REVIEW OF RECENT APPLICATIONS OF MICRO CHANNEL IN MEMS DEVICES

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Abstract
With the rapid growth of the miniaturizations of electronic device, the heat dissipation from these miniaturized electronic devices becomes the major challenge in current scenario. If this heat dissipation is not done effectively, than this will affect the life of device and other electronic devices adversely which will results in decrease efficiency. Micro-channel is the one of the best option for removing heat from the electronic devices, due to its compact size and higher thermal efficiency. Numerous researchers have been investigated behavior of micro-channel heat transfer rate, fluid flow visualizations in the micro-channel and their application by theoretically in nature as well as experimentally. This paper deals with the review of rigorous behavior of micro-channel heat transfer rate, fluid flow visualizations in the micro-channel and their application in industries.

Keywords: Micro-channel, Heat Dissipation, Electronic Device, fluid flow visualizations.

Introduction
Some experimental and theoretical work on flow boiling heat transfer in microchannel had done in the last decades. Both academic and the industrial people have taken interest in this area. The review of following research has been completed on flow boiling heat transfer in microchannel. The literature review has arranged according to similarity to the work done in this thesis. In this literature review emphasis is directed on:

- Numerical study of fluid flow and heat transfer in micro-channels
- Study of Fabrication of the micro-channel.
- Experimental study of fluid flow and heat transfer in micro-channels.

With the development of micro fabrication technology, micro-fluidic systems have been increasingly used in different scientific disciplines such as biotechnology, physical and chemical sciences, electronic technologies, sensing technologies etc. Microchannels are one of the essential geometry for micro-fluidic systems; therefore, the importances of convective transport phenomena in microchannels and microchannel structures have increased drastically. In recent years, a number of researchers have reported the heat transfer and pressure drop data for laminar and turbulent liquid or gas flow in microchannels.

Flow boiling heat transfer in microchannels is now the most popular topic in heat transfer, as the need has arisen for very high heat flux cooling for the new generation of computer chips. Understandings of macroscopic flow and
heat transfer have reached a mature stage, but when it comes to microchannel flow, flow becomes notably different and complex. The universal use of MEMS devices, micro-heat exchangers, micro-fluidics, other biomedical applications like micro drug delivery, have opened a new field for research. This paper deals with the review of rigorous behavior of micro-channel heat transfer rate, fluid flow visualizations in the micro-channel and their application in industries.

**Figure 1: Schematic diagram of micro-channel**

**Characteristic of micro-channel**

Tuckerman et. al. [1] investigated the problem of achieving compact and he had also done some work on high-performance forced liquid cooling of planar integrated circuits. It was found that the use of high-aspect ratio channels for increasing the surface area will further reduce thermal resistance. A new, very compact, water-cooled integral heat sink for silicon integrated circuits has been designed and tested based on these considerations. At a power density of 790 W/cm², a maximum substrate temperature rise of 71°C above the input water temperature had measured, in good agreement with theory. By allowing such high power densities, the heat sink may greatly enhance the feasibility of ultrahigh-speed VLSI circuits.

Kandlikar et. al. [2] studied the effects of the channel size on the flow patterns, and heat transfer and pressure drop performance in micro-channel and mini-channel. Three types of flow where observed namely plug, slug and annular flow. They said that the role of surface tension was very important which caused the formation of uniformly spaced slugs and sometimes liquid rings.

Thome, John R. et. al. [3] studied flow boiling heat transfer results for micro-channels, macroscale versus microscale heat transfer, heat transfer mechanisms in micro-channels and flow boiling models for micro-channels, two-phase flow regimes. It concluded that evaporation is controlled by nucleate boiling in micro channel. In a new elongated bubble flow heat transfer model, Jacobi and Thome (2002) have shown that transient evaporation of the thin liquid films surrounding elongated bubbles is the dominant heat transfer mechanism.

**Hassan et. al.** [4] advised that effect of coolant types should be investigated more in detail. Because of low thermal resistance liquids show better cooling properties as compared to gases. Surface roughness within the micro channel appears to have a major effect on flow behaviour at the micro-scale. Flow transition from laminar flow to turbulent flow at the microscopic level must be analysed in greater details so that one may accurately envisage at which value of Reynolds number this transition take place for all wall roughnesses.

**Morgan et. al.** [5] provides a summary of several approaches to micro-machining by mechanical and electro-discharge means of material removal. The study indicates the potential of mechanical and electro-discharge micro-machining by showing how tools made-up with the Wire Electro-Discharge Grinding process are used to micro-machine conductive and non-conductive materials.

**Ashman et. al.** [6] studied various types of manufacturing processes currently being used in the fabrication of micro heat exchangers and main focus was on passages with hydraulic diameter of less than 200 micrometers. LIGA, Chemical Etching, Stereo lithography, and micro-machining were reviewed. A comparison of different techniques related to tolerances, material compatibility, and ease of manufacturing is given.

