Low Cost Fabrication of Microchannels for Lab-on-a-Chip Applications

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Here we present a detailed characterization of a low cost method of fabricating microchannels for lab-on-a-chip devices using a desktop digital cutting plotter and double-sided pressure sensitive adhesives (PSA). Geometries commonly used in microfluidics devices can be obtained with this method, with consistent channel width as low as 200μm. Such method is less expensive and more rapid than other approaches common to the microfluidics community. For example, when compared to traditional soft lithography(1), the method presented here does not require master molds, degassing of the polymer, plasma treatment or heating sources, and is definitely not as lengthy. Material-wise, the PSA used here is about an order of magnitude less expensive than Sylgard PDMS. Importantly, the use of PSA-based channels leads to robust devices capable of withstanding significant fluid pressures (2). This method is also easy to implement. The complete process, from design to implementation, can be as short as 5 minutes without any complex set up.

The setup we use in this work has an estimate cost of less than $2000 USD and includes a cutter plotter (Graphtec CE6000-40, Japan) and a cold roll laminator (Drytac JetMounter JM18, USA). Designs can be drawn in a number of drawing software suites, but we used SolidWorks due to its availability and easiness to design exact complex geometries. Our goal is to determine the limits of this low cost fabrication technique when fabricating geometries common to lab-on-a-chip devices. A number of parameters defining straight, serpentine and zigzag channels, as shown in figure 1, are studied here. Initial results are shown in figures 2-4 and include the characterization of a 125μm-thick PSA film (FLEXcon Switchmark 212R). Ongoing work is on expanding this characterization to include the impact of film thickness.

We first characterized the minimum width achievable in straight channels, Fig. 1A. After determining 200μm to be such width, albeit with a 6.9% deviation (Fig 2), we proceeded to establish the limits of serpentine channels (Fig. 1B) in both its radius of curvature and channel width. Fig. 3 illustrates how a design featuring thin channels can only be implemented when the radius of curvature is above 800μm. Alternatively, a radius of curvature of 400μm is the lower limit even when the channel width is in the mm range. In the case of zigzag channels, Fig. 1C, the aperture angle was varied along with the channel width. The parameters for a well-defined zigzag channel can be depicted from Fig. 4. Channel aperture angle smaller than 60° is only achieved if the channel width is greater than 400μm. Dimensional accuracy for angles wider than 140°, is only reached if the channel width is above 800μm.

Ongoing work is on characterizing these geometries with different thicknesses and other geometries such as T-junctions for injection purposes. Such characterization will lead to useful design guidelines for the implementation of microchannels using the low cost fabrication technique presented here.

References:

1. Y. Xia and G. M. Whitesides, *Soft lithography*, Annu. Rev. Mater. Sci., 1998, 28, 153–184.
2. Martinez-Duarte, R.; Renaud, P.; Madou, M. *A novel approach to Dielectrophoresis using carbon electrodes*. Electrophoresis 2011, 32, 2385–2392.

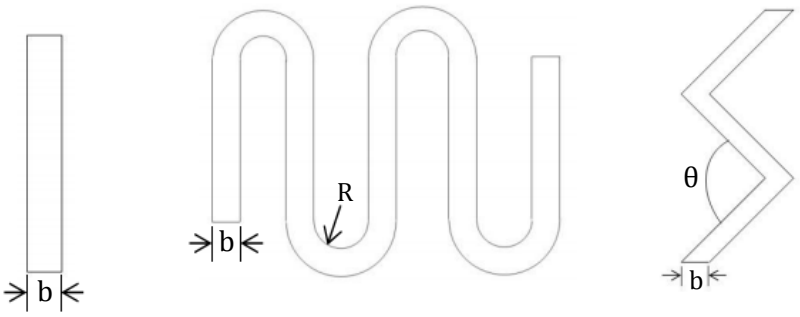


Fig 1: *Geometries studied in this work and their design parameters: A) Straight channel with b as channel width; B) Serpentine channel with b as channel width and R as radius of curvature; and C) Zigzag channel defined by channel width b and angle of aperture θ.*

