. in Mechanical Engineering. He has been at the Oak Ridge National Laboratory (ORNL) since 2009 where he has been involved with the design, construction, and operation of the mechanical systems supporting ORNL's 80,000SF+ of data centers which house Summit, the world's fastest high performance computer, among others. Current work is focused on facility upgrades to enable a future exascale system. He is currently a co-chair of the Energy Efficient HPC Working Group Infrastructure sub-team and is a corresponding member of the ASHRAE TC9.9. David is a registered Professional Engineer with the State of Tennessee and is a Certified Energy Manager (CEM - from the Association of Energy Engineers (AEE)) and a Data Center Energy Practitioner – Specialist (DCEP - from the Department of Energy (DOE)).He has 13 issued patents.

Dr. Alfonso Ortega is the James R. Birle Professor of Energy Technology at Villanova University. He is the Director of the Laboratory for Advanced Thermal and Fluid Systems and the Founding Director of the Villanova site of the NSF Center for Energy Smart Electronic Systems (ES2) founded in 2011. He is currently Associate Director of the NSF ES2 Center.
He received his B.S. from The University of Texas-El Paso, and his M.S. and Ph.D. from Stanford University, all in Mechanical Engineering. He was on the faculty of the Department of Aerospace and Mechanical Engineering at The University of Arizona in Tucson for 18 years. For two years, he served as the Program Director for Thermal Transport and Thermal Processing in the Chemical and Transport Systems Division of The National Science Foundation, where he managed the NSF's primary program funding heat transfer and thermal technology research in U.S. universities. Dr. Ortega is a teacher of thermal sciences and experimental methods. He is an internationally recognized expert in the areas of thermal management in electronic systems. He has supervised over 40 M.S. and Ph.D. candidates to degree completion, 5 postdoctoral researchers, and more than 70 undergraduate research students. He is the author of over 300 journal and symposia papers, book chapters, and monographs and is a frequent short course lecturer on thermal management and experimental measurements.
He is a Fellow of the ASME and received the 2003 SEMITHERM Thermie Award and the 2017 ITHERM Achievement Award in recognition of his contributions to the field of electronics thermal measurements.

Brandon Rubenstein is the Director of Hardware Development Engineering for Microsoft Azure's Cloud Server Infrastructure group. His team is responsible for providing the IT and supporting infrastructure at Hyperscale on which Microsoft's cloud based platforms operate. Brandon was the director, architect and lead designer for the mechanical and thermal systems for Microsoft's current cloud server product line, which is also known within the Open Compute Project as Project Olympus and Opencloud Server. Before this, he designed the thermal solution for the first generation of Microsoft Surface tablet products. Before joining Microsoft, Brandon was the lead thermal engineer for Hewlett Packard's Enterprise Server Group, developing mechanical and thermal solutions for four generations of Hewlett-Packard's Superdome Enterprise server products over 10 years as well as architecting the HP Apollo liquid cooled "thermal busbar" solution.
Brandon holds over 30 patents and has authored and co-authored several technical papers regarding thermal optimization through modelling. Brandon graduated from Purdue University with a BSME and the University of Wisconsin with an MSME.

Continued

The 2019 Harvey Rosten Award

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For Outstanding Work in the Field of Thermal Analysis of Electronic Equipment:

A Generic Processor Temperature Estimation Method




Baver Ozceylan*[1], Boudewijn R. Haverkort[2], Maurits de Graaf[3], Marco E. T. Gerards[1]

[1]University of Twente, Enschede, the Netherlands, [2]Tilburg University, Tilburg, the Netherlands, [3]Thales Nederland B.V., Huizen, the Netherlands
*Corresponding Author

Baver Ozceylan is a graduate of Middle East Technical University (METU), Turkey (2014, BS and 2017, MS). From 2014 to 2018, he was with the Department of Electrical and Electronics Engineering at METU. Since 2018 he has been a PhD candidate at the Design and Analysis of Communication Systems Group of the University of Twente, The Netherlands. His research interests include mathematical modeling and analyzing, wireless commination systems, energy-efficient and energy-aware algorithms and scheduling, thermal modeling and temperature-aware scheduling.

Boudewijn R. Haverkort (Master and Phd, University of Twente, 1986 and 1991, respectively) is full professor and Dean of the Tilburg School of Humanities and Digital Sciences at Tilburg University, Netherlands. Since 2019. Before moving to Tilburg University, he was a full professor at the University of Twente since 2003, and from 1995 to 2002 he was a professor at RWTH Aachen, Germany. From 2009 to 2013 he was scientific director of the public-private Embedded Systems Institute, an applied research institute focusing on high-tech systems design. His field of interest is very wide, encompassing internet technology, cyber-physical systems, smart energy systems, energy management in data centers, computer performance and reliability evaluation, stochastic model checking, as well as data science. He is a Fellow of the IEEE since 2007, and has published around 200 papers about his scientific work in the above fields, and has chaired a large number of international conferences. Since 2016 he is chairman of the Dutch national research program on big data and applications.

Maurits de Graaf is an experienced Innovation Program and Projectmanager with a thorough scientific background. He has guided many research projects from first concepts to final implementation. He received his PhD in 1994 at the University of Amsterdam for the thesis 'Graphs and Curves on Surfaces'. After a period with the telecommunications research institute KPN Research, he started working with Thales Netherlands B.V. in 1999, mainly in the innovation department. Since 2010 he combines this with a part-time position at the University of Twente as associate professor at the department Mathematics of Operations Research (MOR). He co-authored over 30 publications.