**Mohammad Yeakub Ali et. al.** [7] used micro Electric Discharge (ED) Machining for manufacturing of micro-channel and found capacitance and voltage major influencing parameters. Feed rate, capacitance and voltage greatly affect the MRR. In their studies they found that by combining micro ED milling and molding mass replication of miniaturized functional components can be done at a lower cost.

**Harvinder lal et. al.** [8] studied and compared three type of micro machining processes namely wire-cut EDM, micro-slotting and micro-milling. The surface finish of fabricated microchannel in case of wire-cut EDM was observed to be of better-quality as compared to micro end mill cutter, followed by those from slotting saw and the time taken to finish the job using wire-cut EDM was highest. The slotting takes least time to finish the job. The micro machining operation using end mill cutter has intermediate surface finish but at lesser time. The cost of operating the wire-cut EDM was highest, followed...
by end mill cutter and slotting saw.

Sobierska, Ewelina et. al. [9] presented experimental results on flow boiling in a vertical rectangular channel including pressure drop, heat transfer and flow patterns. Comparisons with existing correlations for pressure drop and heat transfer coefficient are carried out and boundaries between flow patterns are determined. Increase in the heat transfer coefficient for two phase flow with increasing heat flux was seen, and decreases with increasing thermodynamic vapour quality. By means of flow visualization three basic vapour flow patterns are distinguished: bubbly, slug and annular flow.

Yu-Tang Chen et. al. [10] studied the characteristics on both fluid flow and heat transfer of methanol in the (100) silicon micro channel heat sink experimentally. In micro channels they used methanol as working fluid in the hydraulic diameter of 57–267 μm for inspecting the friction characters of the fluid flow, the mechanism of bubble nucleation, and the heat convection capabilities in the phase change as well as in a single-phase flow. On the aspect of fluid characteristics, the friction factor with respect to the Reynolds number was investigated experimentally in this paper. It is shown that the effects of the friction and viscosity coefficient for the fluid in the micro-channels are much significant than the macros.

Kandlikar et. al. [11] developed a simple correlation to envisage saturated flow boiling heat transfer coefficients inside horizontal and vertical tubes. A total 24 experimental examinations were performed on saturated flow boiling inside vertical and horizontal tubes. From these data sets a correlation is developed using an additive model and a fluid-dependent parameter, and continuous variation of heat transfer coefficient along an evaporator tube was obtained.

Zhizhao Che et. al. [12] the heat transfer of plugs moving in microchannels subjected to a constant surface-temperature boundary condition is examined systematically. By incorporating the analytical flow field, the heat transfer process in plugs moving in 2D microchannels are simulated. The effects of the Peclet number and the plug length are studied. The heat transfer process is evaluated through the Nusselt number, the heat transfer index, and the maximum fluid temperature. From this study, we can conclude that At a
high Peclet number, the Nusselt number experience oscillation when the heated/fresh fluid in the central region of the plug is being transported to the heated wall by the recirculating flow. As the Peclet number decreases, the oscillation of Nusselt number becomes insignificant. A high Peclet number results in a higher Nusselt number and a lower heat transfer index. Short plugs are favourable for heat transfer in microchannels as compared to long plugs. In the constant-surface-temperature condition, shorter plugs can achieve higher heat transfer indices due to the higher transverse velocity.

Sarangi, R. K, et. al. [17] studied two-phase forced convection modelling on microchannels, in which they used water as fluid medium. The study includes the effects of fluid flow rate, power input and channel geometry on the flow resistance and heat transfer from these micro-channels. Two numerical models were developed assuming homogeneous and annular flow boiling. The effects of non-uniform heat input along the flow direction had been studied. The model predictions were compared with two separate experimental data sets. The models were also shown to be capable of handling non-uniform heat flux in the axial direction.

Conclusions

The rapid growth of high density power electronic, with the increased miniaturisation of microelectronic devices and processing speed, thermal issues are more and more affecting overall electronic packaging and system capabilities. The following observation found from the review.

- Increasing in power input location of boiling front decreases
- Increasing in power input pressure drop increases linearly.
- Variation of pressure along length first decrease with minimal rate in single phase and after reaching in two phase zone pressure is drastically decreases

Effects of process parameters namely power, velocity, spot size diameter, pulse frequency and traverse speed have been studied on channel dimension and surface finish. It can be concluded that both increased power and reduced velocity results in enhanced concentration of laser but thermal effects would be more pronounced in case of increase in power. Based on the study, through designed process parameters, a smooth micro-channel was cut to visualize the flow of DI water for continuity of flow and flow regime. The last decade work shows that the increases the size of micro-channel, surface tension drag from are reduced.

References


Using Laminar Gas-Liquid Segmented Plug Flows”