



Heat transfer enhancement of phase-change materials (PCMs) based thermal management systems for electronic components: A review of recent advances

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ARTICLE INFO

Keywords:
Phase-change material
Electronic components
Thermal management
Thermal conductivity enhancers
Heat sink

ABSTRACT

Thermal control of electronic components using phase-change materials (PCMs) in heat sinks is an efficient method that has attracted the attention of numerous researchers. However, because of its poor thermal conductivity restrict their usage for cooling electronic components. Hence, to overcome this issue, thermal conductivity enhancers (TCEs) are used. The aim of this article is to conduct a review of different TCEs techniques applied on the PCM-based heat sinks. Included are recent papers on experimental and numerical works with an emphasis on analysing the impact of using TCEs such as *fin*, *foam* and *nanoparticles* for improving the thermal performance of the PCM-based heat sinks. According to the literature, few studies have been conducted on PCM-based heat sink under intermittent conditions. In addition, there is a lack of numerical works on hybrid heat sinks that showed great thermal cooling than conventional heat sinks. Furthermore, it seems that the interesting heat transfer capabilities of nanoparticles systems, as passive solutions for electronic thermal management are preferable. Because of their high thermal conductivity, high heat storage and with light weight than *fin* and *foam* as TCEs techniques. Other conclusions and future perspectives are introduced.

1. Introduction

In recent years, the rate of progress in the requirements for electronic devices in various applications such as aerospace, transport and communications are increasingly high due to the rapid growth of society's demand. With the development of integrated circuits technologies that still follow the classical Moore's law, there is a continuous increase of the power density and the miniaturization of electronic components from micro to nanometre increasing circuit speeds and high performance. According to Taiwan Semiconductor Manufacturing company, electronic chips of 3 nm were putting into production in 2021, and chips of 2 nm factory is being built [1]. In addition, the number of electronic components (transistors) that can be embedded on the integrated circuit continues to grow according to Moore's law [1]. For example, the number of transistors mounted in Corei7 was >731 million transistors on a surface of 270 mm², which increased its thermal power rating to

140 W [2]. That makes their peak temperature higher, shortens its life and reduces their performance. However, the electronic component (transistors) working reliability and its operating temperature are closely related and depends exponentially. As estimated by Black's correlation [3], the median time to failure (MTF), in hours is calculated as follows:

$$MTF = \frac{1}{A_p} \exp\left(\frac{E_a}{R_a T}\right) \quad (1)$$

Eq. (1) demonstrated that a slight increase in working temperature could significantly increase the device failure rate. Experimental observations revealed that the electronic components operating, under high-temperature situations can result in failure. At any temperature compared to that of 75 °C, the failure factor increases exponentially with rising the device operating temperature [3], as illustrated in Fig. 1.

Besides failure, a high temperature rise of electronic components will creates inevitable challenges in the thermal management area and

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Recent Advances In Heat Mass Transfer

James P. Harnett



Recent Advances In Heat Mass Transfer:

Recent Advances in Analysis of Heat Transfer for Fin Type Surfaces Bengt Sundén, P. J. Heggs, 2000 Description del editor This volume is concerned with the heat transfer from extended surfaces such as fins attached to a primary transfer surface These are used extensively within heat exchangers and on heat transfer equipment to ensure that a specified rate of heat transfer is achieved between a heat source and sink All of the chapters come from invited contributors and follow a unified outline and presentation Contents Overview of Extended Surface Heat Transfer Fins Coupled Forced Convection Conduction and Thermal Radiation of a Rectangular Fin in a Confined Space Mechanistic Investigation of the Performance of a Triangular Fin Conjugate Free and Mixed Convection Heat Transfer from a Vertical Fin Embedded in a Porous Medium About Fin Performance and Optimization Two Dimensional Effects in Extended Surface Assessment Steady State Heat Transfer and Performance Assessment Multi Louvred Fin Surfaces Methodology for the Design of Multi Stream Plate Fin Heat Exchangers Incorporation of a Consideration of Operability into the Design of Multi Stream Heat Exchangers WIT Press *Recent Advances in Heat and Mass Transfer* James P. Harnett, 1961 *Recent Advances in Heat Pipes* Wael I.A. Aly, 2019-09-18 Heat pipes are considered as an effective thermal solution particularly in high heat flux applications and in situations where there is a combination of nonuniform heat loading limited airflow over the heat generating components and space or weight constraints This book is intended to explore some of the recent advances in heat pipes and their applications in thermal systems The first chapter is an introductory chapter about the recent advances in heat pipes in general The second chapter is about thermosyphon heat pipe technology working principles advantages and disadvantages application ranges and using computational fluid dynamics in modeling thermosyphons The third chapter is about recent research into loop heat pipes LHPs The last chapter presents a novel liquid vapor separator incorporated gravitational LHP *Recent Advances in Heat and Mass Transfer*, 1961 **Recent Advances in Liquid-Liquid Extraction** C. Hanson, 2013-10-22 Recent Advances in Liquid liquid Extraction focuses on the applications of liquid extraction The selection first discusses solvent extraction Concerns include organic and inorganic separations mass transfer process solvent extraction economics and coalescence in liquid liquid systems The book focuses on the chemistry of solvent extraction Extraction by acidic organophosphorus compounds extraction by phosphorus bonded oxygen donor solvents extraction by high molecular weight amines and synergistic extraction are elaborated The book also focuses on industrial organic processes industrial contacting equipment response characteristics and control of extraction processes and calculation of contactors with longitudinal mixing The selection presents the study of longitudinal mixing in liquid liquid contactors Rotating disc contactors packed columns vibrating plate extractors and Oldshue Rushton columns are described The text also discusses heat transfer by direct liquid liquid contact and the coalescence of liquid droplets and liquid dispersion The selection is a vital source of data for readers interested in liquid extraction **Recent Advances in Thermal Engineering** C. V. Chandrashekhara, N. Rajesh

Mathivanan,K. Hariharan,K. H. Jyothiprakash,2024-07-12 This book presents the select proceedings of 21st ISME conference on Advances in Mechanical Engineering It covers the latest research and technological advancements in the area of thermal engineering Various topics covered in this book are multi phase flow alternative fuels fluid mechanics combustion and IC engines fluid machinery heat and mass transfer refrigeration and air conditioning renewable sources of energy thermal systems simulation heat exchangers flow measurements etc The book is useful for researchers and professionals working in thermal engineering and allied fields Recent Advances in Heat Transfer and Micro-structure Modelling for Metal Processing Remn-Min Guo,James J. M. Too,1995 A balance of contributors from the metal industry and academia share theoretical and practical information relevant to meeting the need for conserving energy and resources and the increasing high quality and cost effectiveness demanded by world market competition by applying newly developed modelin *Recent Advances in Fluid Dynamics* Jyotirmay Banerjee,Rupesh D. Shah,Ramesh K. Agarwal,Sushanta Mitra,2022-09-24 This book presents select proceedings of the International Conference on Advances in Fluid Flow and Thermal Sciences ICAFFTS 2021 and summarizes the modern research practices in fluid dynamics and fluid power The content of the book involves advanced topics on turbulence droplet deposition oscillating flows wave breaking spray structure and its atomization and flow patterns in mini and micro channels Technological concerns relevant to erosion of steam turbine blade due to droplets influence of baffle cut and baffle pitch on flow regime bubble formation and propagation in pool boiling design optimization of flow regulating valves are included in the book In addition recent trends in small scale hydropower plant and flow stability issues in nanofluids solar water heating systems and closed loop pulsating heat pipes are discussed Special topics on airflow pattern in railway coach and vortex tube are also included This book will be a reliable reference for academicians researchers and professionals working in the areas of fluid dynamics and fluid power *Recent Advances in Mechanical Engineering* Anoop Kumar Shukla,Bhupendra Prakash Sharma,Ahmad Arabkoohsar,Pradeep Kumar,2023-06-18 This volume comprises the select proceedings of the 3rd Biennial International Conference on Future Learning Aspects of Mechanical Engineering FLAME 2022 It aims to provide a comprehensive and broad spectrum picture of the state of the art research and development in thermal fluids energy and process engineering mechatronics control and robotics material science and engineering solid mechanics and structural engineering dynamics and control engineering design manufacturing and industrial engineering automobile engineering This volume will prove a valuable resource for researchers and professionals in mechanical engineering and allied fields **Recent Advances in Mechanical Engineering, Volume 1** Gujjala Raghavendra,B. B. V. L. Deepak,Manoj Gupta,2024-04-01 This book presents select proceedings of International Conference on Mechanical Engineering Researches and Evolutionary Challenges ICMEch REC 23 It covers the latest research in the areas of mechanical engineering and materials applications Various topics covered in this book are materials composite nano advanced design methodologies Industry 4.0 smart manufacturing thermodynamics mechatronics robotics soft computing and automation The