Marco E. T. Gerards received the M.Sc. degrees in computer science and in applied mathematics from the University of Twente, Enschede, the Netherlands, in 2008 and 2011 respectively. He finished his Ph.D. thesis titled "Algorithmic power management: energy minimisation under real-time constraints" in 2014. Then he worked as a postdoc, until 2016 when he became an assistant professor. His research interests are energy management for smart grids and sustainable computing.

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 criteria 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.

Panel Discussion
Thursday March 19, 2020 2:00p.m – 4:00p.m.

Liquid Cooling

For the last 10 years, Liquid Cooling has been a "technology that will be widely adopted in the next 2 to 3 years." Are we actually at that place now? What are the barriers to adoption that may keep liquids out of electronics chassis for even longer? What are the "dream features" of a cooling technology that would truly remove thermal constraints in your application area (without breaking any laws of physics)? What are the applications where there is no choice but to use liquid for electronics cooling? This panel will provide a unique perspective on these and other questions, with representatives of the following end users and implementers:

- ES2 NSF Industry-University consortium
- Collins Aerospace
- Oak Ridge National Laboratory
- Service Logic
- Microsoft
- Intel

Panel Members:

Cathy Biber, Intel
Greg Crumpton, Service Logic Corporation
David Grant, Oak Ridge National Laboratory (ORNL)
Alfonso Ortega, Villanova University
Debabrata Pal, Collins Aerospace
Brandon Rubenstein, Microsoft

Moderator: Tim Shedd, ZutaCore

Cathy Biber is a thermal engineer currently architecting systems in Intel's Data Platforms Group, working primarily on server products. She has experience across a wide range of electronics cooling applications.

Greg Crumpton was named Vice President of Critical Environments and Facilities in 2016. In his current role, Greg drives Service Logic's vertical market penetration in the mission critical segment, and oversees EH&S across Service Logic and its operating units. Greg joined Service Logic in 2014 with the sale of AirTight Mechanical, the company he founded and has led since 1999. As founder and president, he built a remarkable company that had a proven track record and expertise in serving the mission critical market throughout the Carolinas and is a foremost expert in mission critical applications and facilities. Prior to founding AirTight, Greg worked as a Division General Manager of Project Management and in sales capacities for McKenney's, Inc. Greg serves on the advisory boards of Ebullient, LLC a designer and manufacturer of liquid cooling products for data center applications and Atom Power Inc. a designer and manufacturer of advanced electronic circuit breakers.

Continued

Panel Discussion: Liquid Cooling

Thursday March 19, 2020 2:00p.m – 4:00p.m.

Debabrata Pal is a Technical Fellow working at Collins Aerospace, a United Technologies Corporation company. He has B.S, M.S and Ph.D. all in mechanical engineering. He currently leads thermal design of aircraft electrical and electronic systems. Debabrata actively mentors co-op students and engineers. He prepares and teaches classes on thermal management in the Collins Aerospace Technical University. . He has published book chapters, journal papers, conference papers and various patents.

Dr. Timothy A. Shedd is currently Director of Product Management for ZutaCore, Inc. Most recently, he was the Director of the Graduate Program, Supervisor of Entrepreneurship Programs and an Associate Professor of Mechanical Engineering at Florida Polytechnic University. Prior, he was an Assistant, then Associate, Professor of Mechanical Engineering at the University of Wisconsin from 2001 to 2016. In 2012, while still a faculty member, Shedd founded Ebullient, Inc., to commercialize a two-phase cooling system for data centers. He holds a B.S. in Electrical Engineering from Purdue University and M.S. and Ph.D. degrees in Mechanical Engineering from the University of Illinois at Urbana-Champaign. He has received an NSF CAREER award, an ASHRAE New Investigator Award, and a number of teaching and research awards during his academic career. Most recently (2016), Dr. Shedd has been named a Fellow of ASHRAE (the American Society of Heating, Refrigeration and Air-conditioning Engineers).

Schedule of Events Thursday March 19, 2020 Continued

12:30 p.m. – 2:00 p.m. — **Pine and Cedar**
Awards Luncheon

Harvey Rosten Award
A Generic Processor Temperature Estimation Method
Baver Ozceylan, Boudewijn R. Haverkort, Maurits de Graaf, Marco E. T. Gerards

