Thermal Management Heat Dissipation In Electrical Enclosures

Heat Transfer
Advances in Heat Transfer and Thermal Engineering
Encyclopedia Of Thermal Packaging, Set 3: Thermal Packaging Applications (A 3-volume Set)
Thermal Management of Electronic Systems
Exergy-based Analysis and Optimization of Computer Thermal Management Systems
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Phase Change Material-Based Composite Heat Sinks—An Experimental Approach
Energy Efficient Thermal Management of Data Centers
An American Institute of Aeronautics and Astronautics Series
Thermal Management of Electronics
Design and Analysis of Heat Sinks
Materials for High-Density Electronic Packaging and Interconnection
Thermal Management in Automotive Applications
Thermal Management Research Studies. Volume 1. Electronics Cooling
Thermal Management and Optimization of Heat Transfer from Discrete Heat Sources
Thermal Management of Microelectronic Equipment
Encyclopedia of Thermal Packaging, Set 1: Thermal Packaging Techniques (a 6-Volume Set)
Advanced Materials for Thermal Management of Electronic Packaging
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Encyclopedia Of Two-phase Heat Transfer And Flow Iii: Macro And Micro Flow Boiling And Numerical Modeling Fundamentals (A 4-volume Set)
Thermal Management of Electric Vehicle Battery Systems
Heat Transfer
Qpedia Thermal Management eMagazine, Volume 4
Assessing Polymeric Nanocomposites and Advanced Cooling Techniques for Thermal Management of Next-generation Power Electronics
Assessment of Latent Heat Reservoirs for Thermal Management of QCW Laser Diodes
Carbon Nanotube Films and Microjet Cooling Devices for Thermal Management
Proceedings of 16th UK Heat Transfer Conference (UKHTC2019)
Heat Pipe Design and Technology
Advanced Materials for Thermal Management of Electronic Packaging
Mathematical Modelling, Numerical Methods and Information Technology
Heat Transfer
Thermal Management of Electronic Systems II
Heat Pipes
Design, Experimentation and Applications
Proceedings of EUROTHERM Seminar 45, 20–22 September 1995, Leuven, Belgium
Single Phase and Flow Boiling Heat Transfer and Flow Characterization in Microscale Pin Fin Heat Sinks

SIDNEY CONWAY

Heat Transfer Springer Science & Business Media
Thermal energy is present in all aspects of our lives, including when cooking, driving, or turning on the heat or air conditioning. Sometimes this thermal management is not evident, but it is essential for our comfort and lifestyle. In addition, heat transfer is vital in many industrial processes. Thermal energy analysis is a complex task that usually requires different approaches. With five sections, this book provides information on heat transfer problems and using experimental techniques and computational models to analyse them.
Advanced Thermal Solutions
For the second time, the Eurotherm Committee has chosen Thermal Managment of Electronic Systems as the subject for its 45th Seminar, held at IMEC in Leuven, Belgium, from 20 to 22 September 1995. After the successfui first edition of this seminar in Delft, June 14-16, 1993, it was decided to repeat this event on a two year basis. This volume constitutes the edited proceedings of the Seminar. Thermal management of electronic systems is gaining importance. Whereas a few years ago papers on this subject where mainly devoted to applications in high end markets, such as mainframes and telecommunication switching equipment, we see a growing importance in the "lower" end applications. This may be understood from the growing impact of electronics on every day life, from car electronics, GSM phones, personal computers to electronic games. These applications add new requirements to the thermal design. The thermal problem and the applicable cooling strategies are quite different from those in high end products. In this seminar the latest developments in many of the different aspects of the thermal design of electronic systems were discussed. Particular attention was given to thermal modelling, experimental characterisation

and the impact of thermal design on the reliability of electronic systems.

