

Computational modeling and simulation of electrohydrodynamic (EHD) ion-drag micropump with planar emitter and micropillar collector electrodes

Shakeel Ahmed Kamboh^{1*}, Jane Labadin^{1*} and Andrew Ragai Henry Rigit^{2*}

1,2 Faculty of Computer Science & Information Technology,

2 Faculty of Engineering Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

E-mail: shakeel.maths@yahoo.com, ljane@fit.unimas.my, arigit@feng.unimas.my

Abstract: Computational models can be used to simulate a prototype of electrohydrodynamic (EHD) ion-drag micropump with planar emitter and micropillar collector electrodes. In this study, a simple and inexpensive design of an ion-drag micropump was modeled and numerically simulated. A three-dimensional segment of the microchannel was simulated by using periodic boundary conditions at the inlet and outlet. The pressure and velocity distribution at the outlet and in the entire domain of the micropump was obtained numerically. The effect of the gap between the emitter and the collector electrode, width and the height of micropillar and flow channel height was analyzed for optimum pressure and output flow rate. The enhanced performance of micropump was compared with existing designs. It was found that the performance of micropump could be improved by decreasing the height of micropillar and the gap between both electrodes. The numerical results also show that a maximum pressure head of about 2350 Pa and maximum mass flow rate 0.4 g min^{-1} at an applied voltage 1000 V is achievable with the proposed design of micropump. These values of pressure and flow rate can meet the cryogenic cooling requirements for some specific electronic devices.

1. Introduction

The prominent features of micropumps inspired their use in a wide variety of applications ranging from biotechnology and chemical analysis to space exploration and cooling of micro electro mechanical systems (MEMS) such as sensors and detectors [1-2]. EHD ion-drag micropump is a non-mechanical type of micropump that uses the electric forces (mainly the Coulomb force) in the liquid bulk. The fluid flow is produced due to the friction between moving ions and the working fluids drag [3-4]. Ion-drag micropumps are preferred for pumping single phase incompressible flows because of their attractive features. These pumps are extensively utilized for the applications of fuel injection loops and cryogenic cooling of microdevices [5]. In the last decade, different designs of ion-drag micropumps have been proposed and developed to enhance the output flow rate and pressure. Unfortunately, with the shrinking size of many electronic products still the high pressure output is required in certain applications. On the other hand, the development of new compatible designs of micropumps becomes more challenging because of microfabrication complexity and instruments cost. In such circumstances, the numerical simulation of micropumps plays important role not only to

* To whom any correspondence should be addressed.