Thermi Award
Dereje Agonafer, University of Texas at Arlington

2:00 p.m – 4:00 p.m. — **Oak and Fir**
Panel Discussion: Liquid Cooling

4:00 p.m. – 5:15 p.m. — **San Jose**
Post SEMI-THERM Program Meeting

5:15 p.m. – 6:00 p.m. — **San Jose**
Technical Advisory Board Meeting

6:00 p.m. – 6:45 p.m. — **San Jose**
STEF Board Meeting

Schedule of Events Friday, March 20, 2020

8:30 a.m. – 12:30 p.m. — **Santa Clara**
JEDEC JC 15 Meeting

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Lifetime Achievement Award

Presented To

Dr. Dereje Agonafer

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

Dr. Dereje Agonafer is a Presidential Distinguished Professor in MAE at University of Texas at Arlington (UTA) where he heads two centers: Site Director of NSF I/UCRC in Energy Efficient Systems and Director of Electronic Packaging. After receiving his PhD at Howard University, he worked for 15 years at IBM. In 1991, his work was recognized by being awarded the "IBM Outstanding Technical Achievement Award in Appreciation for Computer Aided Thermal Modeling." Since joining UTA in 1999, he has graduated 225 graduate students (a record for the University) including 22 PhDs and currently advising 15 PhDs and 18 MS students. His new initiative is to start a new center called RAMPES (Center for Reliability Assessment in Micro and Power Electronic Systems) for which he has received significant funding including $1.3M for new equipment, 3000 sq ft of new lab space, Assistant and Associate Professor openings to work with him, and research engineer among others. For his contributions, he has received numerous awards including the 2008 Thermi Award, the 2009 InterPACK Excellence Award, the 2014 ITHERM Achievement Award, and the 2019 ASME Heat Transfer Memorial Award. Professor Agonafer was a Martin Luther King Visiting Professor at MIT during the 2007 academic year. He is a fellow of the National Academy of Inventors, the American Association for the Advancement of Science and the American Society of Mechanical Engineers. In 2019, he was elected to the National Academy of Engineering. According to Dean Crouch, "the first current faculty member elected to the Academy." Professor Agonafer is married to his wife Carolyn and they have two children; a son, Dr. Damena Agonafer who is Professor of Mechanical Engineering & Materials Science at Washington University in St. Louis, and a daughter, Dr. Senayet Agonafer, a Radiologist, who works at Lennox Hill Radiology in New York City.

SEMI-THERM® 36

Mechanical & Aerospace Engineering
The University of Texas at Arlington

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Proudly sponsors the 2020

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 2020 THERMI award is proudly presented to:

Dr. Ross Wilcoxon
Collins Aerospace

Ross Wilcoxon is an Associate Director, Mechanical Engineer in the Collins Aerospace Advanced Technology group in Cedar Rapids, Iowa. He conducts research and supports the development of prototype and production avionics systems for communication, processing, displays and radars. His work is generally related to component reliability, electronics packaging and thermal management with specific areas of research including the development and implementation of glass-based composite coatings, liquid metal cooling, integration of commercial heat pipes into avionics, and determining the reliability of commercial microelectronic components. Dr. Wilcoxon has been a Principal Investigator for research funded by the Office of Naval Research and the Defense Advanced Research Projects Agency. He has 30 US Patents, primarily in microelectronics packaging and thermal management.
Over the past 18 years, Dr. Wilcoxon has served in multiple roles on the SEMI-THERM Program Committee, including Vice-Program/Program/General Chair, Chair of the Technical Committee, head of the Best Paper selection team, and editor for Peer Reviewed papers. He has been an invited speaker at SEMI-THERM, ITherm, IMAPS Thermal ATW and THERMES and has more than forty publications in journals, technical magazines and conferences. Dr. Wilcoxon is also an editor for Electronics Cooling Magazine and has served on engineering advisory boards for South Dakota State University and the University of Iowa. He received a BS in Mechanical Engineering and MS in Engineering from South Dakota State University and a PhD from the University of Minnesota. Prior to joining Rockwell Collins (now Collins Aerospace) in 1998, he was an assistant professor at South Dakota State University.

SEMI-THERM 36 Location: DoubleTree by Hilton San Jose
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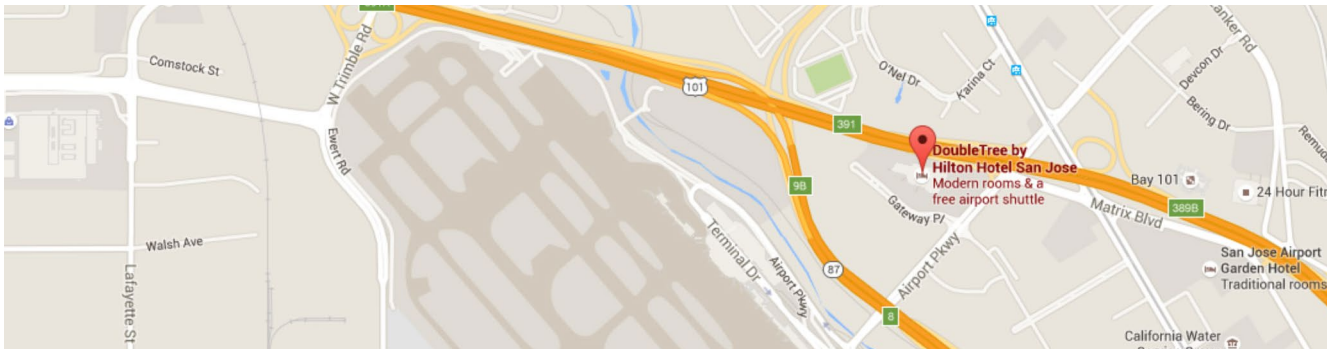

EXHIBITOR LISTINGS

AI Technology, Inc.
AI Technology, Inc. has more than 25 years of experience and successes in helping military, aerospace, computer, and super-computer manufacturers with thermal compound and thermal interface materials for building some of the most reliable electronic devices and computers. Since pioneering the use of flexible epoxy technology for microelectronic packaging in 1985, AI Technology, Inc. has been one of the leading forces in development of patented applications of advanced material and adhesive solutions for electronic interconnection and packaging. The company continues to provide adhesive solutions for component and substrate bonding for both military and commercial applications. It's thermal interface material solutions of patented phase-change thermal pads, thermal grease and gels and thermal adhesives set many bench marks of performance and reliability for power semiconductor and modules, computer and communication electronics.

