SEMI-THERM 36 ADVANCE PROGRAM

Monday March 16, 2020

Short Courses

8:00 a.m. Short Course 1: **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.

8:00 a.m. Short Course 2: **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 hand-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.

8:00 a.m. Short Course 3: **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, say) of an array of heat sinks in a circuit pack represented by an FNM model with embedded tabulations of CFD results is discussed.

8:00 a.m. Short Course 4 **Thermal Management of Li-Ion Battery Packs**
Azita Soleymani, Electronic Cooling Solutions, Inc.

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

1:30 p.m. Short Course 6 **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.

1:30 p.m. Short Course 7 **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.

Tuesday March 17, 2020

8:00 a.m. Welcome Message, General Chair: Pablo Hidalgo, AMD

8:10 a.m. Session 1: **Liquid Cooling**, Session Chair: Timothy Shedd, Zuta-Core, Ltd.

Direct Micro-Pin Jet Impingement Cooling for High Heat Flux Applications
Vahideh Radmard, Binghamton University

Shape Optimization of a Pin Fin Heat Sink
Thomas Menrath, Fraunhofer Institute for Integrated Systems and Device Technology

Wicking Performance Enhancement by Laser Induced Roughness
Sougata Hazra, Stanford University

9:00 a.m. **Keynote: Andy Delano, Microsoft**

Innovations in Thermal Management of Electronic Devices
Highlighting recent innovations and effective techniques for innovating over the course of his career.

Andy Delano leads the Microsoft Surface team's thermal architectural efforts primarily Focusing on the Pro product line. Prior to joining Microsoft in 2012, Andy managed an R&D team within Honeywell's Specialty 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 working on enterprise server and workstation thermal design. While at HP, Andy was also an adjunct professor at CU and taught heat transfer, thermodynamics, and thermal systems design between 1999 and 2005. 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.

10:30 a.m. Session 2: Parallel Session: **Data Center**, Session Chair: Kourosh Nemati, Future Facilities Ltd.

Determination of Cost Savings Using Variable Speed Fans for Cooling Servers
Minh Tran, San Jose State University

On Economic Cooling of Contained Server Racks Using an Indirect Adiabatic Air Handler
Wolfgang Birk, Lulea University of Technology

An Experimental Apparatus for Two Phase Cooling of High Heat Flux Application Using An Impinging Cold Plate And Dielectric Fluid
Cong Hiep Hoang, Binghamton University

Assessment of Dispersion and Transport of Airborne Particulate Contaminants in a Raised Floor Data Center Using CFD
Satyam Saini, The University of Texas at Arlington

Experimental Validation of a Numerically Optimized Array of Heat Sinks
Georgios Karamanis, Transport Phenomena Technologies, LLC

General Guidelines for Commercialization of Small-Scale In-Row Cooled Data Centers
Yaman Manaserh, Binghamton University

10:30 a.m. Session 3: Parallel Session: **Consumer Electronics I**, Session Chair: Alex Ockfen, Facebook/Oculus

Self-Heating Investigation in SOI MOSFET Structures with High Thermal Conductivity Buried Insulator Layers
Konstantin Petrosyants, Moscow Institute of Electronics and Mathematics

Testing and Analysis of Improved Thermal Solutions for a Home Wireless Router
Raul Vargas, Electronic Cooling Solutions

Thermal Acceptability Limits for Wearable Electronic Devices
Mark Andrew Hepokoski, ThermoAnalytics, Inc.

Transient Thermal Model for Wearable Device in Contact with Human Skin
Bruce Guenin, Consultant

DNN-based Fast Static On-chip Thermal Solver
Jimin Wen, ANSYS, Inc.

Microencapsulated Phase Change Materials as Heat Transfer Media in Electronics
John Rasberry, Keysight Technologies

12:40 p.m. Special session: **Luncheon Speaker**: Lieven Vervecken, Diabatix

1:30 p.m.- 6:00 p.m. Exhibits open

2:00 p.m. Vendor Workshops

	Oak	Fir
2:00 p.m.	Siemens Digital Industries Software	Laird Performance Materials
3:00 p.m.	Dongguan Sheen Electronic Technology	T-Global Technology
4:00 p.m.	Future Facilities	Boyd Corporation

5:00 p.m. Special session: **How to Courses**

6:00 SEMI-THERM Dinner

7:30 p.m. Special session: **Evening Tutorial: Realistic Thermal Model for Human Skin in Contact with a Wearable Electronic Device,** Bruce Guenin

Wednesday March 18, 2020

8:00 a.m. Welcome Message General Chair, Pablo Hidalgo, AMD

8:10 a.m. Special session: **THERMI Award Presentation:**
Ross Wilcoxon, Associate Director Mechanical Engineering Mission Systems, Collins Aerospace

9:10 a.m. Session 4: Parallel Session: **Air Movers**, Session Chair: Roger Dickinson

Principles and Advantages of DiaForce Airmover Technology for Upcoming IT Infrastructure Cooling Demand
Wolfgang Laufer, ebm-papst

Inclination Angle Effects on Dual Synthetic Jet Heat Transfer
Sophia Brodish, Oregon State University

Application of Fan Blade Serration to Reduce Fan Noise
Prathamesh M Ghankutkar, Bart Manufacturing, Inc.

