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Application of nanofluids to a heat pipe liquid-block and the thermoelectric cooling of electronic equipment

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ABSTRACT

Microprocessor power dissipation is constantly increasing. An increase in microprocessor size has also resulted in higher heat fluxes. The growth of information technology has rapidly increased over the past few years, causing an increase in the demand for a microprocessor that has a very high computing ability. The previous generation of central processing units (CPU) had 1.17 billion transistors planted in it, which indicates that a significant amount of heat was generated. The total heat dissipation resulting from a high end CPU is approximately 110–140 W, which will increase if the CPU voltage and frequency increase. Conventional air-cooled cooling systems are no longer adequate to remove these heat fluxes. For a number of applications, direct air-cooling systems will have to be replaced or enhanced by other high performance compact cooling techniques. In this study, the application of nanofluids as the working fluid on a heat pipe liquid-block combined with thermoelectric cooling is investigated. The type and effect of volume concentrations of nanofluids, coolant temperature, and thermoelectricsystem as heat pumps of a PC on the CPU's temperature are considered. The results obtained from this technique are compared to those from other conventional cooling techniques. The heat pipe liquid-block combined with the thermoelectric system has a significant effect on heat transfer from the CPU. The higher thermal performance heat pipe liquid-block and thermoelectric cooled system with nanofluids proved its potential as a working fluid.

1. Introduction

In recent years, a significant increase in microprocessor power dissipation coupled with CPU size has resulted in an increase in heat fluxes. Microprocessor heat fluxes have also increased and are expected to exceed 100 W/cm^2 for many commercial applications. Therefore, thermal management is becoming one of most challenging issues and an important subject in regard to cooling system performance.

Conventional air-cooled cooling systems are no longer adequate to remove the aforementioned heat fluxes. For a number of applications, direct air-cooling systems will have to be replaced or enhanced by other high performance compact cooling techniques. Liquid–vapor phase change, impinging jets, spray, direct and indirect liquid cooling, the use of thermoelectric modules and heat pipes are attractive cooling solutions for removing high heat fluxes because of their high heat transfer coefficients. Several studies have been conducted in these areas by many researchers.

Two-phase heat transfer, involving evaporation of a working fluid in a hot area and condensation of vapor in a cold area, can achieve much higher heat fluxes than through conventional forced air-cooling. This explains why considerable research has been redirected towards these approaches for the thermal management of electronics. In direct liquid cooling, electronics are either immersed in a pool or in contact with droplets, jets [1] or sprays of a dielectric liquid [2].

Among cooling techniques for electronic devices, the use of thermoelectric coolers (TECs) combined with air-cooling or liquid cooling approaches, is getting a significant amount of attention [3–7]. The thermoelectric module is a unique solid state heat pump because its direction of heat-pumping is fully reversible. When a DC current flows through thermoelectric couples, one of the surfaces will be cooled whilst the other is heated, depending on the polarity of the current. The amount of heat that can be removed by the hot side depends on the cooling load and the electrical power input as well as the efficiency of thermoelectric module. A thermoelectric cooling system normally consists of three basic components: the thermoelectric module, the heat sink at the hot side of the module and the cold sink component at the cold side of the module. Any thermoelectric module has a maximum temperature difference between the hot side and the cold side, depending on number of junctions and stages of the thermoelectric module. To have an optimal temperature difference, which is the

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