Advanced Power Electronics Thermal Management

Advanced Thermal Management Materials provides a comprehensive and hands-on treatise on the importance of thermal packaging in high performance systems. These systems, ranging from active electronically-scanned radar arrays to web servers, require components that can dissipate heat efficiently. This requires materials capable of dissipating heat and maintaining compatibility with the packaging and dye. Coverage includes all aspects of thermal management materials, both traditional and non-traditional,with an emphasis on metal based materials. An in-depth discussion of properties and manufacturing processes, and current applications are provided. Also presented are a discussion of the importance of cost, performance and reliability issues when making implementation decisions, product life cycle developments, lessons learned and future directions.

This volume contains 40 papers from the following 10 Materials Science and Technology (MS&T'14) symposia: Rustum Roy Memorial Symposium: Processing and Performance of Materials Using Microwaves, Electric and Magnetic Fields, Ultrasound, Lasers, and Mechanical Work Advances in Dielectric

Materials and Electronic Devices Innovative Processing and Synthesis of Ceramics, Glasses and Composites Advances in Ceramic Matrix Composites Sintering and Related Powder Processing Science and Technology Advanced Materials for Harsh Environments Thermal Protection Materials and Systems Advanced Solution Based Processing for Ceramic Materials Controlled Synthesis, Processing, and Applications of Structure and Functional Nanomaterials Surface Protection for Enhanced Materials Performance

The Advanced Power Electronics and Electric Motors (APEEM) program within the DOE Vehicle Technologies Program (VTP) provides support and guidance for many cutting-edge automotive technologies now under development. Research is focused on developing revolutionary new power electronics (PE), electric motor (EM), thermal management, and traction drive system technologies that will leapfrog current on-the-road technologies. The research and development (R & D) is also aimed at achieving a greater understanding of and improvements in the way the various new components of tomorrow's automobiles will function as a unified system to improve fuel efficiency.

Thermal management and reliability are important because excessive temperature can degrade the performance, life, and reliability of power electronics and electric motors. Advanced

thermal management technologies enable keeping temperature within limits; higher power densities; and lower cost materials, configurations and systems. Thermal interface materials, bonded interface materials and the reliability of bonded interfaces are discussed in this presentation.

This report describes the research into advanced liquid cooling, integrated power module cooling, high temperature air cooled power electronics, two-phase cooling for power electronics, and electric motor thermal management by NREL's Power Electronics group in FY13.

Advanced Power Electronics and Electric Motors Annual Report -- 2013

Switching Power Converters

Department of the Interior and Related Agencies Appropriations for 2005

Advanced Automotive Technologies

Hearings Before a Subcommittee of the Committee on Appropriations, House of Representatives, One Hundred Fourteenth Congress, First Session

Energy and Water Development Appropriations for 2006: Dept. of the Army, Corps of Engineers

FY2012 Advanced Power Electronics and Electric Motors Annual Progress Report

Energy and Water Development Appropriations for 2008

Design, Assembly Process, Reliability and

Modeling

This book focuses on two of the most relevant problems related to power management on multicore and manycore systems. Specifically, one part of the book focuses on maximizing/optimizing computational performance under power or thermal constraints, while another part focuses on minimizing energy consumption under performance (or real-time) constraints.
Electric Vehicle Integration into Modern Power Networks provides coverage of the challenges and opportunities posed by the progressive integration of electric drive vehicles. Starting with a thorough overview of the current electric vehicle and battery state-of-the-art, this work describes dynamic software tools to assess the impacts resulting from the electric vehicles deployment on the steady state and dynamic operation of electricity grids, identifies strategies to mitigate them and the possibility to support simultaneously large-scale integration of renewable energy sources. New business models and control management architectures, as well as the communication infrastructure required to integrate electric vehicles as active demand are presented. Finally, regulatory issues of integrating electric vehicles into modern power systems are addressed. Inspired by two courses held under the EES-UETP umbrella in 2010 and 2011, this contributed volume consists of nine

chapters written by leading researchers and professionals from the industry as well as academia.