Analysis Tech
www.analysistech.com
Semiconductor Thermal Testers: Complete measurement systems for device thermal resistance, impedance, & die-attach quality using transient & steady state electrical-junction temperature-measurement. Transient structure function analysis is used to delineate internal-package resistances & measure Rjc via JEDEC 51-14. Power Cycling systems for device life-testing with automatic monitoring of thermal deterioration with age. Test services offered. Thermal Interface Material Testers: ASTM D5470 based testers offering fast & accurate measurement of thermal conductivity & contact resistance of electronic-packaging materials over a wide range of thickness, pressure, & temperature. Test services offered. Event Detectors: Electrical reliability-testers for passive interconnects including solder joints & connectors, with easy integration to thermal-cycle, drop-test, shock, and vibration gear; based on JEDEC and IPC standards for interconnect reliability testing

Alpha Novatech, Inc.
Alpha Novatech, Inc. is your partner for Thermal Solutions.
We offer a wide variety of standard heat sinks and accessories. Our product line includes natural convection, forced convection, and active heat sinks. We also offer various attachment methods and hardware for almost any application. In addition, we can offer free heat sink thermal simulations. Standard or custom heat sinks in prototype to production quantities Quick and easy customization without NRE fees, while featuring short lead times Standard parts are carried in stock Lead time for custom parts of 1-2 weeks is possible for initial quantities.

ANSYS
ANSYS is the leading provider of electronic cooling, electromagnetic field, circuit and system simulation software for the design of high-performance electronic equipment. Companies throughout the world rely on ANSYS software to solve thermal integrity, mechanical reliability, signal integrity, power integrity and EMI challenges in IC, package and PCB and perform power optimization in custom IC's. Ansys develops open and flexible simulation solutions that enable users to simulate design performance directly on the desktop, providing a common platform for fast, efficient and cost-effective product development, from design concept to final-stage testing and performance validation. Engineers rely on ANSYS to achieve first-pass system success when designing mobile communication devices, broadband networking components and systems, integrated circuits (ICs), printed circuit boards (PCBs) and electromechanical systems. ANSYS' unique multiphysics platform provides a highly-accurate design flow for fast, efficient and simulation driven product development.

EXHIBITOR LISTINGS

AOS Thermal Compounds
AOS Thermal Compounds developed the first non-silicone thermal interface materials for AT&T in the 1960's. Today we manufacture the lowest thermal resistance and pump-out resistant thermal greases, unique Micro-Faze thermal pads, and a high performance and economical line of Sure-Form gap fillers.

Boyd Corporation
Boyd Corporation has over 90 years of customer-focused performance success and is a global leader in advanced sealing, thermal management and protection solutions. Aavid, Thermal Division of Boyd Corporation has a long history of developing, designing, testing, optimizing, and fabricating reliable high-performance cooling systems across all industries. By choosing, integrating, or developing the right technology, Boyd delivers solutions that can increase power, improve functionality and reliability, and reduce the cost and size of our customers' applications.

AR Brown
AR Brown is a provider of Aluminum Nitride Powder - high thermal conductivity, low viscosity, high filling rate – As manufacturers, we produce in-house, consistently enabling a stable supply of high-quality products. Compared to spherical products, it has a high filling property and can be expected to improve the properties of resin products with high thermal conductivity.

Cadence Design Systems, Inc.
Cadence, with its software, hardware and semiconductor IP enables electronic systems and semiconductor companies to create the innovative end products that are transforming the way people live, work and play. The company's Intelligent System Design strategy helps customers develop differentiated products—from chips to boards to Intelligent systems—in mobile, consumer, cloud, data center, automotive, aerospace, IoT, industrial and other market segments. Cadence is showcasing Celsius™ Thermal Solver, the industry's first complete electro-thermal co-simulation solution at SEMI-THERM 2020 in San Jose, California. Learn more at www.cadence.com

Binghamton University
S3IP brings together teams of experts from industry and academia to address pressing real-world problems in the systems integration and manufacturing of electronics. Our research centers focus on topics related to electronics packaging, flexible electronics, heterogeneous integration, energy-efficient electronic systems and energy harvesting and storage. Binghamton University, the premier public university in the Northeast, is home to S3IP, a New York State Center of Excellence. Our PhD-level staff members and affiliated faculty, in 6 constituent research centers and 9 laboratories, are ready to assist companies in New York State and beyond with collaborative problem solving. As a result of our combined efforts, our industry partners have reported over $1.5 billion of economic benefit.

CEJN North America
CEJN North America, the Quick Connect Solution Provider, delivers couplings and solutions for your liquid cooling needs. Our Leak-Free, Non-Drip coupling series offers high flow and minimal pressure drop; and Blind Mating options range from DN 3 to DN 19. CEJN's new UltraFlow Series features an extremely high flow combined with an unequalled low pressure drop. Customized solutions are also available. At CEJN, we develop our products for a future in liquid cooled data centers. Contact us: PHONE: 847-263-7200, by email: customer.service.usa@cejn.com, or via www.cejn.us.