Advances in Heat Transfer and Thermal Engineering AIAA

Phase change material (PCM)-based composite heat sinks have attracted great interest in recent decades, especially in the context of thermal management of portable electronic devices such as mobile phones, digital cameras, personal digital assistants, and notebooks. In this monograph, a detailed analysis of plate fin heat sinks and plate fin heat sink matrix is presented, based on in-house experiments. Performance benchmarks are articulated and presented for these heat sinks. The state of the art in the development of PCM-based heat sinks and the challenges are outlined, and directions on future development are provided. It is our sincere hope and trust that this book will not only be informative but also awaken curiosity and inspire thermal management solution seekers to delve deep into the ocean of research in PCM-based heat sinks and discover their own pearls and diamonds.

Encyclopedia Of Thermal Packaging, Set 3: Thermal Packaging Applications (A 3-volume Set) National Academies Press

With this systematic examination of the factors that govern the thermal performance of electronics, the authors solve design problems encountered in developing and analyzing very-high-performance and high-heat-dissipation devices, as well as intermediate and lower-power devices. They explore a wide range of heat transfer technologies and consider their options when employing several different heat transfer modes simultaneously in a system. This important reference provides: Data and correlation's for the analysis and design of electronic equipment; Latest updates on thermal control technology; Review of the fundamentals of heat transfer; Approaches to solving real-world problems of vast complexity. While emphasizing the physics of each subject, the book keeps high-level mathematics to a minimum. Two chapters on conduction and extended surfaces deal with the fundamentals of various heat transfer modes; the other fifteen chapters focus on specific subjects of practical importance to the design of electronic systems. The nine appendices provide useful material, such as property tables for solids and sixteen types of fluids, as well as a comprehensive catalog of topics in connective heat transfer that includes heat transfer correlation's for various physical configurations and thermal boundary conditions. Contents: Introduction; Conduction; Convection; Radiation; Pool Boiling; Flow Boiling; Condensation; Extended Surfaces; Thermal Interface Resistance; Components and Printed Circuit Boards; Direct Air Cooling and Fans; Natural and Mixed Convection; Heat Exchangers and Cold Plates; Advanced Cooling Technologies; Heat Pipes; Thermoelectric Coolers. Appendices: Material Thermal Properties; Thermal Conductivity of Silicon and Gallium Arsenide; Properties of Air, Water, and Dielectric Fluids; Typical Emissivities of Common Surfaces; Properties of Phase-Change Materials; Friction Factor Correlation's; Heat Transfer Correlation's; Units Conversion Table.

Thermal Management of Electronic Systems Advanced Thermal Solutions

Energy Efficient Thermal Management of Data Centers examines energy flow in today's data centers. Particular focus is given to the state-of-the-art thermal management and thermal design approaches now being implemented across the multiple length scales involved. The impact of future trends in information technology hardware, and emerging software paradigms such as cloud computing and virtualization, on thermal management are also addressed. The book explores computational and experimental characterization approaches for determining temperature and air flow patterns within data centers. Thermodynamic analyses using the second law to improve energy efficiency are introduced and used in proposing improvements in cooling methodologies. Reduced-order modeling and robust multi-objective design of next generation data centers are discussed.

Exergy-based Analysis and Optimization of Computer Thermal Management Systems Momentum Press