contents of this book are useful to the researchers and professionals working in the different areas of mechanical engineering *Recent Advances in Finite-time Thermodynamics* Chih Wu,1999 Finite time thermodynamics FTT is one of the newest and most challenging areas in thermodynamics The objective of this book is to provide results from research which continues at an impressive rate The authors make a concentrated effort to reach out and encourage academic and industrial participation in this book and to select papers that are relevant to current problems and practice The numerous contributions from the international community are indicative of the continuing global interest in finite time thermodynamics All represent the newest developments in their respective areas *Recent Advances in Mechanical Engineering* Premananda Pradhan,Binayak Pattanayak,Harish Chandra Das,Pinakeswar Mahanta,2022-06-03 This book presents select proceedings of the International Conference on Recent Advances in Mechanical Engineering Research and Development ICRAMERD 21 It covers the latest research trends in various branches of mechanical engineering The topics covered include materials engineering industrial system engineering manufacturing systems engineering automotive engineering thermal systems smart composite materials manufacturing processes industrial automation and energy system The book will be a valuable reference for beginners researchers engineers and industry professionals working in the various fields of mechanical engineering **Recent Advances in Material, Manufacturing, and Machine Learning** Rajiv Gupta,Devendra Deshmukh,Awanikumar P. Patil,Naveen Kumar Shrivastava,Jayant Giri,R.B. Chadge,2023-05-26 The role of manufacturing in a country s economy and societal development has long been established through their wealth generating capabilities To enhance and widen our knowledge of materials and to increase innovation and responsiveness to ever increasing international needs more in depth studies of functionally graded materials tailor made materials recent advancements in manufacturing processes and new design philosophies are needed at present The objective of this volume is to bring together experts from academic institutions industries and research organizations and professional engineers for sharing of knowledge expertise and experience in the emerging trends related to design advanced materials processing and characterization and advanced manufacturing processes **Recent Advances in Mechanical Engineering** Harish Kumar,Prashant K. Jain,2020-01-24 This book presents the selected peer reviewed papers from the National Conference on Advances in Mechanical Engineering NCAME 2019 held at the National Institute of Technology Delhi India The book covers different areas of mechanical engineering from design engineering to manufacturing engineering A wide range of topics are discussed such as CAD CAM additive manufacturing fluid dynamics materials science and engineering simulation and modeling finite element analysis applied mechanics to name a few The contents provide an overview of the state of the art in mechanical engineering research in the country Given the scope of the topics covered the book will be of interest for students researchers and professionals working in mechanical engineering **Recent Advances in Applied Mathematics and Applications to the Dynamics of Fluid Flows** Suripeddi Srinivas,Badeti Satyanarayana,J. Prakash,2022-10-15 This

book presents select proceedings of the 5th International Conference on Applications of Fluid Dynamics ICAFD 2020 organized by the School of Mechanical Engineering Science VIT AP University India in association with the University of Johannesburg Auckland Park Kingsway Campus South Africa It identifies the existing challenges in the area of applied mathematics and mechanics of solids and fluids and emphasizes the importance of establishing new methods and algorithms to address these challenges The topics covered include diverse applications of fluid dynamics in aerospace dynamics and propulsion atmospheric sciences compressible flow environmental fluid dynamics control structures viscoelasticity and mechanics of composites Given the contents the book will be a useful resource for researchers as well as practitioners working in the area of mechanical engineering and applied mathematics

