2022 21st IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (iTherm 2022)

San Diego, California, USA
31 May - 1 June 2022

Pages 1-632

IEEE Catalog Number: CFP22ITH-POD
ISBN: 978-1-6654-8504-3

Copyright © 2022 by the Institute of Electrical and Electronics 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 is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number: CFP22ITH-POD
ISBN (Print-On-Demand): 978-1-6654-8504-3
ISBN (Online): 978-1-6654-8503-6
ISSN: 1936-3958

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

CURRAN ASSOCIATES INC.
proceedings.com

TABLE OF CONTENTS

21st IEEE InterSociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems

TRACK TI: COMPONENT-LEVEL THERMAL MANAGEMENT

SESSION TI-1A: COMPONENT LEVEL COOLING I

Session Chairs: Ronald Warzoha (United States Naval Academy), Darin Sharar (Army Research Laboratory)

High Performance Compliant Heat Sinks (p115) 1
Mark Schultz, IBM TJ Watson Research

Microprocessor Performance with Multiple Cooling Approaches (p117) 10
Mark Schultz, Pritish Parida, Timothy Chainer, IBM TJ Watson Research

Analysis of Thermal Management Strategies for Packaging High Power Fiber Optic Waveguides (p356) 18
Adam Wilson, Michael Fish, Robert Hoffman, Darin Sharar, US Army Research Laboratory

SESSION TI-1B: POWER ELECTRONICS AND TRANSISTOR COOLING I

Session Chairs: Yuanchen Hu (IBM), Jeffrey Didion (NASA)

Embedded Cooling with 3D Manifold for High Power Application to 3020W Power (p110) 24
Jianyu Du[1], Yuchi Yang[2], Huaiqiang Yu[3], Yulong Liu[3], Jiajie Kang[1], Wei Wang[2], [1]China University of Geosciences, [2]Peking University, [3]Electronics Technology Group Corporation

Dynamic Thermal Management of Power Transistors using Holey Silicon-Based Thermoelectric Cooling (p197) 30
Jiajian Luo[1], Jungyun Lim[1], Archana Venugopal[2], Jingjing Chen[2], Zongqing Ren[1], Jaeho Lee[1], [1]University Of California Irvine, [2]Texas Instruments

Device-level Transient Cooling of β-Ga_2O_3 MOSFETs (p339) 37
Samuel Kim[1], James Spencer Lundh[2], Daniel Shoemaker[2], Bikramjit Chatterjee[1], Kelson Chabak[3], Andrew Green[3], Kyle Liddy[3], Samuel Graham[4], Sukwon Choi[2], [1]Georgia Institute Of Technology, [2]Pennsylvania State University, [3]Air Force Research Laboratory, [4]University of Maryland

SESSION TI-2: TIMS AND HEAT SPREADERS I

Session Chairs: Anil Yuksel (IBM), Stephanie Allard (IBM)

Spatial Thermal Conductivity Variation of Particulate-Filled Thermal Interface Materials (p340) 43
Zechen Zhang, Piyush Kulkarni, Matthias Daeumer, Ahmad Gharaibeh, Je-Young Chang, Bahgat Sammakia, Scott Schiffres, Binghamton University

TIM Coverage Evaluation for High Performance Computing Application (p152) 50
Shane Lin, Ken Zhang, Vito Lin, David Lai, Yu-Po Wang, Siliconware Precision Industries Co Ltd

Effects of Sedimentation Induced Filler Thermal Conductivity Gradients on Thermal Reliability of Potted components (p169) 55
Tejas Manohar Kesarkar, Gabor Balogh, Nitesh Kumar Sardana, Thomas Rupp, Robert Bosch GmbH

Non-Destructive Evaluation of Thermal Interface Materials using Modulated Heating of Selective Cores (p338) 60
Piyush Kulkarni[1], Zechen Zhang[1], Fatemeh Rafsanjani Hejripour[1], Je-Young Chang[2], Bahgat Sammakia[1], Scott Schiffres[1], [1]Binghamton University, [2]Intel

SESSION TI-3: THERMAL MANAGEMENT OF HI PACKAGING

Session Chairs: Scott Schiffres (Binghamton University), Monali Basutkar (IBM)

Thermal Modeling of Direct Bonded Heterogenous Integration (DBHi) MCM Package with Si Microcooler (p161) 66
Risa Miyazawa, Takashi Hisada, Marc Bergendahl, Aakrati Jain, Kamal Sikka, IBM

Thermal Perspective Design Analysis of 3D Stacked Chip Integrated by TSV, Micro-bump and TMV with SOC (p141) 75
Youngsang Cho, Kyoungmin Lee, Kyojin Hwang, Heeseok Lee, Yunhyeok Im, Minkyu Kim, Samsung Electronics

Thermal-Aware Optimization of SoC Floorplan with Heterogenous Multi-Cores (p214) 81
Jongkyu Yoo, Taekeun An, Chigwan Oh, Youngsang Cho, Heeseok Lee, Yunhyeok Im, Minkyu Kim, Minsu Kim, Samsung Electronics

Thermal Design of a Chiplet Module using Monolithic Die and 2.5D/3D Packages (p302) 87
Eric Ouyang[1], Jayden Gu[1], Yonghyuk Jeong[1], Michael Liu[1], Ravi Agarwal[2], Yin Hang[2], [1]JCET Global, [2]Meta Platform

SESSION TI-4: POWER ELECTRONICS AND TRANSISTOR COOLING II

Session Chairs: Prabudhya Roy Chowdhury (IBM), Tuhin Sinha (Amazon)

Deep-Ultraviolet Thermoreflectance Thermal Imaging of GaN High Electron Mobility Transistors (p136) 93
Daniel Shoemaker[1], Anwarul Karim[1], Dustin Kendig[2], Hyungtak Kim[3], Sukwon Choi[1], [1]Pennsylvania State University, [2]Microsanj, [3]Hongik University

Si_3N_4 Manifold Microchannels Cooling System for High Heat Flux Electronic Applications (p128) 98
Yue Qiu, Chirag Kharangate, Jennifer Carter, James McGuffin-Cawley, Case Western Reserve University

Advancement of GaN HEMT Power Electronics on Diamond Substrate (p151) 105
Mei-Chien Lu, Monte Rosa Technology

The 3D Tesla Valve Manifold Two-Phase Cold Plate for the SiC Power Device Module (p159) 111
Xinmeng Li[1], Xin Zhang[1], Wei Li[1], Zhenyu Wang[1], Xiaobin Zhang[2], Yongzhi Zhao[3], [1]Peking University, [2]Microelectronics Institute of Chinese Academy of Sciences, [3]Thirteenth Research Institute Of CETC

SESSION TI-5: TIMS AND HEAT SPREADERS II

Session Chairs: Rinaldo Miorini (General Electric Research), Andrew Bayba and Darin Sharar (Army Research Laboratory)

An Integrated Cooling Effect Package for High Performance Computing Chips (p112) 119
Bo-Jiun Yang, Tai-Yu Chen, Tsung-Yu Pan, Bing-Yeh Lin, Yu-Jin Li, Wen-Sung Hsu, Mediatek

Thermal Fluid Assessment of Cylinders with Multiple Slots in Aligned Flow (p129) 125
Sultan Alshareef, Todd Harman, Timothy Ameel, University of Utah

Layered Unsupervised Learning-based Identification and Quantification of Voids in Package Thermal Interface Materials (p228) 134
Rahul Lall, Kamal Sikka, Isabel De Sousa, IBM