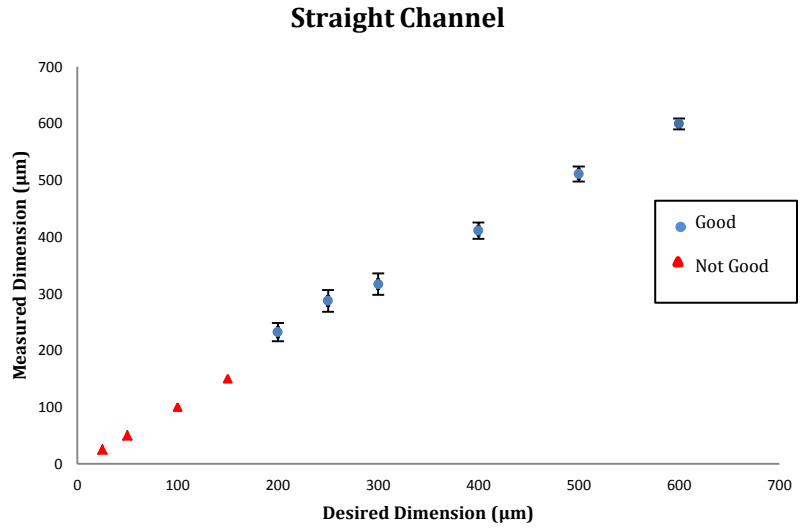


Fig 2: *Average dimensions achieved when cutting channels with different widths. Blue dots depict successfully cut channels while Red triangles indicate unsuccessful attempts. Bars indicate the standard deviation of at least five experiments.*

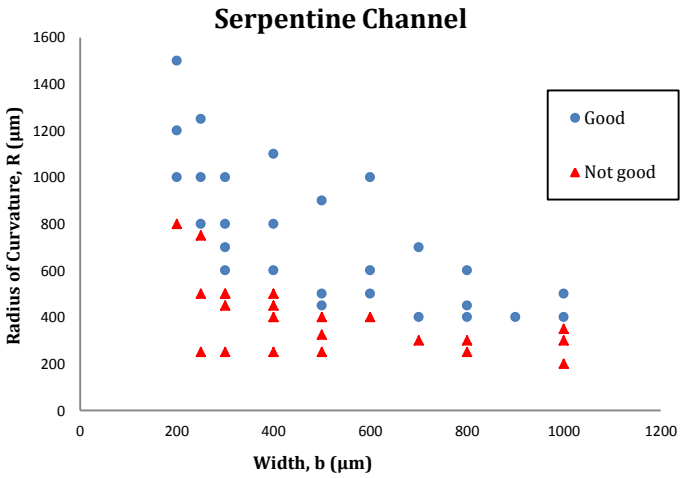


Fig 3: *Relation between width of the channel and Radius of curvature of the serpentine geometry. Red triangles indicate geometries attempted but not achieved. At least five experiments were conducted for each data point.*

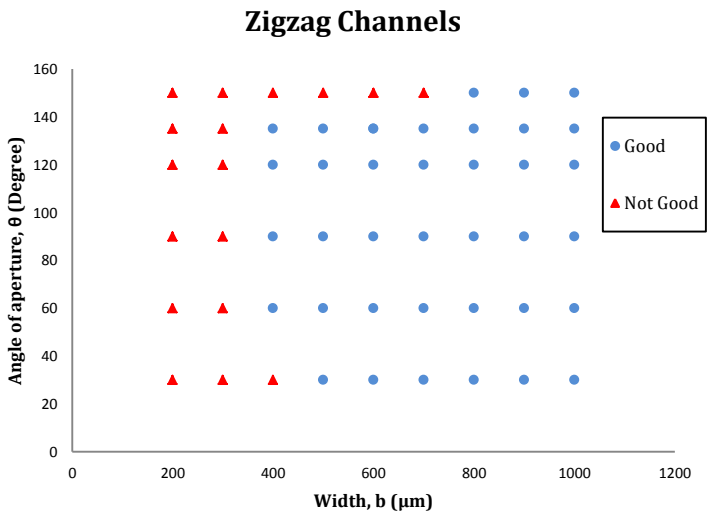


Fig 4: *Relation between the width of channel and the angle of aperture in a zigzag channel. At least five experiments were conducted for each data point.*