This presentation gives an overview of the status and FY09 accomplishments for the NREL thermal management research project 'Air Cooling for Power Electronics'.

The continuing trend toward miniaturization and high power density electronics results in a growing interdependency between different fields of engineering. In particular, thermal management has become essential to the design and manufacturing of most electronic systems. Heat Transfer: Thermal Management of Electronics details how engineers can use intelligent thermal design to prevent heat-related failures, increase the life expectancy of the system, and reduce emitted noise, energy consumption, cost, and time to market. Appropriate thermal management can also create a significant market differentiation, compared to similar systems. Since there are more design flexibilities in the earlier stages of product design, it would be productive to keep the thermal design in mind as early as the concept and feasibility phase. The author first provides the basic knowledge necessary to understand and solve simple electronic cooling problems. He then delves into more detail about heat transfer fundamentals to give the reader a deeper understanding of the physics of heat

transfer. Next, he describes experimental and numerical techniques and tools that are used in a typical thermal design process. The book concludes with a chapter on some advanced cooling methods. With its comprehensive coverage of thermal design, this book can help all engineers to develop the necessary expertise in thermal management of electronics and move a step closer to being a multidisciplinary engineer.

Advanced Thermal Management Techniques for High Power Electronics DevicesAdvanced Thermal Management of Very High Power ElectronicsAssessing Polymeric Nanocomposites and Advanced Cooling Techniques for Thermal Management of Next-generation Power Electronics

Electronics Cooling

Advanced Thermal Management of Very High Power Electronics

Processing and Properties of Advanced Ceramics and Composites VII

Thermal Management of Power Electronics and Electric Motors for Electric-Drive Vehicles (Presentation).

Energy and Water Development Appropriations for 2007

Hearings Before a Subcommittee of the Committee on Appropriations, House of Representatives, One Hundred Eighth Congress, Second Session

Medium and High Power, Second Edition
Energy and Water Development Appropriations for 2015: Department of Energy fiscal year 2015 justifications
Hearings Before a Subcommittee of the Committee on Appropriations, House of Representatives, One Hundred Ninth Congress, First Session
Heat Transfer

This presentation is an overview of the power electronics and electric motor thermal management and reliability activities at NREL. The focus is on activities funded by the Department of Energy Vehicle Technologies Office Advanced Power Electronics and Electric Motors Program.

This book is a technical publication for students, scholars and engineers in electrical engineering, focusing on the pulse-width-modulation (PWM) technologies in power electronics area. Based on an introduction of basic PWM principles this book analyzes three major challenges for PWM on system performance: power losses, voltage/current ripple and electromagnetic interference (EMI) noise, and the lack of utilization of control freedoms in conventional PWM technologies. Then, the model of PWM's impact on system performance is introduced, with the

current ripple prediction method for voltage source converter as example. With the prediction model, two major advanced PWM methods are introduced: variable switching frequency PWM and phase-shift PWM, which can reduce the power losses and EMI for the system based on the prediction model. Furthermore, the advanced PWM can be applied in advanced topologies including multilevel converters and paralleled converters. With more control variables in the advanced topologies, performance of PWM can be further improved. Also, for the special problem for common-mode noise, this book introduces modified PWM method for reduction. Especially, the paralleled inverters with advanced PWM can achieve good performance for the common-mode noise reduction. Finally, the implementation of PWM technologies in hardware is introduced in the last part.

Heat exchangers are a crucial part of aerospace, marine, cryogenic and refrigeration technology. These essays cover such topics as complicated flow arrangements, complex extended surfaces, two-phase flow and irreversibility in heat exchangers, and single-phase heat transfer.