These days, the cooling of new generation electronic servers is a challenge due to the immense heat generated by them. In order to avoid overheating caused by the important rise in temperature appropriate cooling procedures must be used in order to meet the thermal requirement. The current study aims at addressing the issue of overheating in this field, and focuses on the thermal management of electronic devices modelled as a discrete heat sources (mounted in a rectangular cavity) with uniform heat flux applied from the bottom. A review of the literature published regarding the convective heat transfer from heated sources as well as a thorough background on the theory of the cooling of discrete sources by forced convection in rectangular channel is provided in this study. It was showed that the heat transfer performance in channel is strongly influenced by the geometric configurations of heat sources. Therefore, the arrangement and geometric optimisation are the main considerations in the evaluation of thermal performance. Unlike experimental methods that were carried out widely in the past, which provided less cost-effective and more time-consuming means of achieving the same objective, in this study we first explore the possibilities and the advantages of using the CD-adapco's CFD package Star-CCM+ to launch a three dimensional investigation of forced convection heat transfer performance in a channel mounted with equidistant heatgenerating blocks. Numerical results were validated with available experimental data, and showed that the thermal performance of the heat transfer increases with the strength of the flow. The second objective was to maximise the heat transfer density rate to the cooling fluid and to minimise both the average and the maximum temperature in the channel by using the numerical optimisation tool HEEDS/Optimate+. The optimal results showed that better thermal performance was not obtained when the heated sources followed the traditional equidistance arrangement, but was achieved with a specific optimal arrangement under the total length constraint for the first case. Subsequently, for the second case study, on the volume constraints of heat sources, the results proved that optimal configurations that maximise the heat transfer density rate were obtained with a maximum of either the height-to-length ratio or the height-to-width ratio. It was concluded that the heat transfer rate to the cooling fluid increases significantly with the Reynolds number and the optimal results obtained numerically are found to be fairly reliable.

Thermal Hydraulics for Space Power, Propulsion, and Thermal Management System Design Asme Press Book Series on Elec

The downsizing of electronic devices and the consequent increasing power densities pose thermal management challenges for the semiconductor industry. Since the present thermal solutions limit their cooling capacity, developing new cooling methods for electronic devices has become important. This dissertation presents two types of novel methods for heat dissipation from integrated circuits: One is the use of advanced thermal interface materials, such as carbon nanotubes (CNTs), to increase heat dissipation between the solid and solid surface, such as a chip and heat sink. The second method is the use of a microjet impingement device to improve heat transfer between a liquid and solid in a heat sink. As advanced interface materials, vertically aligned carbon nanotube films are promising because of their unique mechanical and thermal properties. The first part of the dissertation describes the design, fabrication, and testing of CNTs using resonators to characterize their mechanical properties. Discussed in detail is the preparation of carbon nanotubes using different recipes, resulting in varied thicknesses of single-walled carbon nanotube films and multi-walled carbon nanotube films. The measurements of the resonant frequency shifts due to the presence of the CNT films using a laser Doppler vibrometer system result in extracted moduli of 0.5-220 [Mu]m-thick nanotube films varying from 1 to 370 MPa. To show how the physics between the effective modulus and thickness are connected, an analysis for the height dependence of the modulus is provided. After an image analysis is presented, a nanotube dynamics simulation based on tube properties and film morphology is introduced to predict mechanical properties. In addition to discussing the proposed interface materials, the second part of the dissertation describes the design, fabrication and testing of microjet impingement cooling, which display high heat capacities, as an advanced thermal management solution. The design of single-jet and multi-jet arrays with different numbers of diameters, locations, and spacing is discussed. Specifically, this part demonstrates how the microjet hydrodynamics are quantified using two-dimensional images by [Mu]PIV techniques, enabling the reconstruction of the three-dimensional flow field. The results indicate that CNT films offer a mechanical compliance that is suitable for TIM applications and that the microscale liquid jet devices provide quantified flow physics for heat sink applications.

Developing Next-generation Textiles for Personal Thermal Management World Scientific

