



## Convective heat transfer studies in macro and mini channels using digital interferometry

V. Sajith<sup>a,\*</sup>, Divya Haridas<sup>b</sup>, C.B. Sobhan<sup>a</sup>, G.R.C. Reddy<sup>c</sup>

<sup>a</sup>School of Nano Science and Technology & Department of Mechanical Engineering, National Institute of Technology, Calicut, Kerala, India

<sup>b</sup>Department of Physics, National Institute of Technology, Calicut, Kerala, India

<sup>c</sup>School of Nano Science and Technology, National Institute of Technology Calicut, India

### ARTICLE INFO

#### Article history:

Received 3 January 2010

Received in revised form

11 April 2010

Accepted 14 April 2010

Available online 21 May 2010

#### Keywords:

Channels

Interferometry

Heat transfer

### ABSTRACT

Convective heat transfer in micro and mini channels has been recommended as an effective heat removal method for various electronic packages and systems. As the traditional method of temperature measurement in channels using the thermocouple probe disturbs the flow field leading to measurement errors, a non-intrusive measurement technique, such as an optical method is preferable for temperature and heat transfer measurement in mini channels. In the present work, convective heat transfer studies have been performed on water flowing through channels of small cross sections of hydraulic diameter 4 mm and 3 mm, using digital interferometric technique. The channels are fabricated using high quality optical glass and aluminum blocks. Mach–Zehnder Interferometry is used for obtaining the temperature distribution in the channels. The interferograms grabbed using a CCD camera, coupled to a computer and digital image processing technique, has been used for obtaining the temperature distribution from the fringes. The temperature profiles are obtained at different sections of the channels for various values of the average Reynolds number and various heating levels. The local and average heat flux values are obtained from the constructed temperature distributions. Results of parametric studies are compared and contrasted with relevant entry length solutions from the literature.

© 2010 Elsevier Masson SAS. All rights reserved.

### 1. Introduction

High heat fluxes from compact electronic packages are one of the critical barriers in the development of new-generation power electronics. Performance of electronic components is highly dependent on their operating temperatures and therefore effective heat dissipation is very much essential to avoid their failure and to insure consistent performance. Even though there are different methods adopted for the thermal management of electronic components, fluid flow through small dimension channels has proved to be an effective method of heat dissipation [6]. Channels having their smallest dimension between 3 mm and 200  $\mu\text{m}$  are generally classified as mini channels and those with above 3 mm are known as conventional channels or macro channels [1]. Some of the conventional theories valid and generally applied for predicting energy and mass transport need to be reinvestigated as the channel size becomes smaller [2,3]. While inconsistencies in fabrication, and flow mal-distribution in channel arrays have been projected as

possible reasons for observed deviations [4,5], one of the significant differences in small cross section channels is the influence of the surface irregularities which become comparatively more pronounced when the channel dimensions are reduced. The potential applications of mini and micro-channels include compact heat exchangers, micro heat pipes, heat spreaders etc. Even though mini channels may not be as effective as micro-channels as far as effective heat dissipation alone is considered, the heat transfer rates obtained from mini channels are considerably high as compared to conventional cooling methods such as usage of fins, extended surfaces, usage of fans and blowers for forced circulation. The mini-channel option has additional advantages such as relatively lower pressure drops, low fabrication cost and ease of fabrication. Therefore, a careful investigation into the fluid flow and heat transfer processes in mini channels is desirable. Even though a few investigations on boiling and multiphase flow in mini channels have been reported, not much attention has been devoted to single-phase flow in mini channels. A comparison of the Nusselt number correlations proposed in the literature for small cross section channels, with correlations for conventional channels in both the laminar and turbulent regimes, points to the differences between these channels and channels of conventional sizes [2].

\* Corresponding author. Tel.: +91 495 2286525; fax: +91 495 2287250.

E-mail address: [sajith@nitc.ac.in](mailto:sajith@nitc.ac.in) (V. Sajith).