SESSION TI-6: JET IMPINGEMENT

Session Chairs: Nicholas Jankowski, Jay Maddux and Darin Sharar (US Army Research Laboratory)

Flow Visualization of Turbulent Jet Impingement with Engineered Surface Modifications through Particle Image Velocimetry (p192) 143
Aaron Smith, Sushil Bhavnani, Roy Knight, Auburn University

Heat Dissipation Characteristics of a Jetting Staggered Microchannel for Cooling a Large-area High-performance SOC Chip (p145) 150
Tingting Lian[1], Zhizhen Wang[1], Hai Yuan[2], Yufeng Jin[3], Wei Wang[3], Shenglin Ma[1], [1]Xiamen University, [2]Xi’an Microelectronics Technology Institute, [3]Peking University

Hotspot Cooling Performance of Two-Phase Confined Jet Impingement Cooling at the Stagnation Zone (p281) 157
Tanvir Ahmed Chowdhury, Shawn Putnam, University of Central Florida

Analysis of Jet and Cross Flow Interaction with Application in Hotspot Electronics Cooling (p345) 166
Christian Corvera, Shadi Mahjoob, California State University Northridge

SESSION TI-7: COMPONENT LEVEL COOLING II

Session Chairs: Dishit Parekh (Intel), Omidreza Ghaffari (University of Sherbrooke)

Experimental Analysis of Heat Transfer to Shear-thinning Viscoelastic Coolants for Optimizing Surface Topographies in Immersed Battery Cooling Systems (p150) 175
David Taylor, Leone Fasciati, Tamal Roy, Dimos Poulikakos, ETH Zuerich

Comparative Performance Investigation between Double-layered Wavy and Zig-Zag Microchannel Heatsinks for Effective Cooling of Concentrated Photovoltaic cells (p164) 182
Dinumol Varghese, Fadi Alnaimat, Bobby Mathew, United Arab Emirates University

Comparison between Direct Winding Heat Exchanger and Slot-liner Confined Evaporative Cooling of Electric Motor (p178) 191
Amitav Tikadar, Yogendra Joshi, Satish Kumar, Georgia Institute of Technology

Enhancing Efficiency and Lifetime of Photovoltaic Systems through Passive Convective Cooling (p278) 201
Erik Soderholm, Eoin Cotter, David McCloskey, Trinity College Dublin

SESSION TI-8: THERMAL MODELING AND ANALYSIS

Session Chairs: Aakrati Jain (IBM), Herman Oprins (imec)

Thermal Analysis of Advanced Back-end-of-line Structures and the Impact of Design Parameters (p177) 210
Xinyue Chang, Herman Oprins, Melina Lofrano, Bjorn Vermeersch, Ivan Ciofi, Olalla Varela Pedreira, Zsolt Tokei, Ingrid De Wolf, imec

Compact Thermal Modelling of Magnetic Components via Real Coded Genetic Algorithm (p138) ... 218
Anshuman Dey[1,2], Navid Shafiei[2], Rahul Khandekar[2], Wilson Eberle[1], Ri Li[1],
[1]University Of British Columbia, [2]Alpha Technologies Ltd

Thermal Modeling and Analysis of High Bandwidth Memory in 2.5D Si-interposer Systems (p162) . 225
Taehwan Kim, Jonggyu Lee, Jaechoon Kim, Eung Chang Lee, Heejung Hwang, Youngdeuk Kim, Dan Oh, Samsung Electronics

Digital Twin Modeling and Simulation of the High-frequency Transformer Based on Electromagnetic-thermal Coupling Analysis (p216) 230
Zhaoxin Wang, Claus Leth Bak, Henrik Sorensen, Filipe Miguel Faria Da Silva, Qian Wang, Aalborg University

SESSION TI-9: COMPONENT LEVEL COOLING III

Session Chairs: Adam Wilson and Darin Sharar (Army Research Laboratory), Travis Mayberry (Raytheon)

Thermoelectrics with Distributed Transport Properties for Higher SWaP-C Electronic Deep Cooling and Thermal Management. (p118) 237
Doug Crane, Bob Madigan, Lon Bell, DTP Thermoelectrics

Flow-through Porous Finned Heat Sinks with Helmholtz Resonators for Combined Heat Dissipation and Tonal as well as Broadband Noise Reduction (p172) .... N/A
Akshay Wagh, Harshavardhan Ronge, Radhika Choudhary, Shankar Krishnan, Sripriya Ramamoorthy, IIT Bombay

Natural Convection Heat Transfer Enhancement using Functionalized Nanodiamonds in Transformer Oil (p237) 242
Vinit Prabhu[1], Ethan Languri[1], Jim Davidson[2], David Kerns[2], Lino Costa[3], Glenn Wilson[4], [1]Tennessee Tech University, [2]International Femtoscience Inc, [3]University Of Tennessee Space Institute, [4]Southern Company

SESSION TI-10: TWO PHASE COOLING

Session Chairs: Todd Bandhauer and Caleb Anderson (Colorado State), Darin Sharar (Army Research Laboratory)

Hollow Micropillar Evaporator for Cooling Wide Bandgap Silicon Carbide Power Converters (p378) 246
Vivek Manepalli[1], Kidus Guye[1], Erdong Song[1], Alex Dutton[1], Daniel Luberda[1], Quan Chau[1],
Yousof Nayfeh[1], Troy Beechner[2], Sean Hoenig[3], Michael Ellis[3], Damena Agonafer[1],
[1]Washington University In Saint Louis, [2]RCT Systems, [3]Advanced Cooling Technologies

Study of the Impact of the Airflow and Filling Ratio on the Thermal Performances of a Two-Phase Immersion Cooling Prototype (p170) 256
Omidreza Ghaffari[1], Chady Al Sayed[1], Manuel Vincent[1], Francis Grenier[2], Simon Jasmin[2], Luc Frechette[1],
Julien Sylvestre[1], [1]Universite De Sherbrooke, [2]Systemex Energies Inc

Comparison of R-1233zd and HFE-7000 Condenser Performance in Pumped Two-Phase Cooling Systems (p186) 262
Aaditya Pegallapati, Nitin Karwa, Honeywell International Inc

Two-phase Modeling for Porous Microchannel Evaporators (p219) 268
Johannes Kohler Mendizabal, Raffaele Luca Amalfi, Ryan Enright, Nokia Bell Labs

SESSION TI-11: HEAT PIPES AND VAPOR CHAMBERS I

Session Chairs: K Matsumoto (IBM), Ankur Miglani (IIT Indore)

Vapor-Chamber Performance Evaluation: The Challenge of Impartial Cross-Platform Comparison (p116) 277
George Damoulakis, Mohamad Jafari Gukeh, Constantine M Megaridis, University of Illinois at Chicago

Heat Pipe Thermal Performance in Heat Pipe Heatsink (p139) 284
Yuanchen Hu, Milnes David, John Madalengoitia, IBM

Design and Thermal Performance Testing of a Vapor Chamber Containing a Wettability Patterned Condenser for High-Heat Flux Applications (p146) 290
Anant Kumar Yadav, Nagesh Devidas Patil, IIT Bhilai

A Novel One-Step Process to Fabricate a Polymeric Thermal Ground Planes (p191) 294
Doriane Hassaine Daoudji, Samaneh Karami, Etienne Leveille, Amrid Amnache, Anthony Ouellet,
Mahmood Salim Shirazy, Luc FreChette, University of Sherbrooke