In this study, heat removal and thermal management solutions for electronic devices were investigated at board-level. The generated heat at an electronic chip, installed on a printed circuit board (PCB), can be dissipated either through a heat sink, that is attached directly to the chip, or can be transferred through the PCB to the other side and then be dissipated to the ambient. In any case, thermal interface materials (TIMs) should be used to reduce the thermal contact resistance (TCR) at the solid-solid interface, and also to electrically insulate the live electrical component from the heat sink which is normally exposed to the ambient. Graphite, due to its low cost, lightweight, low thermal expansion coefficient, high temperature tolerance, and high corrosion resistance properties is shown to be a promising candidate to be used as a TIM. In this study, a new analytical model was developed to predict the thermal conductivity of graphite-based TIMs as a function of pressure applied during the production, and flake mechanical properties. The model was verified with the experimental results obtained from testing multiple graphite-based TIM samples. Transferring the heat to the back of the PCB could potentially provide more surface area for the heat transfer, as normally the backside of PCBs is less populated compared to the front side. However, this comes with its own challenges, due to the low thermal conductivity of the FR4, the main material used in the PCB composition. Thermal vias, which are copper-plated through holes, are proposed as a solution, since they can provide a thermal bridge for heat. A new analytical model was developed for predicting the enhanced thermal conductivity of PCBs equipped with thermal vias. The results were validated by the experimental data obtained from testing nine PCB samples. Effects of vias diameter and their arrangement on the thermal performance were investigated. The results indicated that by using staggered arrangement of thermal vias with larger diameters, the effective thermal conductivity of the PCB can be improved.

Modern Applications for Practical Thermal Management BoD – Books on Demand

Phase change material (PCM)-based composite heat sinks have attracted great interest in recent decades, especially in the context of thermal management of portable electronic devices such as mobile phones, digital cameras, personal digital assistants, and notebooks. In this monograph, a detailed analysis of plate fin heat sinks and plate fin heat sink matrix is presented, based on in-house experiments. Performance benchmarks are articulated and presented for these heat sinks. The state of the art in the development of PCM-based heat sinks and the challenges are outlined, and directions on future development are provided. It is our sincere hope and trust that this book will not only be informative but also awaken curiosity and inspire thermal management solution seekers to delve deep into the ocean of research in PCM-based heat sinks and discover their own pearls and diamonds.

Phase Change Material-Based Composite Heat Sinks—An Experimental Approach Springer Science & Business Media

Publisher's Note: Products purchased from Third Party sellers are not guaranteed by the publisher for quality, authenticity, or access to any online entitlements included with the product. The "hands-on" guide to thermal management! In recent years, heat-sensitive electronic systems have been miniaturized far more than their heat-producing power supplies, leading to major design and reliability challenges — and making thermal management a critical design factor. This timely handbook covers all the practical issues that any packaging engineer must consider with regard to the thermal management of printed circuit boards, hybrid circuits, and multichip modules. Readers will also benefit from the extensive data on material properties and circuit functions, thus enabling more intelligent decisions at the design stage — and preventing thermal-related problems from occurring in the first place.

Energy Efficient Thermal Management of Data Centers Momentum Press

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

An American Institute of Aeronautics and Astronautics Series
Advanced Thermal Solutions

Heat dissipation is a critical limitation in a range of electronic devices including microprocessors, solar cells, laser diodes and power amplifiers. The most demanding devices require dissipation of heat fluxes in excess of 1 kW/cm2 with heat transfer coefficients more than 30 W/cm 2K. Advanced thermal management solutions using phase change heat transfer are the most promising approach to address these challenges, yet current solutions are limited due to the combination of heat flux, thermal resistance, size and flow stability. This thesis reports the design, fabrication and experimental characterization for an evaporation device with a nanoporous membrane for high heat flux dissipation. Evaporation in the thin film regime is achieved using nanopores with reduced liquid film thicknesses while liquid pumping is enhanced using the capillary pressure of the 120 nm pores. The membrane is mechanically supported by ridges that form liquid supply channels and also serve as a heat conduction path to the evaporating meniscus at the surface of the membrane. The combination of high capillarity pores with high permeability channels facilitates theoretical critical heat fluxes over 2 kW/cm2 and heat transfer coefficients over 100 W/cm2K. Proof-of-concept devices were fabricated using a two-wafer stack consisting of a bonded silicon-on-insulator (SOI) wafer to a silicon wafer. Pores with diameters 110 - 130 nm were defined with interference lithography and etched in the SOI. Liquid supply microchannels were etched on a silicon wafer and the two wafers were fusion bonded together to form a monolithic evaporator. Once bonded, the membrane was released by etching through the backside of the SOI. Finally, platinum heaters and Resistive Temperature Detectors (RTDs) were deposited by e-beam evaporation and liftoff to heat the sample and measure the device temperature during experiments, respectively. Samples were experimentally characterized in a custom environmental chamber for comparison to the model using R245fa, methanol, pentane, water and isopropyl alcohol as working fluids. A comparison of the results with different working fluids demonstrates that transport at the liquid-vapor interface is the dominant thermal resistance in the system, suggesting a figure of merit: ... The highest heat flux recorded was with pentane at ... and the highest heat transfer coefficient recorded was with ... not including the substrate resistance. However, the samples were observed to clog with soluble, nonvolatile contaminants which limited operation to several minutes. The clogging behavior was captured in a mass diffusion model and a new configuration was suggested which is resistant to clogging. Evaporation from nanopores represents a new paradigm in phase change cooling with a figure of merit that favors high volatility, low surface tension fluids rather than water. The models and experimental results validate the functionality and understanding of the proposed approach and provide recommendations for enhancements in performance and understanding as well as strategies for resistance to clogging. This work demonstrates that nanoporous membranes have the potential for ultra-high heat flux dissipation to address next generation thermal management needs.

