



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

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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

Wael I.A. Aly



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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

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