EXHIBITOR LISTINGS

Celsia
Celsia specializes in custom heat sink design and manufacturing using liquid two-phase devices: heat pipes and vapor chambers. Through its US headquarters and Taiwan design & production facility, the company's goal is to deliver fast, affordable, and reliable thermal solutions for the most demanding applications including high density electronics, performance CPU / GPU, amplifiers, HBLEDs, ASICS, and rugged systems. In recent years, Celsia has shipped over 2.5 million thermal assemblies to a global custom base in the telecommunications, computer, test equipment, defense, laser, and medical markets.

CPC
CPC thinks beyond the point of connection to help protect valuable electronics. Designed specifically for liquid cooling applications, rugged couplings withstand long periods of connection yet disconnect reliably without drips.

Chroma ATE Inc.
Chroma ATE Inc. Irvine Ca., is a world-leading designer and manufacturer of complete turn-key, IC thermal management and automated IC Handling solutions. Specializing in integrated and fully automated turn-key electronic test and MES solutions for the semiconductor, front and back-end test spaces. Chroma is driven to provide unique, tailored solutions, and technical support to help our US-based customers excel in today's high demanding environment.

Degree Controls
Degree Controls is the leading manufacturer of miniature, board-mount air velocity and temperature sensors for embedded electronics applications, where power density is high, and thermal reliability is paramount. Our sensors are built into high-end electronics all over the world, reporting air velocity and temperature in real time, while directly speed-controlling fans or impellers to eliminate the need for fan controllers.
Our line of research grade, multi-point air velocity sensors with USB plug and play connectivity, are used by electronic and product designers around the world for maximizing cooling, thermal efficiency and reliability. Up to 200 air velocity sensors can be placed on PCB assemblies, or in the chassis, to study air velocity in real time, and prove out thermal engineering designs. Based in New Hampshire, USA, Degree Controls brings 25+ years of thermal engineering and sensor design experience to the electronics market.

COFAN USA
At COFAN USA, we keep your hot technology cool. COFAN USA is an industry leading manufacturer in thermal management solutions with inhouse thermal engineering team providing thermal simulation service and consultation to our customers. With more than 20 years of expertise, we've had the pleasure of serving a diverse customer base in many industries. We offer quick turnaround product inquiries and prototyping services. We pride ourselves in giving the best possible customer service, the highest quality products with the shortest lead time, and competitive pricing in the industry. To learn more about us, please visit www.cofan-usa.com

Delta Fan and Thermal Products Group
The Delta Fan and Thermal Products Group designs and builds innovative cooling systems that perform to the highest standards – even in harsh environments.
The Delta Fan and Thermal product line includes a full range of axial fans, blowers, heat pipes, vapor chambers and liquid cooler products.
Our Delta-exclusive patented design and innovative structure boosts cooling performance and reduces system noise. Delta fans and thermal products are sold globally, serving an array of industries and organizations. Highly efficient cooling solutions can be customized to suit the needs of virtually any business.

EXHIBITOR LISTINGS

Dexerials Corporation

Dexerials Corporation creates advanced materials for a variety of different applications by utilizing its unique set of functional materials, process solutions, and customized technology. Dexerials is promoting three different types of thermal conductive sheets: silicone, acrylic, and carbon fiber. The silicone type features high thermal conductivity and flexibility while the acrylic type does not generate low molecular weight siloxanes (which causes contact failure in electronic devices). The carbon fiber type, with extremely high thermal conductivity of up to 35 W/(m • K), is an ideal fit for thermal countermeasures in high performance CPUs and power ICs. For more information, please visit www.dexerials.jp/en.

Electronics Cooling

Electronics Cooling magazine has been providing a technical data column since 1997 with the intent of providing you, the readers, with pertinent material properties for use in thermal analyses. We have largely covered the most common materials and their associated thermal properties used in electronics packaging.

ITEM Media publishes a portfolio of digital and print magazines within the electronics industry. Our titles are available in a variety of electronic and printed media formats, including digital magazines, e-newsletters, social media feeds, forums, content marketing tools and printed magazines.

Dynatron Corporation

Dynatron Corporation, an industry leader in thermal solutions spanning a wide spectrum of consumer to enterprise products. With missions of CPU coolers sold worldwide since 1995. Dynatron has established its reputation over the years and continues to reinforce it with world class support and inventive ways to keep critical systems operating.

It is also the first company to invent a uniquely designed radiator equipped with a built-in pump into the liquid cooler. Coupled with an integrated Skived fin and its proprietary Vapor Chamber technology into a heatsink, has raised the standard in liquid cooling.

ECS

ECS provides services for companies in a wide variety of industries and applications. Our customers develop products for the avionics, consumer, computing, medical, networking and telecommunications industries. Special needs can also be addressed, such as cooling the electronics for a unique telescope, and the thermal issues in manufacturing processes.

Since its founding, ECS has established a reputation for excellent service to its customers, providing high-quality and cost-effective solutions. Each member of the team is customer-driven and brings a combination of design, analysis and test skills to the issues faced by our customers. Several members of the team have 15 or more years of experience solving thermal problems in a product development or research environment.

Today, ECS is a leading-edge company in thermal management services and is based in the heart of Silicon Valley.

ebm-papst is an innovator and market leader in fans, blowers, and motors with core competencies in motor technology, aerodynamics, and electronics. With over 15,000 products, we provide solutions to a wide range of markets including Air-conditioning and Ventilation, Appliance, Automotive, Commercial Refrigeration, Heating, Industrial, IT / Telecom, Lighting & Digital Signage, Medical, Transportation and more.