Thermal Management of Electronics Springer Science & Business Media

Thermal comfort is significant for the human body. The human body is a very delicate system that has a narrow temperature operation range (normal temperature range at rest: 36 °C to 38 °C). Both high temperature and low temperature are usually harmful and even life-threatening. Nevertheless, to maintain thermal comfort, we still tend to rely on the ambient environment temperature control for thermal comfort until now, such as utilizing the heating, ventilation, and air conditioning (HVAC) system. Insufficient attention has been paid to the textiles we wear every day which are the interface of energy exchange between the ambient and the human body. In my Ph.D. study, I focused on the human body itself and its local environment, explored novel materials and tailored thermal regulation properties for textiles, to realize improved personal thermal management. In Chapter 1, I will introduce the background of human body thermal comfort, basic heat dissipation routes including radiation, conduction, convection and evaporation, and the personal thermal management strategy. This thermal regulation strategy is effective for providing enhanced thermal comfort and decreases dependency on the environment for the human body. Besides, considering the huge thermal mass of the entire environment as compared to the individuals, personal thermal management may help save considerable energy for building heating and cooling. The state-of-the-art textiles for thermal comfort will be generally introduced in this chapter as well. Aiming at controlling human body thermal radiation mainly in the mid-infrared (mid-IR) wavelength range, I will demonstrate the radiative cooling textiles based on polyethylene (PE) in Chapter 2. Nanoporous polyethylene (NanoPE) fibers with cotton-like softness that is mid-IR transparent and visibly opaque were explored with large-scale continuous production technology. Utilizing industrial knitting/weaving techniques, NanoPE fabrics were realized by massively produced NanoPE fibers, showing a 2.3 °C cooling effect corresponding to over 20 % of indoor cooling energy saving, compared to commercial cotton fabric of the similar thickness. Besides superior cooling effect, the nanoPE fabric also displays impressive wearability and durability. Furthermore, through identifying and utilizing unique inorganic pigment nanoparticles that have negligible absorption in the mid-IR region and compounding them into polyethylene matrix, colored radiative cooling textiles based on polyethylene were achieved. In Chapter 3, I will show the work of developing advanced textile for personal perspiration management. Integrating the water transportation channels and heat transport matrix together, the integrated cooling (i-Cool) textile not only shows the capability of liquid water wicking, but also exhibits superior evaporation rate than traditional textiles. Furthermore, compared with cotton, about 2.8 °C cooling effect causing less than one-third amount of dehydration has also been demonstrated on the artificial sweating skin platform with feedback control loop simulating human body perspiration situation. Moreover, the practical application feasibility of the i-Cool textile design principles has been validated as well. Owing to its exceptional personal perspiration management performance in liquid water wicking, fast evaporation, efficient cooling effect and reduced human body dehydration/electrolyte loss, the i-Cool textile can utilize sweat much more efficiently, which is significant for expanding human body activity and adaption limit. Next in Chapter 4, I will introduce a bifunctional asymmetric textile with tailored heat conduction and radiation regulation for personal cooling and warming. A facile surface modification approach applied on an asymmetric textile was demonstrated to realize the bifunctional textile with both cooling and warming modes. The engineered heat conduction and radiation properties in either mode resulted in improved cooling/warming effect. Plus, the expanded difference of heat conduction and radiation in cooling and warming modes also enlarged the thermal comfort zone for the human body with one piece of textile. Finally, in chapter 5, I will summarize my Ph.D. work and prospect the future work that can be explored in the near future.