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Recent Advances in Mechanical Engineering Gaurav Manik, Susheel Kalia, Om Prakash Verma, Tarun K. Sharma, 2022-09-08 This book presents the select proceedings of 2nd International Congress on Advances in Mechanical and Systems Engineering CAMSE 2021 It focuses on the recent advances in mechanical and systems engineering and their growing demands for increase in several design and development activities The contents in this book cover a blend of mechanical engineering computer aided engineering control engineering and systems engineering to design and manufacture useful products Various additional topics covered include mechanics machines materials science thermo fluids and control with state of the art computational methods to analyse innovate design implement and operate complex systems which are economic reliable efficient and sustainable Given the contents this book will be useful for researchers and professionals working in the field of mechanical engineering and allied fields

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Sankaranarayanan, 2021-10-11 This book comprises the proceedings of the 1st International Conference on Future Technologies in Manufacturing Automation Design and Energy 2020 The contents of this volume focus on recent technological advances in the field of manufacturing automation design and energy Some of the topics covered include additive manufacturing renewable energy resources design automation process automation and monitoring etc This volume will prove a valuable resource for those in academia and industry

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Mechanics, Vol II D. K. Maiti, P. Jana, C. S. Mistry, R. Ghoshal, M. S. Afzal, P. K. Patra, D. Maity, 2022-02-26 This book Vol II presents select proceedings of the first Online International Conference on Recent Advances in Computational and Experimental Mechanics ICRACEM 2020 and focuses on theoretical computational and experimental aspects of solid and fluid mechanics Various topics covered are computational modelling of extreme events mechanical modelling of robots mechanics and design of cellular materials mechanics of soft materials mechanics of thin film and multi layer structures meshfree and particle based formulations in continuum mechanics multi scale computations in solid mechanics and materials multiscale mechanics of brittle and ductile materials topology and shape optimization techniques acoustics including aero acoustics and wave propagation aerodynamics dynamics and control in micro nano engineering dynamic instability and buckling flow induced noise and vibration inverse problems in mechanics and system identification measurement and analysis techniques in nonlinear dynamic systems multibody dynamical systems and applications nonlinear dynamics and control stochastic mechanics structural dynamics and earthquake engineering structural health monitoring and damage assessment turbomachinery noise vibrations of continuous systems characterization of advanced materials damage identification and non destructive evaluation experimental fire mechanics and damage experimental fluid mechanics experimental solid mechanics measurement in extreme environments modal testing and dynamics experimental hydraulics mechanism of scour under steady and unsteady flows vibration measurement and control bio inspired materials constitutive modelling of materials fracture mechanics mechanics of adhesion tribology and wear mechanics of composite materials mechanics of multifunctional materials multiscale modelling of materials phase transformations in materials plasticity and creep in materials fluid mechanics computational fluid dynamics fluid structure interaction free surface moving boundary and pipe flow hydrodynamics multiphase flows propulsion internal flow physics turbulence modelling wave mechanics flow through porous media shock boundary layer interactions sediment transport wave structure interaction reduced order models turbo machinery experimental hydraulics mechanism of scour under steady and unsteady flows applications of machine learning and artificial intelligence in mechanics transport phenomena and soft computing tools in fluid mechanics The contents of these two volumes Volumes I and II discusses various attributes of modern age mechanics in various disciplines such as aerospace civil mechanical ocean engineering and naval architecture The book will be a valuable reference for beginners researchers and professionals interested in solid and fluid mechanics and allied fields *Challenges and Recent Advances in Sustainable Oil and Gas Recovery and Transportation* Sanket Joshi, Prashant Jadhawar, Asheesh Kumar, 2023-03-10 Challenges and Recent Advances in Sustainable Oil and Gas Recovery and Transportation delivers a critical tool for today's petroleum and reservoir engineers to learn the latest research in EOR and solutions toward more SDG supported practices Packed with methods and case studies the reference starts with the latest advances such as EOR with polymers and EOR with CCS Advances in shale recovery and methane production are also covered before layering on

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