SESSION TI-12: HEAT PIPES AND VAPOR CHAMBERS II

Session Chairs: Risa Miyazawa (IBM), Chirag Kharangate (Case Western Reserve University)

Design Optimization of an Aluminum-Pentane Grooved Heat Pipe Embedded in a Device Wall (p125) 300
Samet Saygan, Emre Esen, Yigit Akkus, Aselsan Inc

Hybrid Vapor Chamber-based Cooling System for Power Electronics (p114) 306
George Damoulakis, Congbo Bao, Mohamad Jafari Gukeh, Arani Mukhopadhyay, Sudip K Mazumder,
Constantine M Megaridis, University of Illinois at Chicago

Channel Design to Effectively Increase Oscillation Amplitude in Micro-pulsating Heat Pipes (p179) 312
Chuljae Jung, Sung Jin Kim, KAIST

Air-cooled Closed Loop Thermosyphon Cooling System Experimental campaign: Effects of Working Fluid, Heat Load and Air Flow Rate (p256) 317
Enzo Minazzo[1], Gautier Rouaze[1], Jackson Marcinichen[1], John Thome[1], Winston Zhang[2],
[1]JJ Cooling Innovation SARL, [2]Novark Technologies

TRACK TII: SYSTEM-LEVEL THERMAL MANAGEMENT

SESSION TII-1: IMMERSION COOLING AND REFRIGERATION

Session Chairs: Raffaele Luca Amalfi (Nokia Bell Labs), Xiang Zhang (Oregon State University), Amir Shooshtari (University of Maryland)

Modeling the Steady-State Performance of SMA-based Elastocaloric Refrigeration Cycle (p103) 326
Sarah Nguyen[1], Joshua Radice[1], Andrew Smith[1], Darin Sharar[2], Adam Wilson[2], Brian Donovan[1], Ronald Warzoha[1], [1]United States Naval Academy, [2]Army Research Laboratory

Multi-Scale Electroplated Porous Coating for Immersion Cooling of Electronics (p168) 332
Yaser Nabavi Larimi[1], Omidreza Ghaffari[1], Alireza Ganjali[1], Chady Al Sayed[1], Francis Grenier[2], Simon Jasmin[2], Luc Frechette[1], Julien Sylvestre[1], [1]Universite de Sherbrooke, [2]Systemex Energies Inc

Boiling and Condensation of a Dielectric Liquid in a Closed Enclosure for Electronics Cooling Applications (p174) 339
Gabriel Parent, Alireza Ganjali, Omidreza Ghaffari, Chady Al Sayed, Luc Frechette, Julien Sylvestre, Universite de Sherbrooke

SESSION TII-2: AIR COOLING TECHNIQUES AND HEAT EXCHANGERS I

Session Chairs: Shadi Mahjoob (California State University Northridge), Solomon Adera (University of Michigan), Amir Shooshtari (University of Maryland)

Online Server Fan Failure Prediction by Vibration Analysis Augmented by Hardware and Software Telemetry (p213) 346
Derssie Mebratu, Jaiber John, Romir Desai, Rahul Khanna, Intel

Air Leakage Impact on System Thermal Behavior in 3U Chassis (p113) 355
Feng Qi, Biber Catherina, Ming Zhang, Casey Winkle, Intel

Application of Lévêque Analogy to Open Cellular Solids (p165) .... N/A
Sanjeet Kumar, Sripriya Ramamoorthy, Shankar Krishnan, IIT Bombay

A Novel Outdoor Edge Server Design with Hybrid Air Cooling and Refrigeration (p211) 359
Liwen Guo[1], Tzuchun Hung[1], Cheng-Hua Huang[1], Minghua Duan[1], Chiming Jao[1], Vinson Lin[1], Robert Yuan[1], Dechao Kong[2], Hai Du[2], Xiaojin Fan[2], Dong Xun[2], Jun Zhang[3], Min Wu[3], Wenqing Lv[3], Carrie Chen[3], Candy He[3], Nishi Ahuja[3], Qing Qiao[3], [1]Foxconn, [2]Baidu, [3]Intel

SESSION TII-3: AUTOMOTIVE, BATTERIES AND THERMAL STORAGE I

Session Chairs: Patrick Shamberger (Texas A&M), Michael Barako, Michael Barako (Northrop Grumman), Geoff Wehmeyer (Rice University)

Effect of Cell-to-Cell Thermal Imbalance and Cooling Strategy on Electric Vehicle Battery Performance and Longevity (p195) 364
Camilo Escobar, Zhe Gong, Carlos Da Silva, Olivier Trescases, Cristina Amon, University of Toronto

A Dynamic Co-Simulation Framework for the Analysis of Battery Electric Vehicle Thermal Management Systems (p102) 373
Tyler Shelly, Justin Weibel, Davide Ziviani, Eckhard Groll, Purdue University

Automotive Electrical Validation Thermal Tests Analysis (p109) 381
Cristina Mihaela Dragan, University Politehnica Timisoara and Continental Automotive Romania

Flow Optimization for the Thermal Management of Heavy-Duty Batteries Using Viscoelastic Coolants (p130) 388
Tamal Roy, Rico Luengo Miguel, David Taylor, Dimos Poulikakos, ETH Zurich

SESSION TII-4: LIQUID COOLING SOLUTIONS I

Session Chairs: Ajit Vallabhaneni (Qualcomm Technologies), Krishna Vasanth Valavala and Chandra Mohan Jha (Intel)

Experimental Analysis and of a Dual-Evaporator Thermosyphon Cooling System for CPUs and GPUs (p218) 393
Filippo Cataldo[1], Yuri C. Crea[1], Raffaele L. Amalfi[2], [1]Provides Metalmeccanica Srl , [2]Nokia Bell Labs

Experimental Characterization of a Compact Thermosyphon Cooling System Operating with R1234ze(E) and R1233zd(E) low-GWP refrigerants (p137) **400**
Raffaele Luca Amalfi[1], Cong Hiep Hoang[1], Ryan Enright[1], John Kim[1], Filippo Cataldo[2], Jackson Braz Marcinichen[3], John Richard Thome[3], [1]Nokia Bell Labs, [2]Provides Metalmeccanica Srl, [3]JJ Cooling Innovation Sarl

A Study on Compatibility of Thermal Interface Materials with Coolants for Data Center Immersion Cooling (p350) **406**
Liu Yu, Jin Yang, David Shia, Ming Zhang, Intel

Study on Cooling System for SR Motors by Pumpless Forced Convection Boiling Equipment with Liquid Dielectric Coolant (p366) **411**
Hirotsugu Aoyama, Shohei Ohashi, Yu Qiang, Yokohama National University

SESSION TII-5: MOBILE, TELECOMMUNICATION SYSTEMS, and INTERNET of THINGS

Session Chairs: Aastha Uppal (Intel), Columbia Mishra (Industry), Chandra Mohan Jha (Intel)

Thermal Model Simplification of Mobile Device with Adaptive Metamodel of Optimal Prognosis (AMOP) (p210) **419**
Yunhyeok Im[1], Hyungyung Jo[1], Chigwan Oh[1], Young-Sang Cho[1], Jongkyu Yoo[1], Heeseok Lee[1], Myunghoon Lee[2], Vamsi Krishna Yaddanapudi[2], [1]Samsung Electronics, [2]ANSYS

