Faculty of Electrical Engineering & Computer Science
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Development of Horizontal Closed Loop Pulsating Heat Pipe for Thermal Management of Active Pixel Sensor.

ABSTRACT - Masterthesis

Because of rapid advances in semiconductor manufacturing technology, the computing speed of electronic chips is increasing, their size is decreasing, and more transistors can be integrated in their design. Therefore, to dissipate the extremely high power density generated by current chips, effective thermal management is an urgent task that must be addressed for the further development of electronic devices. Heat pipes have been widely applied in the electronic cooling field because they are capable of passively transferring a large amount of heat with a small temperature difference from one point to another. The Closed-Loop Pulsating Heat-Pipe (CLPHP) device has high spreading performance and is capable of removing higher heat fluxes. These apparently simple looking devices are extremely intriguing for theoretical and experimental investigations alike. It is rare to find a combination of such events and mechanisms, like bubble nucleation/collapse and agglomeration, bubble pumping action, pressure/temperature perturbations, flow regime changes, dynamic instabilities, metastable non-equilibrium conditions, flooding/bridging etc., all together contributing towards the thermal performance of the device. CLPHPs have superior performance compared to the traditional heat pipes and will be helpful to solve the present and future electronic cooling problems.

In this study two non-uniform CLPHP is designed and built in conventional metals for the thermal management of active pixel sensors. The non-uniform CLPHP consists of 22 parallel channels (11 turns each in the evaporator section and condenser section) with cross-sections 2 mm x 2 mm (11 channels), and 1 mm x 2 mm (11 channels) are machined directly on the aluminum plate of dimension 124 mm x 73 mm x 4 mm. In order to enhance the performance of the above design more than its optimum heat transfer rate a second model was built with aluminum (Evaporator section and condensation section) and PEEK (Adiabatic section) the working fluids employed are acetone and ethanol. Various tests were performed to find the optimal filling ratio and evaporator length for the effective heat transfer performance and also to prove this HCLPHP can operate in all inclination angles due to the unbalanced capillary force created by the non-uniform channels.