Design and Analysis of Heat Sinks BoD – Books on Demand

The ever increasing requirements for heat dissipation in various thermal management applications such as computer chip cooling and high power electronics have necessitated the need for novel thermal management techniques. Thermal management using heat sinks with microscale features is amongst the prominent techniques developed over the past two decades. In this dissertation, single and phase change heat transfer and pressure drop through one such heat sink, namely microscale pin fin heat sinks ([mu]PFHS), is examined experimentally. In particular, effects of pitch-to-diameter and aspect ratio variations are studied on the thermofluidic performance of studied [mu]PFHSs. Single phase heat transfer and pressure drop of two distinct fluids, liquid nitrogen and Performance Fluid (PF5060) are characterized experimentally through the [mu]PFHSs with staggered diamond shape pin fins. The LN2 and PF5060 experiments' Reynolds number (Re_Dh, based on pin fin hydraulic diameter) is in range of 108-570 and 8-462, respectively. Results are presented in a non-dimensional form in terms of the friction factor (f), Nusselt (Nu), and Reynolds numbers and are compared with the predictions of existing correlations in the literature for micro pin fin heat sinks. Heat sinks with the higher pitch ratio (coarser array) not only show lower pressure drops at a fixed Re_Dh, but also enhance significantly heat transfer rate when compared against the heat sink of the same pin fin size but denser arrangement. Flow visualization experiments using an infrared camera on PF5060 single phase tests are performed to understand the counter-intuitive trends seen in the global results. Flow through heat sinks with the same aspect ratio but larger pitch ratio exhibit unsteady vortex shedding in the wake region of pin fins, which markedly enhances convective heat transfer rate. Existing correlations developed for [mu]PFHSs (such as that by Prasher et al. [1] and Koșar and Peles [2]) are capable of predicting the f and Nu data with good agreement only in the absence of vortex shedding, while the unsteady flow past the transition Re_Dh results in poor comparison of correlations with experimental data. A comparison of the experimental Nu data of PF5060 (Pr[approx. equal to]12.2) with the data of LN2 (Pr[approx. equal to]1.9) shows significant change between the slopes of the curves of two fluids only in the heat sinks without vortex shedding. In the heat sinks with unsteady vortex shedding, the Nu_Dh curves show significantly decreased dependency on Pr number. Consequently, separate correlations are developed for predicting Nu in the case with and without unsteady vortex shedding using data from two distinct fluids and four PFHS geometries over a range of Re_Dh from 8 to 643. Given the clear heat transfer enhancement that occurs for certain pitch ratio designs of PFHSs in single phase flows, flow boiling experiments with PF5060 are performed to clarify whether additional changes to the pressure drop and two-phase heat transfer coefficient occur upon the introduction of the unsteady vortex shedding. Subcooled ([delta]T_sub=12.5°C) and saturated flow boiling of PF5060 through the micro pin fins are investigated. The heat sinks are tested at three constant mass fluxes of 30, 60, and 100 kg/m2.s with heat fluxes ranging from 1.1 to 17.8 W/(cm2) based on the planform area of the heat sinks. Flow regimes are studied with high speed imaging. Nucleate boiling heat transfer is the dominant mechanism for exit vapor qualities less than 0.5; at higher qualities annular film evaporation becomes dominant. The salient effect of unsteady vortex shedding is in elimination of wall temperature overshoot. In nucleate boiling regime, the heat sinks with unsteady flow flapping show higher two-phase heat transfer coefficients. The predictions of existing correlations for h_tp in literature are not in good agreement with the experimental data (MAE>30%) and show a systematic deviation depending on the [mu]PFHSs dimensions.