9:10 a.m. Session 5: Parallel Session: **Consumer Electronics II**, Session Chair: Alex Ockfen, Facebook/Oculus

Reduction of Surface Touch (Skin) Temperatures Using Composites of Graphite with Ultra-High Spreading Capacity and Insulation with Ultra-Low Thermal Conductivity
Mitchell Warren, WL Gore & Associates

An Analysis of Temperature Variation Effect on Response and Performance of Capacitive Microaccelerometer Inertial Sensors
Jacek Nazdrowicz, Lodz University of Technology

PID 5 Measurement of Performance Parameters of Ultra-Thin Vapor Chamber Under Microgravity
Wei-Keng Lin, Kenny Hsaio T-Global Technology Co., Ltd

10:30 a.m. Session 6: Parallel Session: **Two Phase**, Session Chair: Robin Bornoff, Mentor- A Siemens Business

Numerical Investigation of Coolants for Chip-embedded Two-Phase Cooling,
Pritish R. Parida, IBM Research

Numerical Investigation of Two-Phase Immersion Cooling using FC-72 Dielectric Fluid,
Amirreza Niazmand, University of Texas at Arlington

Empirical Study of Oscillating Heat Pipe Heat Spreaders for High Heat Flux Applications
Joe Boswell, ThermAvant Technologies

Experimental Characterization of Refrigerant based Two-Phase Cold Plates to 1000 W: Thermal Metrology and Metrics
Felipe Valenzuela, Villanova University

Design and Optimization of Micropillar Structures for Enhanced Evaporative Cooling of High-Powered Electronics
Damena Agonafer, Washington University

Actively Cooled Two-phase Cold Plate for High Heat Flux Electronics
Michael Ellis, Advanced Cooling Technologies, Inc.

10:30 a.m. Session 7: **Automotive/Aerospace/Outdoor/TIM I**
Session Chair: Shailesh Joshi, Toyota Research Institute

Validated Model Calibration for Simulation Aided Thermal Design
Raul Catalin Cioban, SC Robert Bosch SRL

Thermal and EMI Performance of Natural Graphite Sheet Heat Sinks with Embedded Heat Pipes
Martin Cermak, Simon Fraser University

Developing a Proper Mission Profile to Extend Thermal Margin
Brian Philofsky, Xilinx

Effects of Solder Voiding on the Reliability and Thermal Characteristics of Quad Flatpack No-lead (QFN) Components, Ross Wilcoxon, Collins Aerospace

Calibration of a Detailed FDA Thermal Model to Test Data
Patrick Loney, Northrop Grumman

12:40 p.m. **Luncheon Speaker**: **Bletchley Park: Enigma, Ultra, and the Making of Colossus - The Development of the First Digital Computing Systems,** David L. Saums, DS&A LLC

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 was 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. The 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 arose from what would otherwise have been the ashes of defeat.

1:30 p.m. Exhibits open

2:00 p.m. Vendor Workshops

	Oak	Fir
2:00 p.m.	Siemens Digital Industries Software	NeoGraf Solutions
3:00 p.m.	InfraTec	Ansys
4:00 p.m.	CPC	MSC Software - Cradle

5:30 p.m. Exhibitor Reception

7:00 p.m. Special session: **Panel Discussion A Networking Panel to Promote Pathways for Diversity in Industry**

Thursday March 19, 2020

8:00 a.m. Welcome Message: General Chair, Pablo Hidalgo, AMD

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

Monte Carlo Prediction of PPM Failure Rate Using a Parametric Reduced Order Model
Robin Bornoff, Mentor - A Siemens Business

Thermal Characterization of a Virtual Reality Headset During Transient and Resting Operation
Rachel C McAfee, Oregon State University

Cross Correlation Method for Images Alignment: Application to 4 Buckets Calculation in Thermoreflectance
Metayrek Youssef, IFSTTAR

9:10 a.m. Special session: **Embedded Tutorial**: TBD

10:30 a.m. Session 9: **Automotive/Aerospace/Outdoor/TIM II**
Session Chair: Shailesh Joshi, Toyota Research Institute

Smart Pole Active Electronics Thermal Solution
Walter Mark Hendrix SRC Design Solutions, LLC

Experimental Measurement and Finite Element Analysis of Thermal Conductivity of Alumina/Silicone Polymer Composites
Masakazu Hattori, Fuji Polymer Industries Co., Ltd.

CVD Polycrystalline Diamond for Laser Diode Applications
Firooz Faili, Element Six Technologies

11:30 a.m. Special session: **Thermal Hall of Fame Lifetime Achievement Award Presentation**: TBA

12:30 Special session: **Awards Luncheon**
Harvey Rosten Award, Thermal Hall of Fame Award, Thermi Award

2:00 p.m. **LIQUID COOLING PANEL**

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 the 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:

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

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Exhibitors		
AI Technology	Dexerials	ManZai
Alpha Novatek	Dongguan Sheen	MSC SW
Analysis Tech	Dynatron	Neograf
Ansys	ebm-papst	Netzsch
Binghamton	Element Six	Schlegel
Boyd Corp.	Fujipoly	Shin-Etsu/MicroSi
CEJN	Future Facilities	Staubli
Celsia	Hermetic Solutions	Sysmetric
Chroma	Indium	T Global
Cofan	Infratec	TE Connectivity
Colder Prod. Corp.	Klinger IGI	TEA
Delta	Laird	Wacker Chem.
	LongWin	WL Gore