Supporting Information

Rapid Prototyping of Microchannels with Surface Patterns for Fabrication of Polymer Fibers

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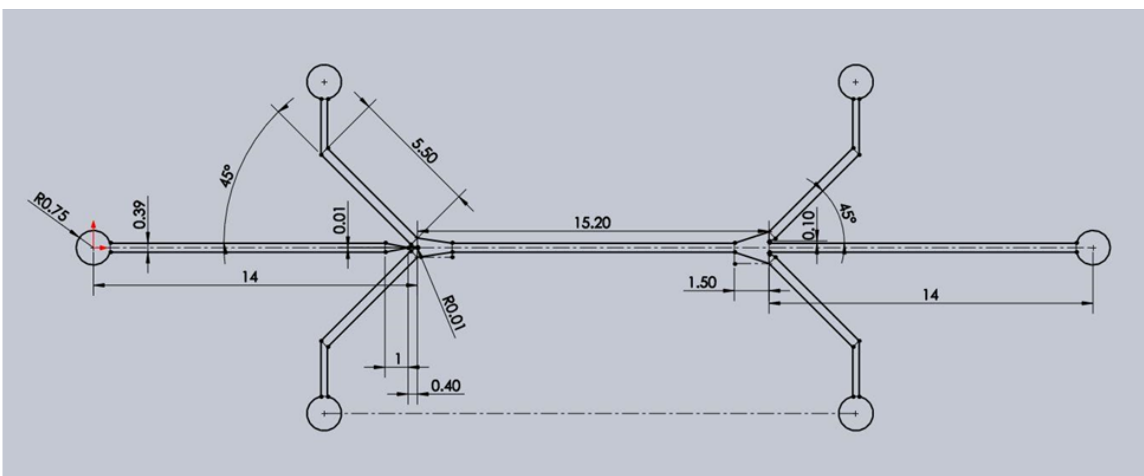
Experimental Section

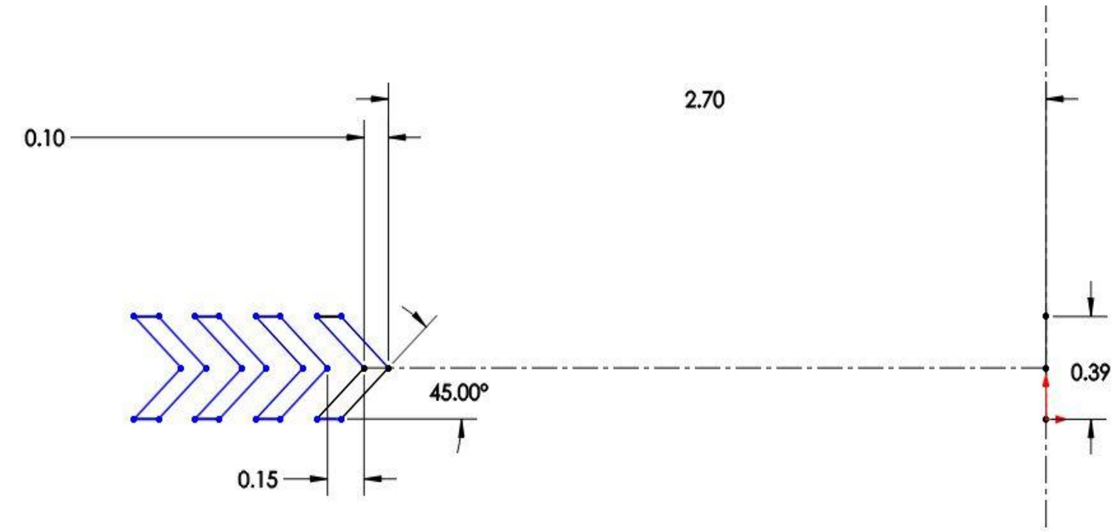
Channel Geometry

SolidWorks was used to create two two-dimensional images which were printed multiple times onto Shrinky-Dink thermoplastic sheets. The design we chose was created to match a flow cytometer from our previous work[1]. The detail drawings of this device are presented in Figure S1.

A



B



C

Figure S1: A) Top-plane dimensions of flow cytometer created in SolidWorks. B) Top-plane dimensions of chevron grooves for one half of the microchannel. C) Three-dimensional target geometry to scale. The microfluidic device used to create microfibers was made by cutting the flow cytometer geometry in half. All units are in millimeters or degrees, respectively.

Guide to Zygo Profilometry Measurements

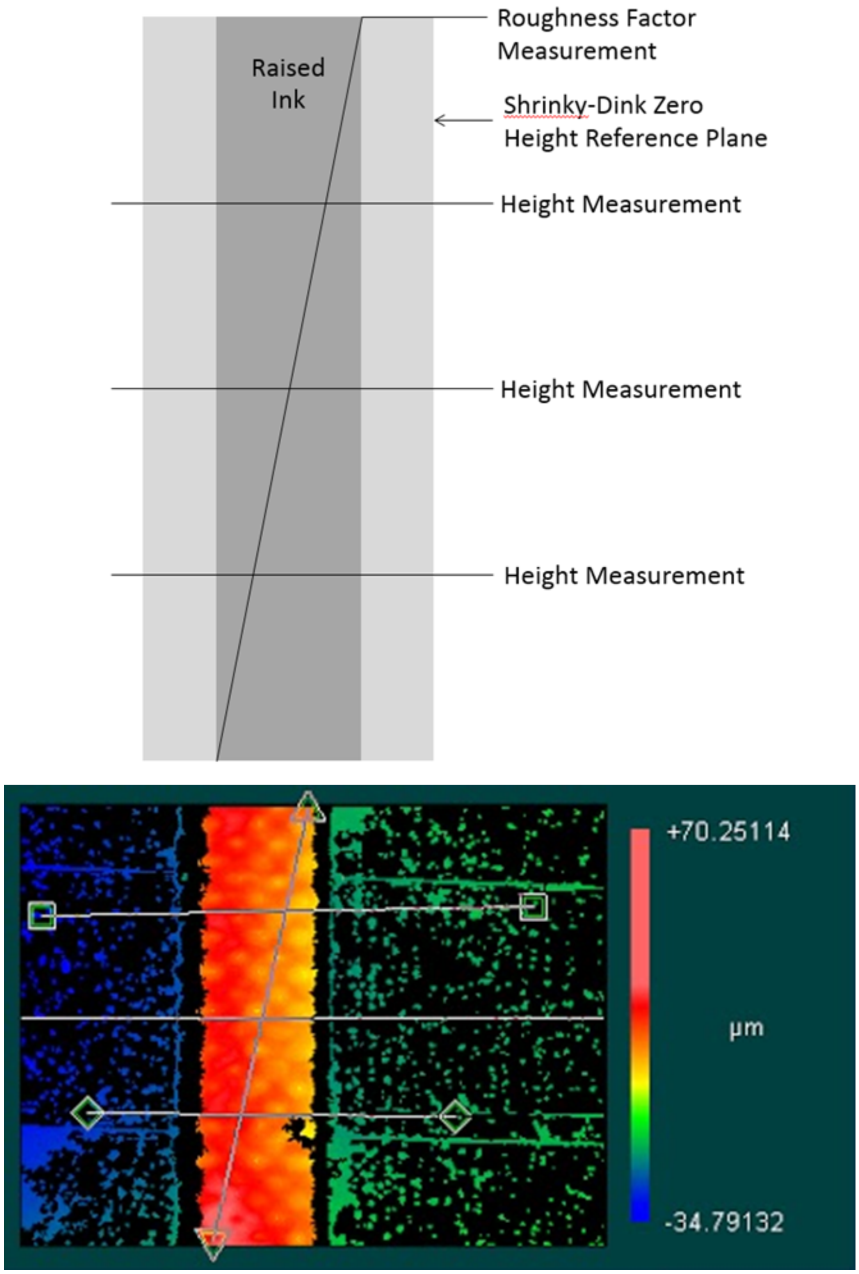


Figure S2: Profilometry measurement technique. Three height measurements were made for each sample channel at the center of the template approximately 50 µm apart with the Shrinky-Dink plane set as the zero height reference. Height values were reported by taking the average height across the channel subtracted by the average height of the reference plane to either side of the channel. Similarly, one roughness measurement was made diagonally across a 2 mm x 390 µm strip at the center of the template. The roughness value was reported directly from the profilometry software.

Microfluidic Device Fabrication

A microchannel with four chevron grooves was used to fabricate polymer nanofibers. Polydimethylsiloxane (PDMS) pre-polymer is poured onto the microfluidic template with the defined channel geometry and cured at 85°C for approximately 20 minutes. This process is repeated with the same template to create a second PDMS half. Holes were created on one of the halves at the inlets with a punch to allow for plastic tubing. The two sides of the PDMS microchannels were then submitted to plasma treatment for 20 seconds and aligned under microscope. The microchannel was allowed to bind overnight and high density polyethylene (HDPE) tubing was inserted into the inlet holes for connecting Polytetrafluoroethylene (PTFE) syringe tubes. The device was then cut in half, and both the wide inlet and narrow inlet sides were used to create fibers by the process outlined in the paper body.

Cost Analysis for Table 1

Silicon wafer:

Overhead total - $500,000+

- Electric Furnace
- UV light - $380 – Reference [2]
- Multi-wire Saw - $475,000 – MWS-610-SD wire saw – Quote from Takatori service representative
- Polisher

Per template total – $0.30/cm^2 @ 78.5 cm^2 = $23.56 – Mean value of reference [3] and area of a standard 100 mm diameter silicon wafer.

- Blank Silicon Wafer
- Photoresist
- Mask
- Etchant

3D printing:

Overhead total – $4,000

- 3D printer – $4,000 – Miicraft+ 3D printer – Quote from service representative

Per template total – $1.24

- Plastic (Clear Resin) - $150/500g @ 1.18g/cm3 with estimated 3.5 cm3 volume based on our previous molds = $1.24 – Quote from Miicraft service representative for cost and Sculpteo Detail Resin data sheet for density

PMMA micromilling:

Overhead total – $6,000 - $18,000

- Micromill - $6,000 – Minimill/1 – Minitech Machinery Corporation
- Micromill - $18,000 – Minimill/4 – Minitech Machinery Corporation
- Toolbits – Cost was ignored as it is significantly less than the micromill

Per template total – $0.48

- PMMA – $137.02/48’’ x 96’’ x 1/8’’ @ 4’’ x 4’’ x 1/8’’ = $0.48 – McMaster-Carr

Copper substrate:

Overhead total – $1,600

- Laserjet printer – $1,600 - Xerox

Per template total – $4.58

- Copper - $19/sq. ft. @ 105mm x 148mm sheets = $3.18 – Reference [4]
- Dicing tape - $0.25 (estimated)
- Copper Etchant CE-100 – $42.50/quart @ 25mm x 75mm x 0.35 μm etch with etching of 8-10 oz Cu/gallon specified = $0.43 – Transene Company, Inc.
- Special registration black toner - $0.40 (estimated)
- Acetone - $509/16L @ 10mL (estimated) = $0.32 – Sigma Aldrich

Shrinky-Dink:

Overhead total- $1,670

- Laserjet printer – $1,600 - Xerox
- Conventional oven – $70 – Black and Decker TO3250XSB Toaster Oven

Per template total – $0.40

- Shrinky Dinks ‘Crystal Clear’ Shrinkable Plastic – $6/10 sheets @ 3 templates/sheet = $0.20 – Shrinky Dinks
- Toner – $0.20 (estimated) - HP 64X High Yield Black Original Laserjet Toner

References

[1] Hashemi N, Howell JPB, Erickson JS, Golden JP, Ligler FS. Dynamic reversibility of hydrodynamic focusing for recycling sheath fluid. Lab on a Chip. 2010;10:1952-9.
[2] