

Microfabrication and Test of a Three-Dimensional Polymer Hydro-focusing Unit for Flow Cytometry Applications

Ren Yang¹, Daniel L. Feedback², and Wanjun Wang¹

Department of Mechanical Engineering

Louisiana State University

Email: wang@lsu.edu

Phone: 225-578-5807

Fax: 225-578-5924

²NASA-Johnson Space Center

Mail Code SK

2101 NASA Parkway

Houston, TX 77058

Abstract

This paper details a novel three-dimensional (3D) hydro-focusing micro cell sorter for micro flow cytometry applications. The unit was microfabricated by means of SU-8 3D lithography. The 3D microstructure for coaxial sheathing was designed, microfabricated, and tested. Three-dimensional hydrofocusing capability was demonstrated with an experiment to sort labeled tanned sheep erythrocytes (red blood cells). This polymer hydro-focusing microstructure is easily microfabricated and integrated with other polymer microfluidic structures.

Keywords: SU-8, three-dimensional hydro-focusing, microfluidic, microchannel, cytometer

1. Introduction

Flow cytometric devices are very important for a wide range of biomedical research and clinical diagnostics. Conventional-sized flow cytometers are not novel and are widely used both in research and for clinical diagnostic purposes. Currently available commercial flow cytometers

tend to be large and very expensive. The analytical sample is injected into the system, diluted, labeled, hydro-focused, and the cells are counted and sized by fluorimetric and electrical means. Figure 1 shows the principle of operation for the hydro-focusing unit of conventional flow cytometers. The cells are labeled and driven to flow through a nozzle so that light scattering or fluorescence measurements can be used for analyses.

In recent years, one of the fast developing fields in science and engineering has been microelectromechanical systems (MEMS) technology. Many research efforts have been made in developing different types of micro-cytometry systems [1-12]. Micro-sized flow cytometry devices and components offer many potential benefits, including the ability to reduce device and sample sizes, development of low cost, single-use disposable devices, and improved device portability for field use along with low consumption of sample and buffer fluids, and reduction in the biohazard risk level.

In microfabricated flow cytometers, micro grooves are etched on a substrate such as silicon or glass. With a glass or polymer cover bonded on the top, micro channels are created to form a chamber with a size that permits cells to pass through a sensing unit for categorization and enumeration [1]. Because it is very difficult to develop a truly microfabricated cytometer, some researchers have tried to avoid the difficulties of complicated microfluidic systems and micro optical systems. Weigl et al. [2-9] have used a simple design based on fluid/fluid extraction and developed a complete passive fluidic device that can be used to separate cells. The principle of hydro-focusing in a microchannel is based on the laminating cells with sheath flow. Their sample focusing system is only focused in the plane of substrate, not in the vertical direction between the top and bottom planes. In the vertical direction, fluid friction may make the cells not well focused. The cells along vertical direction therefore have different flow velocities.

G. Goranovic et al. [14] microfabricated a micro cell sorter with a "chimney" structure in silicon by reactive ion etching (RIE). Three-dimensional flow sheathing was obtained by injecting a sample into the sheath flow in a perpendicular direction. This design is difficult to integrate into other micro fluidic and micro optical measurement systems. Additionally, RIE microfabrication is an expensive approach.