An Advanced Fanless AIoT Smart Edge Gateway with Thickness Thermal Pad Design (p212) **425**
Huayong Yuan[1], Wei Chen[1], Michael King[2], Aaron Wu[2], Barry Chen[2], Clio Chiu[2], Karen Tseng[2], Lulu Su[2], Richard Chang[2], Ryan Yang[2], Shoes Leu[2], Allen Liang[3], Jun Zhang[3], Haibin Chen[3], Liang Liu[3], Danny Kuo[3], Kunye Zhu[3], Nishi Ahuja[3], Qing Qiao[3], Eric Li[3], [1]Tencent, [2]Inventec, [3]Intel

The Study of Thermosyphon Solution for High Performance Switch (p217) **430**
Yaoyin Fan, Peng Xiao, Wei Liu, Celestica

SESSION TII-6: AUTOMOTIVE, BATTERIES AND THERMAL STORAGE II

Session Chairs: Krishna Shah (Academia), Jagadeesh Radhakrishnan (Industry), Chandra Mohan Jha (Intel)

Development and Validation of Resistance-Capacitance Model for Phase Change Material Embedded in Porous Media (p135) **436**
Tanjebul Alam, Daniel Bacellar, Jiazhen Ling, Vikrant Aute, University of Maryland

Transient Study of Phase Change Material Based Hybrid Heat Sink for Electronics Cooling Application. (p274) **443**
Priyanka Borkar, Vijay Duryodhan, Indian Institute of Technology Bhilai

Control of a Hybrid Thermal Management System: A Heuristic Strategy for Charging and Discharging a Latent Thermal Energy Storage Device (p307) **450**
Michael Shanks, Neera Jain, Purdue University

Performance Characterization of a Novel Low-Cost Additively Manufactured PCM-to-Air Polymer Composite Thermal Energy Storage (p311) **460**
Veeresh Ayyagari, Gargi Kailkhura, Raphael Mandel, Amir Shooshtari, Michael Ohadi, University of Maryland

SESSION TII-7: AIR COOLING TECHNIQUES AND HEAT EXCHANGERS II

Session Chairs: Patrick Shamberger (Texas A&M), Taravat Khadivi (Meta), Gavin Stanley (Microsoft)

Numerical Investigation of Adjustable Air Amplifiers as an Alternative to Fans in Data Centre Servers (p236) **469**
Eoin Oude Essink[1,2,3], Tim Persoons[2,3], Gordon O Brien[2], Sajad Alimohammadi[1,2,3], [1]Technological University Dublin, [2]Trinity College Dublin, [3]Environmental Research Institute

Design of a Microchannel Heat Exchanger for Extreme Environments (MHXEE) (p321) **475**
Zhengda Yao, Raphael Mandel, Amir Shooshtari, Hugh Bruck, Michael Ohadi, University of Maryland

Impact of Improved Ducting and Chassis Re-design for Air-Cooled Servers in a Data Center (p322) **485**
Himanshu Modi, Uschas Chowdhury, Dereje Agonafer, University of Texas at Arlington

SESSION TII-8: LIQUID COOLING SOLUTIONS II

Session Chairs: Roxana Family and Amir Shooshtari (University of Maryland), Betty Archer (Microsoft)

Numerical Evaluation of Bimetallic Self-Adaptive Fins Acting as Flow Disturbing Elements Inside a Microchannel (p266) ... 493

Montse Vilarrubi[1,3], Desideri Regany[1], Francesc X Majos[1], Manel Ibanez[1], Joan Ignasi Rosell[1], Josep Illa[1], Ferran Badia[1], Amrid Amnache[2], Etienne Leveille[2], Rajesh Pandiyan[2], Luc G Frechette[2,3], Jerome Barrau[1,3], [1]Universitat de Lleida, [2]Universite de Sherbrooke, [3]Universal Smart Cooling S.L.

Simulation of a Heat Pipe Test Fixture: Laminar, Internal, Forced Convection in a Tubed Cold Plate (p121) ... 500

Joshua Smay, Advanced Cooling Technologies

Pool Boiling Performance of Surfaces Produced by Femtosecond Laser Surface Processing and Copper Hydroxide Nanoneedle Growth (p188) ... 510

Justin Costa-Greger[1], George Damoulakis[2], Graham Kaufman[1], Suchit Sarin[1], Chase Pettit[1], Jeffrey Shield[1], Constantine Megaridis[2], Craig Zuhlke[1], George Gogos[1], [1]University of Nebraska-Lincoln, [2]University of Illinois at Chicago

A Novel Cost-Efficient High-Performance Aluminum Cold Plate Solution for Liquid Cooling System (p209) ... 520

Xianguang Tan[1], Li Su[1], Hongmei Liu[1], Jiajun Zhang[1], Jun Zhang[2], Lijuan Feng[2], Wenbin Tian[2], Allen Liang[2], Hang Cheng[2], Nishi Ahuja[2], Qing Qiao[2], [1]Kuaishou University, [2]Intel

SESSION TII-9: DATA CENTER THERMAL MANAGEMENT

Session Chairs: Arjang Shahriari (Qualcomm), Kanan Pujara (Intel), Amir Shooshtari (University of Maryland)

IT Equipment Cooling Assessment and Metrics (p131) ... 524

James VanGilder , Wei Tian , Michael Condor, Schneider Electric

Multiphysics Thermal-Acoustics Modeling of a Server in a Data Center (p140) ... 530

Pranay Nagrani, Arshad Alfoqaha, Dustin Demetriou, Seth Bard, IBM

An Advanced Cold Plate Liquid Cooling Rack Design for Hyperscale Data Center (p240) ... 537

Yuehlin Tsai[1], Guilin Wang[1], Yuehong Jin[1], Sheng Li[1], Wenyi Fang[1], Guofeng Chen[1], Kai Wang[1], Jun Zhang[2], Yuehong Fan[2], Yuyang Xia[2], Wenbin Tian[2], Hang Cheng[2], Xingping Ruan[2], Hongxing Zhou[2], Nishi Ahuja[2], Qing Qiao[2], [1]JD.COM Technology, [2]Intel

SESSION TII-10: THERMAL MANAGEMENT IN ELECTRIC AIRCRAFT

Session Chairs: Martinus Arie (Amazon), Amir Shooshtari, Farah Singer (University of Maryland)

Evaporative Cooling of High Power Density Motors: Design and Analysis (p107) ... 542

Ryan Smith, Amitav Tikadar, Satish Kumar , Yogendra Joshi, Georgia Institute of Technology

Optimization of Hydrogen Generator for UAVs (p227) ... 550

Christopher Barrow[1], Geo Jong Kim[2], Cutler Phillippe[3], John Maddox[1], Hyun Tae Hwang[1], [1]University of Kentucky, [2]Korea Research Institute of Chemical Technology, [3]University of Illinois Urbana-Champaign

In-slot Cooling Channel for High Power Density Electric Motor with Encapsulation Channels (p306) ... 558

Zhaoxi Yao, Raphael Mandel, Patrick McCluskey, University of Maryland

Thermal Management Performance of an Additively Manufactured Jet Impingement Cooler for Power Electronics (p362) ... 564

Reece Whitt, David Huitink, University of Arkansas

SESSION TII-11: ADVANCED MODELING OF THERMAL SYSTEMS

Session Chairs: Ameya Limaye (Intel), Anali Soto (Industry), Chandra Mohan Jha (Intel)

Package Level Thermal Analysis of Backside Power Delivery Network (BS-PDN) Configurations (p257) ... 570

Herman Oprins, Jose Luis Ramirez, Bjorn Vermeersch, Geert Van Der Plas, Eric Beyne, imec