EXHIBITOR LISTINGS

Element Six

Who we are: Element Six is a global leader in the design, development and production of synthetic diamond and tungsten carbide supermaterials. Part of the De Beers Group, we employ over 1,900 people. Our primary manufacturing sites are located in the UK, Ireland, Germany, South Africa, and the US.

Our mission: We strive to deliver extreme performance through the development of cutting-edge synthetic diamond and tungsten carbide solutions.

Our history: Since 1959, our focus has been on developing the diamond synthesis process to enable innovative synthetic diamond and tungsten carbide solutions. As well as being the planet's hardest material, diamond's extreme and diverse properties give it high tensile strength, chemical inertness, broad optical transmission and very high thermal conductivity.

Find out more about us at e6.com

Fujipoly

Fujipoly is a world leader in the manufacture of Sarcon® Thermal Interface Materials, which are used to help keep sensitive electronic components cool by eliminating the air gap between the component and heat sink. Our products range in thermal conductivity from 1.0m watt/m-K to 17 watt/m-K, offering some of the lowest thermal resistance in the industry. Our product line-up consists of soft Gap Filler Pads, Conformable Putties, Form-In-Place Gap Fill Materials, as well as custom and standard die-cut thin film materials. Our wide range of material types, coupled with the widest range of thermal conductivity, allows us to meet most design criteria. Fujipoly has nine locations in North America, Europe, and Asia making it easy for us to assist our customers at the local level.

Future Facilities

We set Future Facilities up to deliver the power of engineering simulation into the hands of an emerging data center industry. We created a tool optimized for data centers, designed to be used by the DC professional, and made it powerful, intelligent, automated and connected. Five years later, we tuned our technology to deliver the same benefits to the thermal management of electronics and provide an integrated toolset for these two converging industries. We develop engineering simulation software that allows our customers to quantify and qualify business decisions balancing risk against cost. Our offering covers the full spectrum starting from electronics design to data center design and operations. Our software provides a safe, offline environment in which to create virtual prototypes, troubleshoot existing designs and run what-if scenarios for future configurations.

Indium Corporation

Indium Corporation is a premier materials manufacturer and supplier to the global electronics, semiconductor, thin-film, and thermal management markets. Products include solders and fluxes; brazes; thermal interface materials; sputtering targets; indium, gallium, germanium, and tin metals and inorganic compounds; and NanoFoil®. Founded in 1934, Indium has global technical support and factories located in China, Malaysia, Singapore, South Korea, the United Kingdom, and the USA.

For more information about Indium Corporation, visit www.indium.com or email abrown@indium.com. You can also follow our experts, From One Engineer To Another® (#FOETA), at www.facebook.com/indium or @IndiumCorp.

InfraTec

The Dresden-based company InfraTec GmbH Infrarotsensorik und Messtechnik has been a specialist for products and services in the field of infrared technology for 25 years. Now about 220 staff are employed. In the business division of sensor systems, custom-made components are produced on more than 1.000 m^2 of clean room space – especially pyroelectrical infrared detectors – for clients worldwide. With its business division of infrared measurement InfraTec ranks among the large suppliers of thermography and non-military thermal imaging. InfraTec has been supplying thermal imaging technology like its high-end camera series ImageIR® to demanding customers. Specific solutions tailored to electronic and microelectronic testing have been developed which today suit the needs of customers in the value chain of LED development and manufacturing.

EXHIBITOR LISTINGS

Jones Tech
Jones Tech provides creative thermal and EMI solutions to improve the reliability of electronic equipment. Established in 1997, with its rich R&D resources and manufacturing experience, Jones Tech has been serving consumer electronics, telecommunications, IT, medical, and renewable energy customers. We are a long-term supplier to 4 of the top 5 Silicon Valley companies. Our thermal interface material (TIM) includes thermal pads, gel, grease, thermal phase change materials (PCM), and graphite TIM. For heat spreaders, we are a leading supplier of synthetic and natural graphite. We have in-house rotary and flatbed die-cutting capabilities. For heat storage materials, we offer PCM pads, gel and potting material. We can help with manual or robotic dispensing. Additionally, we help solve problems with EMI and RF related components.

Klinger IGI
Klinger IGI is an AS9100 / ISO 9001-2015 / ITAR registered manufacturer, specializing in precision cut thermal interface and gap pads, EMI/RFI shields, acoustic and vibration dampers, washers and spacers, filters, and custom gaskets and seals for OEMs and Tier 1s in the highly regulated aerospace, electronics, medical, and energy industries. Klinger IGI delivers total solutions with a large selection of material options, proven manufacturing technologies and simple integration of manufactured production parts with tight tolerances. We offer expertise in selecting the most cost-effective material solutions while supporting the design of your parts with effective manufacturing and assembly operations.

Laird Performance Materials
Laird Performance Materials enables high-performance electronics. We create advanced protection solutions for electronic components and systems. World-leading technology brands rely on us for improved protection, higher performance and reliability, custom structural designs and faster time-to-market. We solve design issues through innovative products such as EMI suppression or absorption materials, thermal interface materials, structural and precision metals, magnetic ceramic products, and multi-functional solutions. This latter product family solves multiple EMI, thermal, and structural design issues simultaneously using a single process solution.