Materials for High-Density Electronic Packaging and Interconnection Springer

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.

Thermal Management in Automotive Applications Butterworth-Heinemann

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.

Thermal Management Research Studies. Volume 1. Electronics Cooling World Scientific

An innovative cooling concept called 'venturi flow cooling' has been introduced and developed for potential use in the thermal management of the advanced high power electronic devices. Single phase cooling medium is effectively used to create very high velocities in localized region of interest to improve heat transfer. Several different test apparatus have been built to investigate the heat transfer and flow phenomena. Using the venturi flow system and water, power devices, such as MCT and IGBT, were successfully tested at their rated current and frequency levels never possible with other cooling methods. Heat flux up to 257 W/(sq. cm) and heat transfer coefficient up to 13 W/(sq. cm). deg C were demonstrated in this cooling system. This cooling technique is highly recommended for the future electronic cooling applications of the emerging more electric airplane systems involving very high intensity localized heat dissipation devices. This report presents the detailed descriptions of all aspects of this project.

Thermal Management and Optimization of Heat Transfer from Discrete Heat Sources Heat TransferThermal Management of Electronics

The Eurotherm Committee has chosen Thermal Management of

Electronic Systems as the subject of its 29th Seminar, at Delft University of Technology, the Netherlands, 14-16 June 1993. This volume constitutes the proceedings of the Seminar. Thermal Management is but one of the several critical topics in the design of electronic systems. However, as a result of the combined effects of increasing heat fluxes, miniaturisation and the striving for zero defects, preferably in less time and at a lower cost than before, thermal management has become an increasingly tough challenge. Therefore, it is being increasingly recognised that cooling requirements could eventually hamper the technical progress in miniaturisation. It might be argued that we are on the verge of a revolution in thermal management techniques. Previously, a packaging engineer had no way of predicting the tempera tures of critical electronic parts with the required accuracy. He or she· had to rely on full-scale experiments, doubtful design rules, or worst-case estimates. This situation is going to be changed in the foreseeable future. User-friendly software tools, the acquisition and integrity of input and output data, the badly needed training mea sures, the introduction into a concurrent engineering environment: all these items will exert a heavy toll on the flexibility of the electronics industries. Fortunately, this situation is being realised at the appropriate management levels, and the interest in this seminar and the pre-conference tutorials testifies to this assertion.

<u>Thermal Management of Microelectronic Equipment</u> Wiley-Interscience

Set III of this encyclopedia is a new addition to the previous Sets I and II. It contains 26 invited chapters from international specialists on the topics of numerical modeling of two-phase flows and evaporation, fundamentals of evaporation and condensation in microchannels and macrochannels, development and testing of micro two-phase cooling systems for electronics, and various special topics (surface wetting effects, microfin tubes, two-phase flow vibration across tube bundles). The chapters are written both by renowned university researchers and by well-known engineers from leading corporate research laboratories. Numerous 'must read' chapters cover the fundamentals of research and engineering practice on boiling, condensation and two-phase flows, two-phase heat transfer equipment, electronics cooling systems, case studies and so forth. Set III constitutes a 'must have' reference together with Sets I and II for thermal engineering researchers and practitioners.

