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Review on fabrication and experimental study of microchannel heat sinks for cooling of electronic components ☆

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Abstract

Microchannels are widely used in electronic components for higher heat dissipation rate and for providing optimum performance and durability for electronic devices. In this paper, various aspects of microchannel including its fabrication and experimental study are being reviewed. fabrication of microchannels can be done using machining techniques like micro-milling, electric discharge machining, laser beam machining, lithography, injection molding, dry and wet etching. Experimental comparison of fluid flow and heat transfer characteristics in manufactured microchannel heat sinks utilising laminar water flow as a coolant in common applications. Also, coolants like hybrid and non-hybrid nanofluids, ethylene glycol, phase changing material, graphene, etc. are used to enhance the thermal conductivity and heat dissipation rate in microchannel heat sinks. Experimental studies on various output parameters like surface roughness, tool wear rate, and material removal rate are examined. Complex structured microchannel heat sinks are also considered. The variations in process parameters with respect to material removal rate and surface roughness can be found using an experimental study. Also, optimization of various process parameters along with material removal rate and surface quality can be performed using numerical analysis. Heat dissipation performance based on the geometry of the microchannel heat sink is explored. These aspects determine the pressure drop characteristics as well as fluid flow and heat transfer capability of a microchannel heat sink. It is inferred that fabrication, experimental and numerical factors have a remarkable influence on the fluid flow and heat dissipation performance of the microchannel heat sink.

Introduction

Microchannel heat sinks have a higher heat transfer rate compared with conventional heat sinks due to their ratio of large surface area to volume. Microchannels are fabricated using silicon, aluminium, copper along with polymers and ceramics. The width and depth of the microchannel heat sink ranges from 124μm to 175μm and 70μm to 80μm. The width and depth of microchannel heat sink with HAZ ranges from 187μm to 232μm and 130μm and 180μm. Cooling in a microchannel heat sink is obtained by using a heat sink substrate having high thermal conductivity and containing a large number of channels that are parallel and have a small diameter along its cross-section.

Microchannel heat sinks are normally compact and lightweight thus helping the coolant to absorb heat and undergo phase change along the length of the microchannel heat sink. Usually, heat dissipation in microchannel heat sink is undergone using forced air-convection cooling. Various coolants used for heat transfer in microchannel heat sink include water, Ethylene glycol, Phase changing material (PCM), nanofluids containing nanoparticles like Al_2O_3, graphene and also hybrid nanofluids like graphene nanofluid with Iron oxide etc. The maximum Thermal Design Power (TDP) of current processors is up to 225W with a heat dissipation rate of 140W/cm^2. In the future by 2026, it is forecasted to be 800W and heat dissipation rate is predicted up to 400W/cm^2. There is a growing demand for effective cooling technologies due to fast advances in power density and the downsizing of electronic products. In order to achieve efficient thermal management of electronic devices, effective cooling techniques should be developed such as microchannel heat sinks to maintain the optimum performance and long life of electronic devices.

Microchannel fabrication has always been a difficult task utilising traditional manufacturing methods. Nowadays microchannels are fabricated using EDM, Wire-EDM, micro milling, dry and wet etching, lithography, laser beam machining, additive manufacturing, and Injection moulding. Variations in parameters for microchannels with the same cross-section might occur when they are created using different manufacturing procedures. When comparing actual specimens to theoretical specimens, certain surface irregularities are always present, and this results in a difference in dimension. The fluid flow and heat transfer properties of the microchannel heat sink may be significantly affected by cross-section irregularities. The precision and surface smoothness of the microchannel are significantly affected by changes in process parameters (See Table 1).

Section snippets

Fabrication of microchannel using Wire-EDM

Microchannels fabricated using electrical discharge machining have high aspect ratio on metals without forming any burrs on them. It can't be used with polymers directly. Micro electrical discharge machining produces a substantially smoother surface than micro end milling (35–55 nm Ra). The input process parameters for electrical discharge machining are Current, Pulse on, Pulse off, voltage, spark gap, spark time, tool material, tool dimensions, feed rate, capacitance, discharge energy, tool…

Experimental study of microchannel heat sink

Experimental analysis of fabricated microchannels is performed for predicting the fluid flow and heat transfer parameters for cooling applications in heat sinks. The experiments are performed using an experimental setup that consists of peristaltic pump, thermocouple, hot plate with heater unit, Insulator, and data acquisition unit. Thermocouple with bead size ranging from 0.1 mm to 0.8 mm is used for measuring temperature at various points in the surface of the microchannel. Certain parameters …

Conclusion

Major aspects of the microchannel heat sink which include fabrication study and experimental performance analysis have been reviewed in this paper. Microchannel heat sinks are mainly fabricated using metal, polymers, ceramics, etc. Materials having high thermal conductivity are used for fabricating microchannels. Various fabrication techniques which include EDM, LBM, micro milling, etching, etc. are reviewed. Certain fabrication techniques resulted in major surface irregularities and difficulty …

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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References (23)

A. Mogra *et al.*
Fabrication of square microchannel for experimental investigation of two phase flow using conventional machining process
Perspect. Sci. (2016)

P. Sreeraj *et al.*
Surface roughness analysis of micro channels produced by wire-electrical discharge machining
Mater. Today: Proc. (2021)

M.K. Mohammed *et al.*
Optimization of Nd:YAG laser for microchannels fabrication in alumina ceramic
J. Manuf. Processes (2019)

X. Zhang *et al.*
Experimental study on liquid flow and heat transfer in rough microchannels
Adv. Condens. Matter Phys. (2019)

B. Kim
An experimental study on fully developed laminar flow and heat transfer in rectangular microchannels
Int. J. Heat Fluid Flow (December 2016)

J.-C. Chu *et al.*

Experimental and numerical study on the flow characteristics in curved rectangular microchannels
Appl. Therm. Eng. (2010)

M. Kalteh *et al.*
Experimental and numerical investigation of nanofluid forced convection inside a wide microchannel heat sink
Appl. Therm. Eng. (2012)

Naveed Ahmed, Mohammad Pervez Mughal, Waqar Shoaib, Syed Farhan Raza, and Abdulrhman M. Alahmari, WEDM of Copper for...

M. Saleh *et al.*
Milling microchannels in Monel 400 alloy by wire EDM: an experimental analysis
Micromachines (2020)

Ramendra Singh Niranjan, Onkar Singh, J. Ramkumar, Optimization of Process parameters for Laser Fiber micromachining of...

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Cited by (2)

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