From 2.5D to 3D Chiplet Systems: Investigation of Thermal Implications with HotSpot 7.0 (p184) ... 577

Jun-Han Han[1], Xinfei Guo2, Jiao Tong[2], Kevin Skadron[1], Mircea Stan[1], [1]University Of Virginia, [2]Shanghai Jiao Tong University

Development of a Graph-based Modeling Framework for Transient Exergy Analysis (p360) **583**
Andrew Manion[1], William Malatesta[2], Neera Jain[1], [1]Purdue University, [2]Naval Air Systems Command

Thermal Analysis of Boiling Pot with Single Coil Induction Cooker (p363) **593**
Chia-Wei Lin[1], Hsueh-Che Liu[1], Yu-Lun Chang[1], Yu-Chen Lin[2], Ying-Yuan Chen[3], Chun-Wei Lin[3],
Ming-Shi Huang[1], Hua-Yi Hsu[1], [1]National Taipei University of Technology, [2]Purdue University, [3]Delta Inc

SESSION TII-12: LIQUID COOLING SOLUTIONS III

Session Chairs: Patrick Shamberger (Texas A&M), Betty Archer (Microsoft), Roxana Family (University of Maryland)

Two-phase Thermofluidic Modeling and Validation of a Multi-zone Microchannel Evaporator (p182) **599**
Qianying Wu[1,2], Todd Salamon[1], [1]Nokia Bell Labs, [2]Stanford University

Thermal Management of Two-Sided Heat Load on a Cold Plate Considering the Friction Stir Welding Process (p120) **609**
Murat Parlak, Ergun Ors, Vedat Yagci, Aselsan Inc

Pool Boiling Heat Transfer Enhancement using Femtosecond Laser Surface Processed Aluminum in Saturated PF-5060 (p187) **617**
Justin Costa-Greger, Logan Pettit, Andrew Reicks, Suchit Sarin, Chase Pettit, Jeffrey Shield,
Craig Zuhlke, George Gogos, University of Nebraska-Lincoln

TRACK M: MECHANICS AND RELIABILITY

SESSION M-1: ANALYSIS AND CHARACTERIZATION OF CRACK AND INTERFACE FAILURE I

Session Chairs: SB Park (Binghamton University), Ke Pan (Binghamton University)

Effect of Long-Term Isothermal Exposure on Chip/Underfill Interfacial Crack Growth under Mode-I Fatigue Loading (p283) **625**
Pradeep Lall, Aathi Pandurangan, Auburn University

Study of Interface Reliability of PCB-UF Interface in FCBGAs under Sustained High Temperature Operation in Automotive Underhood Environments (p297) **633**
Pradeep Lall, Padmanava Choudhury, Auburn University

Sharp Interface Simulation of IMC Growth and Void Evolution in Solder Microbumps (p335) **641**
Huanyu Liao, Chetan Jois, Sudarshan Prasad, Ganesh Subbarayan, Purdue University

SESSION M-2: SOLDER CONSTITUTIVE LAW AND PROPERTY/RELIABILITY CHARACTERIZATION I

Session Chairs: Sathya Raghavan (IBM), Pavan Rajmane (Qualcomm)

High Strain Rate Mechanical Properties of M758 Solder at Extreme Surrounding Temperatures, with 100°C Isothermal Aging for up to 180 Days (p293) **648**
Pradeep Lall, Vishal Mehta, Jeff Suhling, Ken Blecker, Auburn University

Characterization of Constitutive Equation of Sn-Bi by Studying Creep Behavior of Flip Chip Solder Joints (p244) **663**
Chongyang Cai, Ke Pan, Karthik Deo, Yangyang Lai, Junbo Yang, Jing Wang, Seungbae Park,
Binghamton University

Effect of SAC105 Solder Alloys High Strain Rate Property Evolution on Plastic Work at Low Operating Temperatures (p315) **669**
Pradeep Lall[1], Vikas Yadav[1], Jeff Suhling[1], David Locker[2], [1]Auburn University, [2]US Army CCDC-AvMC

High Strain Rate Materials Characterization at Low Test Temperatures for Thermally Aged SAC-Q Solder Alloys (p316) **681**
Pradeep Lall[1], Vikas Yadav[1], Jeff Suhling[1], David Locker[2], [1]Auburn University, [2]US Army CCDC-AvMC

SESSION M-3: SOLDER CONSTITUTIVE LAW AND PROPERTY/RELIABILITY CHARACTERIZATION II

Session Chairs: Sathya Raghavan (IBM), Pavan Rajmane (Qualcomm)

Novel Test Device for Non-destructive Experimental Characterization of Void Evolution in Microscale Solder Joints Subjected to Thermal Aging (p337) 697
Sudarshan Prasanna Prasad, Chetan Jois, Ganesh Subbarayan, Purdue University

The Effect of Bismuth Content on Mechanical Property Evolution of SAC+Bi Lead Free Solders Subjected to Long Term Thermal Exposures (p372) 705
Mohammad Al Ahsan, S M Kamrul Hasan, Jeffrey Suhling, Pradeep Lall, Auburn University

A Crystal Plasticity Finite Element Modeling to Explain the Effects of β-Sn Crystal Orientation on SAC305 Solder Ball Deformation (p376) 713
Debabrata Mondal, Jeffrey Suhling, Pradeep Lall, Auburn University

Evaluation of Directional Properties of SAC305 Solder Joints Using the Nanoindentation Technique (p377) 720
Debabrata Mondal, Mohammad Ashraful Haq, Jeffrey Suhling, Pradeep Lall, Auburn University

SESSION M-4: THERMAL AND MECHANICAL CHARACTERIZATION of BATTERY AND POWER ELECTRONICS

Session Chairs: Ved Soni (Auburn University), David Huitink (University of Arkansas)

Building Reliable FE Simulation Models for a Better Behavior Prediction of Power Electronic Systems (p238) 727
Heiner Moeller[1], Rainer Dudek[1], Alexander Otto[1]1, Sven Rzepka[1,2],
[1]Fraunhofer ENAS, [2]Technical University of Chemnitz

Accelerated Life Cycling of Additively Printed Flexible Linear Charging Circuits and its Effect on Evolution of Line Resistance and Charging Current (p308) 735
Pradeep Lall[1], Ved Soni[1], Scott Miller[2], [1]Auburn University, [2]NextFlex Manufacturing Institute

A Benchmark Study on the Thermal Performance and Life of Different Structures of SiC Chip Modules (p367) 743
Gakuto Hiraoka[1], Ryotaro Yoshikawa[1], Yuta Ito[1], Qiang Yu[1], Yuji Komatsu[2], Thomas Chiron[2], Wolfgang Schön[3],
[1]Yokohama National University, [2]ZF Japan Co., [3]ZF Friedrichshafen AG

Evaluation of High Cycle Fatigue Life of Solder Jint in Si Power Module (p368) 751
Yuta Hashimoto, Shingo Nakayama, Qiang Yu, Yokohama National University

SESSION M-5: MATERIAL AND PROCESS CHARACTERIZATION OF ADVANCED ELECTRONICS PACKAGES I

Session Chairs: Vishal Mehta (Auburn University), Jin Yang (Intel)

Evolution of Fatigue Reliability of UF-Substrate Interfaces under High Temperature Exposure (p295) 756
Pradeep Lall, Padmanava Choudhury, Auburn University

Thermal Stability and Viscoelasticity Behavior of Underfill Encapsulants in Sustained High Temperature Environment up to 1 year (p320) 764
Pradeep Lall, Yunli Zhang, Jeff Suhling, Auburn University

