

2016 32nd Thermal Measurement, Modeling & Management Symposium (SEMI-THERM 2016)

**San Jose, California, USA
14-17 March 2016**



**IEEE Catalog Number: CFP16SEM-POD
ISBN: 978-1-5090-2337-0**

**Copyright © 2016 by the Institute of Electrical and Electronic Engineers, Inc
All Rights Reserved**

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

******This publication is a representation of what appears in the IEEE Digital Libraries. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP16SEM-POD
ISBN (Print-On-Demand):	978-1-5090-2337-0
ISBN (Online):	978-1-5090-2336-3
ISSN:	1065-2221

Additional Copies of This Publication Are Available From:

Curran Associates, Inc
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: (845) 758-0400
Fax: (845) 758-2633
E-mail: curran@proceedings.com
Web: www.proceedings.com

TABLE OF CONTENTS

SEMICONDUCTOR THERMAL MEASUREMENT AND MANAGEMENT SYMPOSIUM

SEMI-THERM Committees	v
Rosten Award	vi
SEMI-THERM Short Courses	vii
SEMI-THERM Keynote Speaker: John Parry	xiii
SEMI-THERM "Tear Down" Sessions	xvii

Session 1: System-Level Cooling

Chair: Pablo Hidalgo, Thermacore

Green Performance Characterization of Electronics Cooling Methods: From Air through Hybrid to Direct Two Phase Touch Cooling	1
Alexander Yatskov, Lloyd Olson, Thermal Form Function Inc.	

Cooling Ability of Heat Sinks with Oscillating-fan Models using Electromagnetic Force	7
H. C. Su, H. Y. Xu, DaStrong Corp.	

Analytical Investigation of Thermal Contact Resistance (TCR) Behavior under Time-Dependent Thermal Load	15
--	----

 Mehran Ahmadi¹, Mohammad Fakoor Pakdaman², Majid Bahrami¹

¹Simon Fraser University, ²British Columbia Institute of Technology

A Modified Steady-State Method for Measurement of In-Plane Thermal Conductivity	22
Ali Gholami, Mehran Ahmadi, Majid Bahrami, Simon Fraser University	

Improved Router and Server OPEX, Acoustics and Leakage Power through Advancements in ASIC/CPU Design	27
Marlin Vogel, Juniper Networks; Jesse Galloway, Amkor Technology; David Nelson, Nelson Acoustics	

Session 2: LEDs

Chair: Genevieve Martin, Philips Lighting

Influence of Dome Phosphor Particle Concentration on Mid-Power LED Thermal Resistance	33
Anton Alexeev, Genevieve Martin, Volker Hildenbrand, Karel-Joop Bosschaart, Philips Lighting	

Creating Multi-port Thermal Network Models of LED Luminaires for Application in System Level Multi-domain Simulation Using Spice-like Solvers	44
--	----

 András Poppe^{1,2}, János Hegedűs¹, Albin Szalai¹, Robin Bornoff², James Dyson²

¹Budapest University of Technology, ²Mentor Graphics Corp, Mechanical Analysis Division

Power Over Ethernet Thermal Analysis with an Engineering Mechanics Approach	50
James Petroski, Design by Analysis Technical Consulting LLC	

In-Plane Effective Thermal Conductivity of a Single-Layered Metallic Wire-Mesh Screen	57
Karthik S. Remella, Frank M. Gerner, University of Cincinnati	

Session 3: System-Level Cooling

Chair: Sandeep Ahuja, Intel

A Novel Approach to Determining Compute Headroom on a Server Platform	66
Thanunathan Rangarajan, Jay L Vincent, Intel Corporation	

Impacts of Local Cooling Technologies on Air Cooled Data Center-Server Performance: Test Data Analysis of Heatsink, Direct Liquid Cooling and Passive 2-Phase Enhanced Air Cooling Based on Loop Heat Pipe	71
Maxime Vuckovic, Nicolas Depret, Calyos SA	

Compact Liquid Enhanced Air Cooling Thermal Solution for High Power Processors in Existing Air-cooled Platforms	81
--	-----------

Devdatta P Kulkarni, Robin Steinbrecher, Intel Corporation

Flow Visualization of Two Phase Flow of R245fa in a Microgap with Integrated Staggered Pin Fins ...	86
--	-----------

Pouya Asrar, Xuchen Zhang, Craig E. Green, Peter A. Kottke, Thomas E. Sarvey, Andrei Fedorov, Muhammed S. Bakir, Yogendra K. Joshi, Georgia Institute of Technology

Session 4: Computational Fluid Dynamics (CFD)

Chair: John Fernandes, Facebook

A New Approach to Predict Fan Failures with Fan Speed Correlation	90
--	-----------