Encyclopedia of Thermal Packaging, Set 1: Thermal Packaging Techniques (a 6-Volume Set) John Wiley & Sons

Thermal and mechanical packaging — the enabling technologies for the physical implementation of electronic systems — are responsible for much of the progress in miniaturization, reliability, and functional density achieved by electronic, microelectronic, and nanoelectronic products during the past 50 years. The inherent inefficiency of electronic devices and their sensitivity to heat have placed thermal packaging on the critical path of nearly every product development effort in traditional, as well as emerging, electronic product categories.Successful thermal packaging is the key differentiator in electronic products, as diverse as supercomputers and cell phones, and continues to be of pivotal importance in the refinement of traditional products and in the development of products for new applications. The Encyclopedia of Thermal Packaging, compiled in four multi-volume sets (Set 1: Thermal Packaging Techniques, Set 2: Thermal Packaging Tools, Set 3: Thermal Packaging Applications, and Set 4: Thermal Packaging Configurations) provides a comprehensive, one-stop treatment of the techniques, tools, applications, and configurations of electronic thermal packaging. Each of the author-written volumes presents the accumulated wisdom and shared perspectives of a few luminaries in the thermal management of electronics.The four sets in the Encyclopedia of Thermal Packaging will provide the novice and student with a complete reference for a quick ascent on the thermal packaging 'learning curve,' the practitioner with a validated set of techniques and tools to face every challenge, and researchers with a clear definition of the state-of-the-art and emerging needs to guide their future efforts. This encyclopedia will, thus, be of great interest to packaging engineers, electronic product development engineers, and product managers, as well as to researchers in thermal management of electronic and photonic components and systems, and most beneficial to undergraduate and graduate students studying mechanical, electrical, and electronic engineering.Set 3: Thermal Packaging ApplicationsThe third set in the Encyclopedia includes two volumes in the planned focus on Thermal Packaging Applications and a single volume on the use of Phase Change Materials (PCM), a most important Thermal Management Technique, not previously addressed in the Encyclopedia. Set 3 opens with Heat Transfer in Avionic Equipment, authored by Dr Boris Abramzon, offering a comprehensive, in-depth treatment of compact heat exchangers and cold plates for avionics cooling, as well as discussion on recent developments in these heat transfer units that are widely used in the thermal control of military and civilian airborne electronics. Along with a detailed presentation of the relevant thermofluid physics and governing equations, and the supporting mathematical design and optimization techniques, the book offers a practical guide for thermal engineers designing avionics cooling equipment, based on the author's 20+ years of experience as a thermal analyst and a practical design engineer for Avionics and related systems.The Set continues with Thermal Management of RF Systems, which addresses sequentially the history, present practice, and future thermal management strategies for electronically-steered RF systems, in the context of the RF operational requirements, as well as device-, module-, and system-level electronic, thermal, and mechanical considerations. This unique text was written by 3 authors, Dr John D Albrecht, Mr David H Altman, Dr Joseph J Maurer, with extensive US Department of Defense and aerospace industry experience in the design, development, and fielding of RF systems. Their combined efforts have resulted in a text, which is well-grounded in the relevant past, present, and future RF systems and technologies. Thus, this volume will provide the designers of advanced radars and other electronic RF systems with the tools and the knowledge to address the thermal management challenges of today's technologies, as well as of advanced technologies, such as wide bandgap semiconductors, heterogeneously integrated devices, and 3D chipsets and stacks.The third volume in Set 3, Phase Change Materials for Thermal Management of Electronic Components, co-authored by Prof Gennady Ziskind and Dr Yoram Kozak, provides a detailed description of the numerical methods used in PCM analysis and a detailed explanation of the processes that accompany and characterize solid-liquid phase-change in popular basic and advanced geometries. These provide a foundation for an in-depth exploration of specific electronics thermal management applications of Phase Change Materials. This volume is anchored in the unique PCM knowledge and experience of the senior author and placed in the context of the extensive solid-liquid phase-change literature in such diverse fields as material science, mathematical modeling, experimental and numerical methods, and thermofluid science and engineering.