Investigation of Transient Liquid Phase Bonding to Low Temperature Co-Fired Ceramic Substrates (p343) 772
John Harris, David Huitink, University of Arkansas

SESSION M-6: MATERIAL AND PROCESS CHARACTERIZATION OF ADVANCED ELECTRONICS PACKAGES II

Session Chairs: Vishal Mehta (Auburn University), Jin Yang (Intel)

Development of a Numerical Simulation Model for Predicting the Temperature of a Flip-Chip Package (p183) 776
Juhyeon Lee[1], Sung Jin Kim[1], Bo-Seung Kim[2], [1]KAIST, [2]Samsung Electronics

Permeation of Moisture our of EPDM Rubber Hoses (p222) **780**
Prabjit Singh, Larry Palmer, IBM

Analysis of Process-dependent Mechanical Properties of Sintered Copper Nanoparticle Pillars for the Plating-free Bumping by Finite Element Method (p303) **786**
Sayuri Kohara, Toyohiro Aoki, Chinami Marushima, Christine Taylor, Kuniaki Sueoka, Takashi Hisada, IBM

Characterization of Viscoelastic Behavior of Epoxy Molding Compounds Subjected to Sustained High Temperature Environment up to 1 year (p319) **794**
Pradeep Lall, Yunli Zhang, Jeff Suhling, Auburn University

SESSION M-7: RELIABILITY OF ELECTRONIC COMPONENTS UNDER HARSH ENVIRONMENT

Session Chairs: Chongyang Cai (Binghamton University), Jun Zhang (Intel)

Qualification of the Samtec SEAM and SEAF Connectors for Use as a Printed Circuit Board Assembly (PCBA) Stacking Connector in Space Applications (p252) **802**
Neil Dalal, Nabid Farvez, Kyle Anderson, Allison Orr, Sharon Ling, Ryan Hacala, Johns Hopkins University

Optimal Thermo-mechanical Reliability Design of 2.5D Lidless Package (p270) **810**
Junbo Yang, Chongyang Cai, Pengcheng Yin, Ke Pan, Yangyang Lai, Jing Wang, Seungbae Park, Binghamton University

Size Determination of Voids in the Soldering of Automotive DC/DC-Converters via IR Thermography (p272) **816**
Nils Jahn, Martin Pfost, TU Dortmund

Evaluation of Lifetime of Through-Hole Solder Joints Considering Mounting Process and Variation (p379) **823**
Tomohiro Tsuyuki, Qiang Yu, Yuki Ohno, Akihiro Takikawa, Hisataka Fukasu, Kouji Shio, Yokohama National University

SESSION M-8A: ANALYSIS AND CHARACTERIZATION OF CRACK AND INTERFACE FAILURE II

Session Chairs: KE PAN (Binghamton University), SB Park (Binghamton University)

Correlation of Scanning Acoustic Microscopy and Transient Thermal Analysis to Identify Crack Growth in Solder Joints (p255) **831**
Maximilian Schmid, Joseph Hermann, E Liu, Gordon Elger, Technische Hochschule Ingolstadt

Interfacial Fracture Toughness of EMC/Substrate Interface Under Mode-I Dynamic Loading with Long-Term High Temperature Aging (p286) **837**
Pradeep Lall, Aathi Pandurangan, Auburn University

Evolution Of Interfacial Properties Under Long Term Isothermal Aging Of PCB/Potting Compound Interfacial Samples under Pure Mode-I Loading (p287) **843**
Pradeep Lall[1], Aathi Pandurangan[1], Ken Blecker[2], [1]Auburn University, [2]US Army CCDC-AC

Influence of Sustained High Temperature Exposure on the Interface Bond Strength between TIM-Copper Substrates (p296) **851**
Pradeep Lall, Padmanava Choudhury, Auburn University

SESSION M-8B: THERMAL-MECHANICAL COUPLED DESIGN AND CHARACTERIZATION

Session Chairs: Padmanava Choudhury (Auburn University), Jeff Suhling (Auburn University)

Impact of FEOL Cross-heating on the Thermal Performance of Advanced BEOL (p163) **858**
Melina Lofrano, Bjorn Vermeersch, Herman Oprins, Seongho Park, Zsolt Tokei, imec

An Advanced Thermal and Mechanical Design Optimal for High Density Storage Server Reliability (p242) **867**
Shiqiang Zheng[1], Zhilin Zheng[1], Hongmei Liu[1], Weihua Cao[1], Xin Wang[1], Jiajun Zhang[1], Jun Zhang[2], Yingqiong Bu[2], Xingping Ruan[2], Qing Qiao[2], [1]Kuaishou Technology, [2]Intel

Reliability Assessment of Cu-Al WB under Automotive Temperatures in Presence of Ionic Contamination and Voltage Bias (p333) 874
Pradeep Lall, Sungmo Jung, Auburn University

Phase Field Simulations of Solder Void Evolution under Thermal Aging (p348) 884
Chetan Jois, Sudarshan Prasad, Ganesh Subbarayan, Purdue University

SESSION M-9: ARTIFICIAL INTELLIGENCE/MACHINING LEARNING APPLICATION TO ELECTRONICS PACKAGING

Session Chairs: Jinesh Narangaparambil (Auburn University), Karsten Meier (Technische Universitaet Dresden)

Parametric Study of the Geometry Design of Through-silicon Via in Silicon Interposer (p231) 890
Ke Pan, Yangyang Lai, Jiefeng Xu, Pengcheng Yin, Jonghwan Ha, Chongyang Cai, Junbo Yang, Seungbae Park, Binghamton University

Effect of High and Low Storage Temperatures, Storage Duration and Varying Depth of Discharge on Coin Cell SOH Degradation (p310) 898
Pradeep Lall[1], Ved Soni[1], Guneet Sethi[2], Kok Yiang[2], [1]Auburn University, [2]Amazon Lab 126

Remaining Useful Life Estimation using a Combined Physics of Failure and Deep Learning-based Approach on SAC305 Solder PCBs Subjected to Thermo-Mechanical Vibration Loads (p314) 906
Pradeep Lall[1], Tony Thomas[1], Jeff Suhling[1], Ken Blecker[2], [1]Auburn University, [2]US Army CCDC-AC

SESSION M-10: BGA PACKAGE MACHANICAL PROPERTIES AND RELIABILITY I

Session Chairs: Kartik Goyal (Auburn University), Abhishek Deshpande (Qualcomm Technologies)

Assembly Reliability of eWLP, Die-, and Die-Size BGAs (p148) 919
Reza Ghaffarian, JPL-NASA

Thermal and Mechanical Lid Design for a Multi-Chip Modular Flip-Chip Package (p166) 928
Javed Shaikh, Krishnendu Saha, Stephan Stoeckl, Eng Huat Goh, Intel

Copper Trace Failures in Ball Grid Array (BGA) Packages under Sequential Harmonic Vibration and Temperature Cycling (p223) 933
Abhishek Deshpande[1], Idowu Olatunji[1], Manuel Bascolo[1], Abhijit Dasgupta[1], Ulrich Becker[2], Gabor Jokai[2], [1]University of Maryland, [2]Robert Bosch GmbH

Effect of Thermal Mechanical Solutions on Solder Joint Reliability of Bare-Die BGA with Substrate Stiffener (p301) 938
Phil Geng, Intel

SESSION M-11A: BGA PACKAGE MACHANICAL PROPERTIES AND RELIABILITY II

Session Chairs: Kartik Goyal (Auburn University), Abhishek Deshpande (Qualcomm Technologies)