Cong Li, Abishai Daniel, Nishi Ahuja, Intel Corporation

Thermal and Mechanical Properties of Vertically Aligned Carbon Fiber Epoxy Composites	95
--	-----------

Jeffrey Meth, Stephen Zane, Michael Demko, Thuy Mai, Robert Pryor, Holly Salerno, DuPont

Thermal Management of a Pico Projector by Using Multiple Fans with a Piezoelectric Actuator System	99
---	-----------

Hsiao-Kang Ma, Shao-Kai Liao, Bo-Ting Lin, National Taiwan University

Automatic Calibration of Detailed IC Package Models	105
--	------------

Byron Blackmore, Mentor Graphics Corporation

A Circuit-Based Approach for Electro-Thermal Modeling of Lithium-Ion Batteries	113
---	------------

Maryam Yazdanpour¹, Peyman Taheri¹, Abraham Mansuri², Ben Schweitzer³,

¹Simon Fraser University, ²American University in Dubai, ³AllCell Technologies

Session 5: Advanced Thermal Materials

Chair: Hussam Kabbani

Stable Thermoreflectance Thermal Imaging Microscopy with Piezoelectric Position Control	128
--	------------

Alexander Shakouri¹, Amirkoushyar Ziabari², Dustin Kendig¹, Je-Hyeong Bahk^{2,3}, Yi Xuan², Peide D. Ye², Kazuaki Yazawa^{1,2}, Ali Shakouri^{1,2}, ¹Microsanj, LLC., ²Purdue University, ³University of Cincinnati

Thermal Specifications for Pluggable Optics Modules	133
--	------------

Bonnie Mack, Terence Graham, Ciena Corporation

Issues in Testing Advanced Power Semiconductor Devices	143
---	------------

Gabor Farkas¹, Zoltan Sarkany^{1,2}, Marta Rencz^{1,2},

¹Mentor Graphics, ²Budapest University of Technology and Economics

A Synergistic Model for Thermal Conductivity with Hybrid Fillers in Polymeric Matrix Composites .	151
--	------------

Mei-Chien Lu, Independent Researcher

Session 6: Data Centers

Chair: Nishi Ahuja, Intel

Cooling Anomaly Detection for Servers and Datacenters with Naïve Ensemble	157
--	------------

Cong Li, Intel Corporation

Expanding the Envelope for Indirect/Direct Evaporative Data Center Cooling Using Thermal Energy Storage	163
--	------------

Jeff Luttrell, Abhishek Guhe, Dereje Agonafer, University of Texas-Arlington

Thermal Management in Rack-Scale Architecture System with Shared Power and Shared Cooling	171
--	------------

Haifeng Gong, Nishi Ahuja, Chuan Song, Chun Wang, Xiang Zhou, Gabriel C Cox, Intel Corporation

Management and Predictions of Operational Changes and Growth in Mission Critical Facilities	178
--	------------

Husam A Alissa, Kourosh Nemati, Bahgat G. Sammakia, Binghamton University;

Tom Wu, Mark J. Seymour, Future Facilities

Cabinet Level Prediction of IT Deployment in Operational Condition Changes 185

Kourosh Nemati, Husam A. Alissa, Bruce T. Murray, Bahgat Sammakia, Binghamton University;
Tom Wu, Mark J. Seymour, Future Facilities

Session 7: Thermoelectrics

Chair: Rahima Mohammed, Intel

Thermodynamic Investigation of a Typical Commercial Refrigeration System 192

Farshid Bagheri, Mohammad Ali Fayazbakhsh, Majid Bahrami, Simon Fraser University

Subtractive Design: A Novel Approach to Heatsink Improvement 198

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

Session 8: Mobile Graphics and Harsh Environment

Chair: Bill Maltz, Electronic Cooling Solutions

Thunderbolt Active Cable Thermal Analysis 206

Li Yuan, Catharina Biber, Hengju Cheng, Intel Corporation

Application of Phase Change Materials in Handheld Computing Devices 213

Darryl Moore, Arun Raghupathy, William Maltz, Electronic Cooling Solutions Inc

Additional Paper:

**Novel MOR Approach for Extracting Dynamic Compact Thermal Models with
Massive Numbers of Heat Sources 218**

L. Codecasa, A. Magnani, V. D'Alessandro, N. Rinaldi, A.G. Metzger, R. Bornoff, J. Parry

SUBMIT A PAPER FOR SEMI-THERM 33!

As you further develop a technique or application, consider documenting it for the thermal community. **SEMI-THERM 33** will begin accepting abstracts during the summer (deadline is September 15, 2016). We welcome your submissions! Visit us at www.semi-therm.org.