Hybrid Capillary-Flap Valve for Vapor Control in Point-of-Care Microfluidic CD

T. Thio, A.A. Nozari, N. Soin, M.K.B.A. Kahar, S.Z.M. Dawal, K.A. Samra, M. Madou, and F. Ibrahim

Introduction

Microfluidics allows for the miniaturization of a complete laboratory onto a compact disc (CD). Centrifugal microfluidics, or microfluidic CDs, is a unique approach to the field of microfluidics where fluids (reagents/ chemicals/clinical samples) are elegantly manipulated by rotating specialized CDs [1]. At its core, the platform only requires a spinning motor and disposable plastic disc containing a fluidic network (as shown in Figure 1).

Please refer to the full text

Microfluidic CDs rely on the centrifugal force to move fluids, uses smaller volume of reagents, and perform several experiments in parallel, resulting in faster results at lower costs [2]. Various fluidic functions such as mixing, decanting, etc can be automated on microfluidic CDs [3] to perform laboratory processes ranging from blood sample preparation to complete nucleic acid analysis [4,], [5]. Microfluidic CDs reduces the cost, footprint, and user input of a diagnostic platform, allowing cost-effective, portable and automated diagnostic tools to be developed for use in pointof-care applications. For point-of-care applications, prolonged storage may be necessary, and the reagents/ chemicals might evaporate and mix together before actual usage, compromising on the integrity of the result. To complement the use of capillary valves, this paper introduces a hybrid capillary-flap valve method that is cheap, easy to implement, and provides segregation of vapor for use in point-of-care microfluidic CDs.

MICROFLUIDIC VALVES

Microfluidic valves are essential for flow control of sample and reagents on a microfluidic CD. There are two categories of valves, namely passive valves, and active valves. Passive valves have no moving parts and work on the principle of the capillary effect [6]. Active valves on the other hand require moving parts such as a membrane or plunger that requires external mechanical, pneumatic, electric or thermal force for actuation.

Capillary and Siphon Valves

Capillary valves prevent fluid flow for rotational speeds below the burst frequency of the valve. Two kinds of passive valves, hydrophilic and hydrophobic valves can be designed. A hydrophilic valve can be created by having a sudden expansion in the geometry of a channel inlet on a hydrophilic surface [7]. A hydrophobic valve can be created by either having a hydrophobic patch in the middle of a channel, or having a sudden narrowing in the geometry of a channel inlet. [8]. The figure 2 depicts these valves.

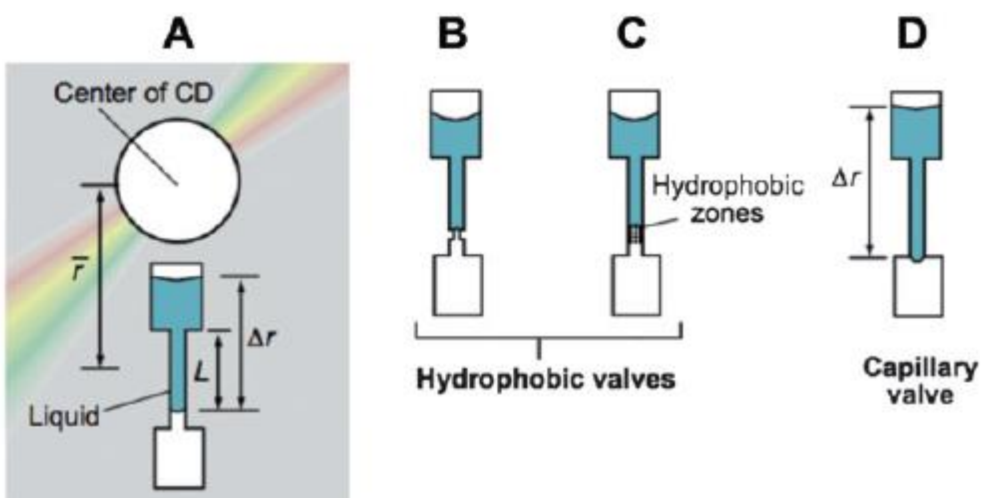

Fig. 2 Description of a microfluidic CD (A), A source and destination chamber connected by a channel, (B) Hydrophobic valve made by a narrowing in the channel, (C) Hydrophobic valve made by the application of

hydrophobic material in the channel, (D) Capillary valve [8]

A siphon valve operates on the principle of the capillary effect. Unlike the capillary valves, a siphon valve prevents fluid flow at high rotational speeds. Figure 3 shows the operation of a typical U-shaped siphon valve. The hydrophilic U-shape channel between the two chambers primes the liquid from the source to the destination chamber. At high rotational speed, the centrifugal force pushes the liquid outward away from the center of the CD, trapping it at the bottom of the U shape channel. [9] [10].

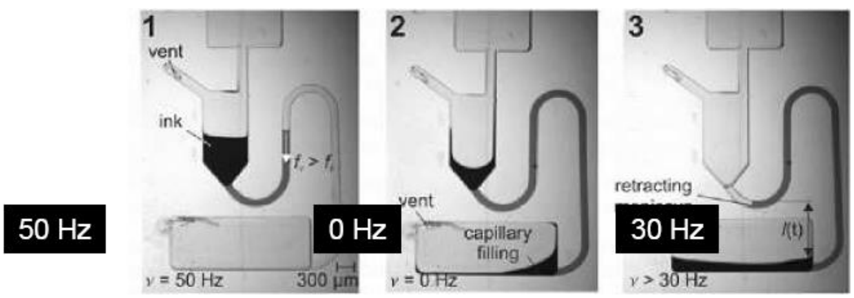

Fig. 3 Fluidic push pull through siphoning. [9] [10]

Capillary and siphon valves allow for a wide range of applications on a microfluidic CD, however they do not provide segregation of vaporized liquid.

Membrane Valves

A membrane valves is constructed with a membrane layer parallel to the channel layer [11] [12]. When pressure is applied onto the membrane layer, the membrane deflects and blocks the flow in the parallel channel. Figure 4 shows a membrane type valve by Weaver et al [12]. The control channel is below the membrane, with the flow channel above the membrane. When pressure is applied, the membrane deflects upward and closes off the flow channel. The membrane valve provides flexibility in flow control, however the fabrication process requires careful layering of the plastic and membrane layers onto the micro device.

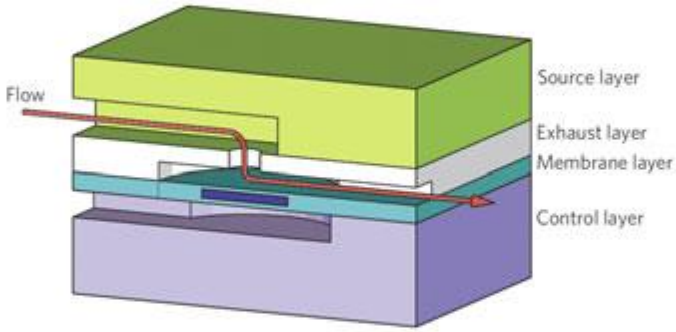

Fig. 4 The membrane valve opens when no pressure is applied [12]

Flap Valves

A flap valve is constructed by embedding a thin film within the microluific layers. Figure 5 shows a 3-way flap valve demonstrated by Mahalanabis et al [13]. The flap valve is normally closed for the 1st channel, and normally opened for the 2nd channel. When given an active pressure of 24.13 kPa, the flap moves down and blocks the 2nd channel while allowing liquid to flow from the 1st channel.

Full text is available at :

http://link.springer.com/chapter/10.1007/978-3-642-21729-6_144