Influence of Component Interconnect with Printed Copper Circuits on Realized Mechanical and Electrical Characteristics in FHE Applications (p324) 944
Pradeep Lall[1], Jinesh Narangaparambil[1], Scott Miller[2], [1]Auburn University, [2]NextFlex National Manufacturing Institute

Non-Intrusive Two-Way Coupling for Multiscale Analysis of Electronic Packages (p328) 954
Sai Sanjit Ganti, Yaxiong Chen, Ganesh Subbarayan, Purdue University

Modeling Effect of Underfill Property Evolution on the FCBGA Reliability at Sustained Automotive Underhood Temperatures (p332) 963
Pradeep Lall, Madhu Kasturi, Haotian Wu, Jeff Suhling, Edward Davis, Auburn University

Drop Shock Performance of SAC-Bi Alloys Compared to SnPb (p371) 976
Palash Vyas, Mohamed El Amine Belhadi, Xin Wei, Ehab Hamasha, Abdallah Alakayleh, Arvind Srinivasan, Raj Kiran Akula, Sad Hamasha, Jeff Suhling, Pradeep Lall, Auburn University

SESSION M-11B: LEAD FREE SOLDER CHARACTERIZATION AND RELIABILITY I

Session Chairs: Reza Ghaffarian (Jet Propulsion Laboratory), Phil Geng (Intel)

Effect of Evolution of High Strain Rate Properties on Plastic-Work of SAC305 Alloy with 100℃ Aging for Periods up to 240-days (p294) 983
Pradeep Lall[1], Vishal Mehta[1], Jeff Suhling[1], Ken Blecker[2], [1]Auburn University, [2]US Army CCDC-AC

Effect of Prolonged Storage on High Strain Rate Mechanical Properties of QSAC10 and QSAC20 Solders after Exposure to Isothermal Aging of 50°C (p299) 999
Pradeep Lall, Mrinmoy Saha, Jeff Suhling, Auburn University

Evolution of High-Temperature and Low-Temperature High Strain Rate Properties of SAC-R Solder after Sustained Exposure to 50°C (p300) 1009
Pradeep Lall[1], Mrinmoy Saha[1], Jeff Suhling[1], Ken Blecker[2], [1]Auburn University, [2]US Army CCDC-AC

Fatigue and Shear Properties of Novel Lead-free Solder Joints with Low Melting Temperature (p370) 1021
Xin Wei[1], Mohamed El Amine Belhadi[1], Palash Pranav Vyas[1], A R Nazmus Sakib[2], Sa'd Hamasha[1], Haneen Ali[1], [1]Auburn University, [2]NXP Semiconductors

SESSION M-12A: LEAD FREE SOLDER CHARACTERIZATION AND RELIABILITY II

Session Chairs: Reza Ghaffarian (Jet Propulsion Laboratory), Phil Geng (Intel)

Evolution of the Creep Behavior for SAC305 Lead Free Solder Exposed to Various Thermal Profiles (p373) 1028
S M Kamrul Hasan, Mohammad Al Ahsan, Jeffrey Suhling, Pradeep Lall, Auburn University

Indentation Creep Properties Evolution of Lead-free Solder Joints Subjected to Thermal Cycling (p374) 1036
Mohamed El Amine Belhadi, Xin Wei, Qais Qasaimeh, Palash Pranav Vyas, Rong Zhao, Ehab Hamasha, Duha Ali, Jeff Suhling, Sa'd Hamasha, Pradeep Lall, Haneen Ali, Barton Prorok, Auburn University

Mechanical Behavior and Microstructure Evolution in SAC+Bi Lead Free Solders Subjected to Mechanical Cycling (p375) 1044
Mohammad Ashraful Haq, Mohd Aminul Hoque, Jeffrey Suhling, Pradeep Lall, Auburn University

SESSION M-12B: MECHANICS AND FEA OF INTEGRATED ELECTRONIC PACKAGES

Session Chairs: John Harris (University of Arkansas), Pradeep Lall (Auburn University)

Damage Progression in Electronic Molding Compounds under Sustained High Temperature for up to 1 year in Automotive Underhood Environments (p317) 1052
Pradeep Lall, Yunli Zhang, Auburn University

Finite Element Modeling Strategies for Studying Mechanical Design Tradeoffs in Heterogeneously Integrated Packages (p357) 1060
David Halbrooks[1], Ganesh Subbarayan[1], Huayan Wang[2], Gamal Rafai-Ahmed[2], Suresh Ramalingam[2], [1]Purdue University, [2]Xilinx Inc

Performance Analysis of the Analog Path of Read-Out Integrated Circuit for MEMS Structures under Temperature Variation. (p359) 1069
Mariusz Jankowski, Jacek Nazdrowicz, Andrzej Napieralski, Lodz University of Technology

TRACK E: EMERGING TECHNOLOGIES AND FUNDAMENTALS

SESSION E-1: THERMAL MANAGEMENT STRATEGIES 1

Session Chairs: Darshan Pahinkar (Florida Institute of Technologies), Saket Karajgikar (Facebook)

Topology Optimization of an Air-cooled Heat Sink for Transient Heat Dissipation using a Homogenization Approach (p132) 1077
Abhijeet Banthiya, Serdar Ozguc, Liang Pan, Justin Weibel, Purdue University

High Performance Pulsating Heat Pipe for Electronics Cooling (p149) 1084
Haris Constantinou[1], Sebastien Lani[2], Gautier Rouaze[3], John Thome[3], [1]EPFL, [2]CSEM, [3]JJ Cooling Innovation

CYTOP for Bonding Highly Oriented Pyrolithic Graphite to be used as Heat Spreader in Mobile Devices (p180) 1093
Diego Vaca, Vanessa Smet, Yogendra Joshi, Satish Kumar, Georgia Institute of Technology

SESSION E-2: THERMAL MANAGEMENT STRATEGIES 2

Session Chairs: Satyam Saini (University of Texas at Arlington), Xiaopeng Qu (Microsoft)

Pulsating Heat Pipe Fin Plates for Enhancing Natural and Forced Convection Cooling of Electronics: Experimental Campaign (p273) **1099**
Gautier Rouaze[1], Jackson Marcinichen[1], John Thome[1], Kangnin Xiong[2], Winston Zhang[2],
[1]JJ Cooling Innovation SARL, [2]Novark Technologies

Reworkable and Rehealable Packaging Materials from the Introduction of Orthogonal Dynamic Covalent Chemistries (p194) **1107**
Teddie Magbitang, Lucas Moore, Roy Yu, Kamal Sikka, Akhiro Horibe, Rudy Wojtecki, IBM

Chip-level Thermal Simulation for a Multicore Processor using a Multi-Block Model Enabled by Proper Orthogonal Decomposition (p329) **1113**
Lin Jiang, Anthony Dowling, Yu Liu, Ming-Cheng Cheng, Clarkson University

Equivalent Thermal Conductivity of a Composite Structure Considering Heat Spreading on Neighboring Layers (p381) **1120**
Young Hoon Hyun, Bruce Won Lee, Ki Wook Jung, Byeong Yeon Cho, Yunhyeok Im, Dan Oh,
Samsung Electronics

SESSION E-3: NANOSCALE HEAT TRANSFER

Session Chairs: Ronald Warzoha (United States Naval Academy), Jingjing She (Georgia Tech)