Power Electronic Packaging presents an in-

depth overview of power electronic packaging design, assembly,reliability and modeling. Since there is a drastic difference between IC fabrication and power electronic packaging, the book systematically introduces typical power electronic packaging design, assembly, reliability and failure analysis and material selection so readers can clearly understand each task's unique characteristics. Power electronic packaging is one of the fastest growing segments in the power electronic industry, due to the rapid growth of power integrated circuit (IC) fabrication, especially for applications like portable, consumer, home, computing and automotive electronics. This book also covers how advances in both semiconductor content and power advanced package design have helped cause advances in power device capability in recent years. The author extrapolates the most recent trends in the book's areas of focus to highlight where further improvement in materials and techniques can drive continued advancements, particularly in thermal management, usability, efficiency, reliability and overall cost of power semiconductor solutions.

An examination of all of the

multidisciplinary aspects of medium- and high-power converter systems, including basic power electronics, digital control and hardware, sensors, analog preprocessing of signals, protection devices and fault management, and pulse-width-modulation (PWM) algorithms, Switching Power Converters: Medium and High Power, Second Edition discusses the actual use of industrial technology and its related subassemblies and components, covering facets of implementation otherwise overlooked by theoretical textbooks. The updated Second Edition contains many new figures, as well as new and/or improved chapters on: Thermal management and reliability Intelligent power modules AC/DC and DC/AC current source converters Multilevel converters Use of IPM within a "network of switches" concept Power semiconductors Matrix converters Practical aspects in building power converters Providing the latest research and development information, along with numerous examples of successful home appliance, aviation, naval, automotive electronics, industrial motor drive, and grid interface for renewable energy products, this edition highlights advancements in packaging technologies, tackles the advent of hybrid circuits able

to incorporate control and power stages within the same package, and examines design for reliability from the system level perspective.

Energy and Water Development Appropriations for 2006
Advanced Pulse-Width-Modulation: With Freedom to Optimize Power Electronics Converters
Advanced Techniques for Power, Energy, and Thermal Management for Clustered Manycores
Electric Vehicle Integration into Modern Power Networks
High Efficiency Power Supply Using New SiC Devices
Hearings Before a Subcommittee of the Committee on Appropriations, House of Representatives, One Hundred Tenth Congress, First Session
Advanced Materials for Thermal Management of Electronic Packaging
Advanced Thermal Management Techniques for High Power Electronics Devices
Ceramic Transactions
Power Electronic Packaging

The field of power electronics devices has seen two significant trends in recent years: rapid miniaturization of devices and the replacement of silicon-based devices with wide bandgap semiconductor materials-based devices (Silicon Carbide (SiC), Gallium Nitride (GaN)). The end result of these advancements are devices that need advanced

cooling technologies to dissipate ultrahigh high and concentrated heat loads. Multiple advanced thermal management solutions such as liquid cooling, jet, and spray impingement have been proposed as potential solutions. The present dissertation quantifies the benefits of key advanced cooling techniques for thermal management of power electronics packages. An analytical modeling framework based on a thermal resistance circuit has been utilized to estimate the maximum heat flux that can be dissipated from a power electronics package, and the junction temperatures at varying levels of power dissipation. Analysis was conducted for heat sinks made of copper (k=400 W/mK) and a polymer (k=20 W/mK). The developed modeling framework takes into account heat spreading in both lateral directions while capturing the influence of material properties on the spreading angle. The model can, therefore, be considered to capture 3D effects as well. Additionally, 3D Finite Element Analysis (FEA) simulations have been carried out to compare with the findings of the analytical model. This dissertation also studies the influence of polymeric encapsulants of varying thermal conductivities on the resulting temperature distributions in the package via steady 2D coupled electro-thermal simulations. Overall, the methodology and results presented in this dissertation provide insights for selecting optimal combinations of thermal management technologies and advanced polymeric materials, based on the heat dissipation requirements of power electronics packages

The Advanced Power Electronics and Electric Motors (APEEM) program within the DOE Vehicle Technologies Office (VTO) provides support and guidance for many cutting-edge automotive technologies now under development. Research is focused on developing revolutionary new power electronics (PE), electric motor (EM), thermal management, and traction drive system technologies that will leapfrog

current on-the-road technologies. The research and development is also aimed at achieving a greater understanding of and improvements in the way the various new components of tomorrow's automobiles will function as a unified system to improve fuel efficiency.

