SEMI-THERM 36

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 30 th 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.

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.

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.

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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, say) 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.

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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.

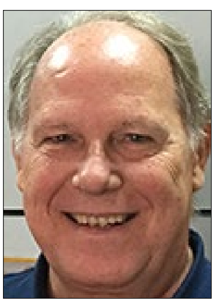
Short Courses Monday, March 16, 2020

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.

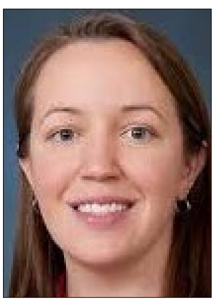
Short Courses Monday, March 16, 2020

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.

SEMI-THERM takes place at:
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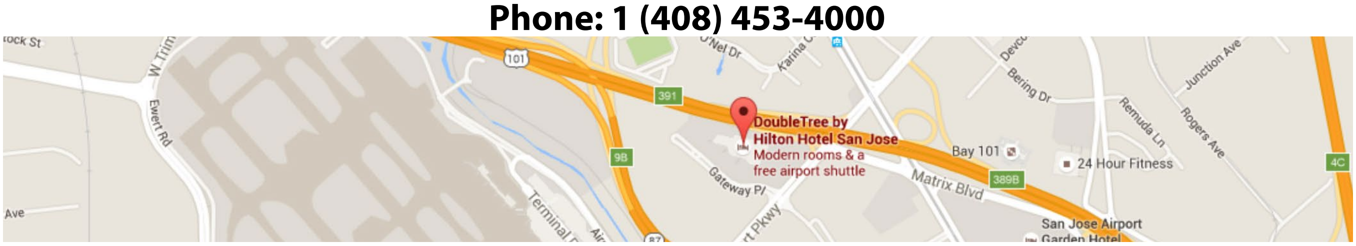
Phone: 1 (408) 453-4000



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