An Approximated Model of Boltzmann Transport Equation for Nano-Scale Thermal Analysis (p200) **1128**
Chih-Cheng Chang, Hong-Wen Chiou, Yu-Min Lee, National Yang Ming Chiao Tung University

Full-field Pump-probe Thermoreflectance Imaging for Characterization of Thin Films and 3D Integrated Circuits (p189) **1136**
Sami Alajlouni, Kerry Maize, Ali Shakouri, Purdue University

Extending the Thermal Slip Boundary Condition at the Solid-Fluid Interface (p285) **1146**
Joseph Thalakkottor, South Dakota School of Mines and Technology

Quantifying Interfacial Thermal Conductance at Solid-liquid Interfaces using Frequency-domain Thermoreflectance and Analytical Methods (p290) **1150**
Kenny Yu[1], Ryan Enright[2], David McCloskey[1], [1]Trinity College Dublin, [2]Nokia Bell Labs

SESSION E-4: MACHINE LEARNING AND AI

Session Chairs: Yuanchen Hu (IBM), Paul Paret (National Renewable Energy Laboratory)

The Optimal Solution of Reflow Oven Recipe based on Physics-guided Machine Learning Model (p232) **1156**
Yangyang Lai, Ke Pan, Jonghwan Ha, Chongyang Cai, Junbo Yang, Pengcheng Yin, Jiefeng Xu,
Seungbae Park, Binghamton University

Circuit-level thermal modelling of Silicon Photonic Transceiver Array using Machine Learning (p108) **1162**
David Coenen[1,2], Herman Oprins[2], Ingrid De Wolf[1,2], [1]KU Leuven, [2]imec

SSD Thermal Throttling Profile Prediction using Neural Network (p111) **1170**
Chaolun Zheng, Hedan Zhang, Steve Chi, Ning Ye, Western Digital Corporation

Deep Learning Neural Network Approach for Correlation between Print Parameters and Realized Electrical Performance and Geometry on Ink-Jet Platform (p313) **1175**
Pradeep Lall[1], Tony Thomas[1], Kartik Goyal[1], Scott Miller[2],
[1]Auburn University, [2]NextFlex Manufacturing Institute

SESSION E-5: METROLOGY TECHNIQUES

Session Chairs: Zhe Cheng (University of Illinois at Urbana-Champaign), Jungwan Cho (Sungkyunkwan University)

Zener Diode Reverse Breakdown Voltage as a Simultaneous Heating and Temperature Sensing Element (p173) **1184**
Rachel McAfee[1], Michael Fish[2], Joshua Gess[1], [1]Oregon State University, [2]US Army Research Laboratory

Design and Development of an Automated Lithium-Ion Battery Temperature and Internal Pressure Monitoring Device (p203) 1189
Samba Gaye, Jana Catuche, Mehdi Kabir, Jiajun Xu, University of the District of Columbia

Thermal Characterization of Continuous Pitch Carbon Fiber 3D-Printed using a 6-Axis Robot Arm (p206) 1195
Uday Sinan Olcun, Roger Kempers, York University

SESSION E-6: ADDITIVE MANUFACTURING 1

Session Chairs: David Deisenroth (National Institute of Standards and Technology), Todd Bandhauer (Colorado State U)

Process Development for Fabrication of Copper Additive-Multilayer Circuits with Component Attachment using ECA and LTS (p323) 1201
Pradeep Lall[1], Jinesh Narangaparambil[1], Kyle Schulze[1], Curtis Hill[2], [1]Auburn University, [2]QuantiTech Inc

Prediction of Electrical Performance and Print Geometry for Inkjet Additive Circuits via Statistical Modeling (p288) 1210
Pradeep Lall[1], Kartik Goyal[1], Scott Miller[2], [1]Auburn University, [2]NextFlex Manufacturing Institute

Performance of Component Interconnection Methods on Direct Write Additive Silver Circuits (p331) 1221
Pradeep Lall[1], Jinesh Narangaparambil[1], Scott Miller[2],
[1]Auburn University, [2]NextFlex National Manufacturing Institute

SESSION E-7: ADDITIVE MANUFACTURING 2

Session Chairs: Georges Pavlidis (University of Connecticut), Ping-Chuan Wang (SUNY-New Paltz),
Felipe Valenzuela Gaete (Villanova University)

Development of Additive Manufactured Metal Wick Structures for Two-Phase Heat Transfer Applications (p230) 1233
Ahmed Elkholy[1], Jason Durfee[2], Roger Kempers[1], [1]York University, [2]MAGNA Corporation

Component Attachment to Inkjet Additive Printed Circuits to Achieve Flexible RF Filters using Silver and Copper Nanoparticle Metal Inks (p289) 1238
Pradeep Lall[1], Kartik Goyal[1], Scott Miller[2], [1]Auburn University, [2]NextFlex National Manufacturing Institute

Interaction of Photonic Curing Process Parameters on Additively Printed Copper Circuits (p325) 1248
Pradeep Lall[1], Jinesh Narangaparambil[1], Curtis Hill[2], [1]Auburn University, [2]QuantiTech Inc

Intra- and Inter-device Passive Thermal Management using Solid-solid Nickel Titanium Phase Change Materials (p364) 1258
Darin Sharar[1], Christopher Peters[2], Kimberly Olver[3], Adam Wilson[1], Harvey Tsang[1], David Altman[2],
[1]US Army Research Laboratory, [2]Raytheon, [3]Fibertek Inc

SESSION E-9: RELIABILITY PHYSICS

Session Chairs: Patrick McCluskey (University of Maryland), Brian Donovan (United States Naval Academy)

Analysis of Temperature Variation Influence on Damping Coefficient and Q-factor of 2-DOF Vibratory Rotational Velocity Sensor (p251) 1265
Jacek Nazdrowicz, Mariusz Jankowski, Adam Stawinski, Andrzej Napieralski, Lodz University of Technology

Reliability Characterization and Modeling of Flexible LCO battery Under Flexing and Calendar Aging for SOH Degradation Analysis (p291) 1272
Pradeep Lall[1], Hyesoo Jang[1], Scott Miller[2], [1]Auburn University, [2]NextFlex National Manufacturing Institute

SOH Degradation of Curved and Flat Li-ion Thin Flexible Batteries Subjected to Flex-to-Install Testing at Various Fold Diameters (p312) 1278
Pradeep Lall, Ved Soni, Auburn University

SESSION E-10: MULTI-PHASE HEAT TRANSFER

Session Chairs: Solomon Adera (University of Michigan), Douglas Hopkins (North Carolina State University), Mark Schultz (IBM), Jorge Padilla (Google), Sadegh Khalili (IBM)

Exploring the Design Features of Wettability-Patterned Surfaces for Condensation Heat Transfer (p122) **1285**
Mohamad Jafari Gukeh, George Damoulakis, Constantine Megaridis, University of Illinois at Chicago

The Effect of Fin Array Height and Spacing on Heat Transfer Performance during Pool Boiling from Extended Surfaces (p124) **1293**
Maureen Winter, Justin Weibel, Purdue University

Numerical Analysis of Passive Manifold Microchannel Heat Exchanger Enhancements (p207) **1300**
Daniel Jovin, Jun Jie Harrison Hui, Kim Tiow Ooi, Nanyang Technological University

SUBMIT A PAPER FOR ITherm 2022!

As you further develop a technique or application, consider documenting it for the thermal community. **ITherm** will begin accepting abstracts this autumn. We welcome your submissions! Visit us at **www.ieee-itherm.net**.

ITherm 2022 is June 1-3, 2022 in Las Vegas, NV USA – *be there!*