LISAT
LISAT, manufacturer of Thermal Interface Material & EMI products. HQ in U.S., LISAT have operations in Asia. In U.S., we provide Thermal Management Solution to customers & work with R&D Engineers at Design Centres. We provide technical support & samples to our customers to test our materials. Our Asia operations provide manufacturing, converting, technical & sales to customers' worldwide. Our products : TIM Pad, Insulator, Silicon Free TIM, Gel, Grease, Mylar, Graphite, Conductive Plastic, Conductive Elastomer, Fabric-Over-Foam, Microwave Absorbing Material, Metal Finger Stock, EMI Shielding Solution, Switching Power Supply, Desktop & Wall Mount Adaptor, Metal Core PCB, Ceramic PCB. Email alan@lisat.net

Long Win
Long Win specializes in research, design, manufacture and service of scientific instruments for thermal managing, material & fluid mechanic and educational fields. Long Win holds a leading position on research, measurement and inspection apparatus for the electronic cooling market. Some of their product lines include thermal-related measurement apparatus for fan performance, TIMs, cooler modules, heat pipes, vapor chambers, IC packages, LEDs, liquid cooling, thermal and flow test for servers, racks and data center, and natural-convection simulation. They have more than 100 types of apparatus in their 18,000 sq. ft. lab which is located in Taiwan and a lab based in Livermore, California.

Mentor, a Siemens business
Siemens PLM Simcenter portfolio includes a range of simulation software and test equipment solutions to aid development of a virtual digital twin of a product for improved design and lifecycle management. This portfolio now includes 30+ year industry leading Simcenter Flotherm electronics cooling software product family and Simcenter T3STER thermal test hardware solutions from Mentor, a Siemens business.
Find out about the latest in enhancements to Simcenter Flotherm and Simcenter Flotherm XT at SEMI-THERM, and seek more information on other simulation tools in the portfolio incl. multi-physics simulation software (Simcenter STAR-CCM+), CFD for designers (Simcenter FLOEFD).
In semiconductor thermal measurement, characterization and thermal reliability, find out the latest on Simcenter T3STER test solution family. This includes latest developments in thermal measurement to support automatic thermal simulation model calibration and LED multi-domain models, TIM material testing, and power semiconductor thermal reliability testing (SIMCENTER POWERTESTER range).

EXHIBITOR LISTINGS

Man Zai
As a leader in electronic liquid cooling system, Man Zai offers a wide range of thermal modules for CPU, VGA, LED, Bio-Chemical and automotive electronic device. The thermal team is equipped with state of the art hardware and software, which includes wind tunnel testing, hydraulic test equipment, simulation software, helium & air leakage test equipment and ultra-high-speed pre-filling technology. We are able to establish long-term relationships with several world-wide famous brand names. The quality system and sophisticated R&D capability in Man Zai will provide our customers the best thermal solution.

NeoGraf Solutions, LLC
NeoGraf Solutions, LLC, a world leader in graphite materials science, has been manufacturing carbon and graphite products for over 135 years in Lakewood, Ohio. Today, our high-performance products are used in a variety of demanding applications in a diverse array of industries. We specialize in development and manufacture of high quality natural and synthetic graphite sheets and powders used in the latest consumer electronic devices, building & construction materials, transportation, and sealing & gasketing. With internal research, development, and manufacturing capabilities, NeoGraf provides high quality products, environmentally sustainable solutions, and new opportunities for our customers.

NETZSCH Instruments
NETZSCH Instruments provides a complete instrument line and laboratory testing for thermal analysis with industry leading products for evolved gas analysis (QMS, FT-IR, GC-MS). When it comes to Thermal Analysis, Calorimetry (adiabatic & reaction) and the determination of Thermophysical Properties, NETZSCH has it covered. Our 50+ years of applications experience, broad state-of-the-art product line and comprehensive service offerings ensure that our solutions will not only meet your every requirement but also exceed your every expectation.

MSC Software
MSC Software develops simulation software technology that enables engineers to validate and optimize their designs using virtual prototypes. Our CFD solutions are characterized by their user-friendly interfaces, high accuracy, and high efficiency. Customers in almost every part of manufacturing use our software to complement, and in some cases even replace the physical prototype "build and test" process that has traditionally been used in product design.

Schlegel
Schlegel Electronic Materials (SEM) invented highly conductive fabric over foam shielding gaskets in 1987, marking a major breakthrough for the electromagnetic interference shielding of electronic enclosures and has become the pre-eminent manufacturer of electromagnetic interference (EMI) shielding products.
SEM offers a full range of EMI shielding products including gaskets, Thermal Interface Materials, I/O backplane shielding gaskets, BeCu Fingerstock, and conductive tapes. laminates, and a newly developed line of absorbers. These products enable the computer, telecommunications, military, medical and electronics industries to meet global requirements for electromagnetic compatibility (EMC). From concept to production, SEM's complete portfolio of shielding products combines highly conductive materials with flexible foams and coatings to provide the latest EMI containment solutions.

Thermexit
Nanoramic Thermexit™ is a line of high-end thermal interface gap filler pads. Nanoramic's gap fillers are a non-reactive, non-silicon, no cure system featuring high thermal conductivity and high thermal stability. Nanoramic produces 2 novel product lines, a High Performance TIM Gap Filler and an Electrically Insulating TIM Gap Filler.

