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Application of nanofluids in computer cooling systems (heat transfer performance of nanofluids)

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ABSTRACT

Nanofluids are stable suspensions of nano fibers and particles in fluids. Recent investigations show that thermal behavior of these fluids, such as improved thermal conductivity and convection coefficients are superior to those of pure fluid or fluid suspension containing larger size particles. The use of enhanced thermal properties of nanofluids for the cooling of computer microchips is the main aim of this research. Base fluid used, was various compositions of a mixture of deionized water and ethylene glycol. Three nanoparticles of silica, alumina and titania were used, each with three different volumetric concentrations in the base fluid. The effect of the flow rate of nanofluid in the cooling process has also been investigated. Results show enhanced heat transfer in the cooling of the microchip as indicated in the considerable reduction of the operating temperature of processor when using the nanofluid as compared to application of pure fluid. As expected it was observed that an increase in the flow rate of the nanofluid resulted in decrease in the processor temperature. The largest decrease observed was for alumina nanofluid, which decreased processor temperature from 49.4 to 43.9 °C for 1.0% of volumetric concentration and flow rate of 1.0 L per minute when compared with the pure base fluid with the same flow rate. Results suggest that there should be a balance between volumetric concentration of nanoparticles and the flow rate to satisfy the economy and power consumption of cooling the system.

1. Introduction

In electronic industry, improvement of the thermal performance of cooling systems together with the reduction of their required surface area has always been a great technical challenge. Research carried out on this subject can be classified into three general approaches; finding the best geometry for cooling devices, decreasing the characteristic length and recently increasing the thermal performance of the coolant. The latest approach is based on the discovery of nanofluids. Nanofluids are liquid–solid suspensions in which particles with the size of 1–100 nm are suspended in a heat transfer fluid. Nanofluids are expected to have a better thermal performance than conventional heat transfer fluids due to the high thermal conductivity of suspended nanoparticles. In recent years there have been several investigations showing enhancement of thermal conductivity of nanofluids. Eastman et al. [1] investigated the thermal conductivity of nanofluid of 0.3% volume fraction of copper nanoparticles in ethylene glycol. Using the hot-wire method; they observed over 40% enhancement of thermal conductivity in comparison with pure base fluid. They also found that decreasing the size of nanoparticles had an important role in the improvement of thermal conductivity. Steady-state parallel-plate method was used by Wang et al. [2] to measure the effective thermal conductivity of Al_2O_3 and CuO nanoparticles in water and ethylene glycol. The average size of particles was 28 and 23 nm, respectively. They also reported an increase in thermal conductivity of nanofluids compared to the pure base fluids. The reasons for these unusual growths in thermal conductivity of nanofluids have been investigated by Keblinski et al. [3] and Eastman et al. [4]. In their works, Brownian motion of nanoparticles, molecular-level layering of base fluid at the interface, the effect of heat transfer in nanoparticles and the influence of particle clustering were introduced as possible mechanisms for the increase of thermal conductivity. Investigating on stationary nanofluids, they realized that the effect of Brownian motion could be neglected compared to the greater effect of thermal diffusion. Wang et al. [2] suggested that thermal conductivity of nanofluids is a function of particle structure and microscopic motion in which microscopic motion consists of Brownian motion and inter-particle forces.

For heat transfer applications of flowing fluids, convective heat transfer coefficient is a better indicative parameter than the thermal conductivity. For force convective heat transfer, Lee and Choi [5]

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