The complete editorial contents of Qpedia Thermal eMagazine, Volume 3, Issues 1 - 12 features in-depth, technical articles covering the most critical areas of electronics cooling.

Featuring contributions from the renowned researchers and academicians in the field, this book covers key conventional and emerging cooling techniques and coolants for electronics cooling. It includes following thematic topics: - Cooling approaches and coolants - Boiling and phase change-based technologies - Heat pipes-based cooling - Microchannels cooling systems - Heat loop cooling technology - Nanofluids as coolants - Theoretical development for the junction temperature of package chips. This book is intended to be a reference source and guide to researchers, engineers, postgraduate students, and academicians in the fields of thermal management and cooling technologies as well as for people in the electronics and semiconductors industries.

The need for advanced thermal management materials in electronic packaging has been widely recognized as thermal challenges become barriers to the electronic industry’s ability to provide continued improvements in device and system performance. With increased performance requirements for smaller, more capable, and more efficient electronic power devices, systems ranging from active electronically scanned radar arrays to web servers all require components that can dissipate heat efficiently. This requires that the materials have high capability of dissipating heat and maintaining compatibility with the die and electronic packaging. In response to critical needs, there have been revolutionary

advances in thermal management materials and technologies for active and passive cooling that promise integrable and cost-effective thermal management solutions. This book meets the need for a comprehensive approach to advanced thermal management in electronic packaging, with coverage of the fundamentals of heat transfer, component design guidelines, materials selection and assessment, air, liquid, and thermoelectric cooling, characterization techniques and methodology, processing and manufacturing technology, balance between cost and performance, and application niches. The final chapter presents a roadmap and future perspective on developments in advanced thermal management materials for electronic packaging.

Hearings Before a Subcommittee of the Committee on Appropriations, House of Representatives, One Hundred Ninth Congress, Second Session

Advanced Thermal Management Materials

Advanced Thermal Modelling and Management Techniques to Improve Power Density in Next Generation Power Electronics

Qpedia Thermal Management – Electronics Cooling Book, Volume 1

Innovative Processing Methods For Synthesizing Advanced Structural And Functional Materials

Assessing Polymeric Nanocomposites and Advanced Cooling Techniques for Thermal Management of Next-generation Power Electronics

Power Electronics Thermal Management R & D (Presentation).

Performance and Reliability of Interface Materials for Automotive Power Electronics (Presentation).

Energy and Water Development Appropriations for 2016

Compact Heat Exchangers

This project will investigate and develop thermal-management strategies for wide bandgap (WBG)-based power electronics systems. Research will be carried out to deal with thermal aspects at the module- and system-level. Module-level research will focus on die- and substrate-integrated cooling strategies and heat-transfer enhancement technologies. System-level research will focus on thermal-management strategies for the entire power electronics system to enable smart packaging solutions. One challenge with WBG device-based power electronics is that although losses in the form of heat may be lower, the footprint of the components is also likely to be reduced to reduce cost, weight, and volume. Combined with higher operational temperatures, this creates higher heat fluxes which much be removed from a smaller footprint, requiring advanced cooling strategies.

Thermal Management of Electronics

FY2011 Advanced Power Electronics and Electric Motors Annual Progress Report

Annual Report to Congress, Fiscal Year 1996

Qpedia Thermal Management – Electronics Cooling Book, Volume 3

... United States Forest Service, Department of Energy

Air Cooling Technology for Advanced Power Electronics and Electric Machines (Presentation).

Energy and Water Development Appropriations for 2008: Dept. of Energy FY 2008 budget justifications: budget highlights, NNSA, other defense activities

Department of the Interior and Related Agencies Appropriations for 2005: Justification of the budget estimates: United States Forest Service, Department of Energy

A Festschrift for A.L. London