EXHIBITOR LISTINGS

Shin-Etsu MicroSi

Shin-Etsu MicroSi is the leader in Thermal Interface Material, and we have developed an extensive line of Molding Compounds, Encapsulents, Silicon and Epoxy coatings along with die Attachment Materials. The quality of our thermal interface material is among the most advanced in semiconductor manufacturing and has a wide range of use in thermal interface material applications. Some of which include thermal gels and grease, phase change materials, and high hardness silicone rubber pads. Shin-Etsu products are delivered globally to many major and minor companies involved in the fabrication process of electronics and microelectronics.

Stäubli

Stäubli is an innovative mechatronics solutions provider with three dedicated activities: Connectors, Robotics and Textile. With a workforce of over 4500, Stäubli has a presence in 25 countries and agents in 50 countries around the world. As one of the leading manufacturers of quick connector systems, Stäubli covers connection needs for all types of fluids, gases and electrical power. These standard or specific products – including single and multiple connectors, tool changers and quick mold change systems – combine performance, quality, safety, dependability and durability.

Sysmetric

Sysmetric develops thermal management solutions for testing and validation engineers.

Sysmetric cooling systems aim to answer the new market demands to validate Silicon DUT (Device under test) under new validation temperature standards of 150W@-40 ºC up to 1KWatt@ 125ºC.

Specialized fields including:

– Semiconductor testing
– Medical devices
– Climate chambers
– Laser systems.

TCPoly, Inc.

TCPoly has developed ultra-high thermal conductivity composites and phase change materials that can be used to manufacture high performance heat transfer products on low-cost 3D printers including lightweight, corrosion resistant, and high-performance heat exchangers, heat sinks, cold plates, and heat conductive cases and enclosures. Their patented materials can achieve effective thermal conductivities greater than 50 W/m-K and can be formulated to be electrically insulating, thermochromic, and have tunable EDS/EMI properties. TCPoly is a total thermal solutions provider, offering a full suite of services from product design and testing to custom materials formulation and product production. Their production partners can make thousands of 3D printed parts per month and are constantly growing their capacity as additive manufacturing technology evolves.

TE Connectivity

TE Connectivity is a global technology and manufacturing leader creating a safer, sustainable, productive, and connected future. For over 75 years, its connectivity and sensor solutions have enabled advancements in transportation, industrial applications, medical technology, energy, data communications, and the home. With 78,000 employees, including more than 7,000 engineers, in nearly 150 countries, it ensures that every connection counts.

EXHIBITOR LISTINGS

T-Global Technology
T-Global Technology is dedicated to the development, manufacture and research of all-rounded thermal solution products. We provide our customers with thermal simulation, rapid sampling, customized products and professional technical support. With rich experience in research, development and marketing, T-Global is already become the designated and direct supplier of over 3,000 enterprises worldwide.

ThermoAnalytics
ThermoAnalytics provides thermal solutions for complex vehicle engineering simulation. Our software, TAITherm, is the industry's most complete and flexible thermal modeling software, one that can predict the full range of temperature distribution in your product or system. TAITherm can model a variety of thermally sensitive components including transient brakes, underhood, exhaust and underbody simulation, HVAC, cabin, battery packs for HEV/EV, and more. ThermoAnalytics' rapid transient thermal analysis can couple to FEA and CFD software, a key component to an efficient design process. Our software is commonly used in the automotive, aerospace, heavy vehicle, and railway industry. ThermoAnalytics also offers advanced consulting services with our engineering teams that specialize in thermal, CFD, infrared simulation and testing.

Thermal Engineering Associates
TEA is a company founded by Bernie Siegal, a 35+-year veteran and recognized technical leader in the semiconductor thermal field. The company's mission is to provide a central source for the products and services necessary for proper semiconductor thermal measurement and modeling and solutions to attendant thermal management problems. Through its own products and services, augmented by an extensive network of technical experts around the world, TEA can assist customers in finding solutions. The Tech Briefs and Hot Links pages provide useful information to those interested in semiconductor and electronics thermal issues. We welcome the opportunity to discuss your thermally-related measurement, modeling and/or management requirements.

W. L. Gore & Associates
W. L. Gore & Associates is a global materials science company dedicated to transforming industries and improving lives. We are a privately held company with a 60-year heritage of working together with each other and our customers to develop innovations that improve the world.
Gore has served the electronics industry for many years and we are excited to showcase our latest breakthrough material for thermal management in mobile electronic devices. Our thermal insulation material, GORE® Thermal Insulation, can help thermal engineers solve challenging hot spot issues in thin device designs. Please stop by our booth to learn more.

ThermAvant Technologies
ThermAvant Technologies, LLC designs, develops and delivers custom thermal solutions to improve size, weight, performance and/or costs of advanced energy and technology platforms. The leading provider of Oscillating Heat Pipe products, ThermAvant also offers custom Cold Plates, Ejector Refrigerators, and Design & Engineering services.

WACKER is a global silicone leader with a broad portfolio of products designed for the needs of the electronics industry. Our SEMICOSIL®, SilGel®, and ELASTOSIL® brands are globally recognized in the industry. Please stop by our booth and learn how our potting gels, adhesives, and newest thermal interface materials can help you meet your design challenges.

Student Scholarships

Scholarships will be given to each of the best papers in the general or specific technology areas described below.

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Best Student Paper in the area of
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$1,000
Best Student Paper in the area of
Energy-Smart Electronic Systems Technology and/or Application

To be eligible, candidates must:
- Be senior undergraduate or graduate students at a recognized university
- Part of a significant contributor on an academic or industry team
- Be the first or second student author of the technical paper
- Be the paper presenter at SEMI-THERM

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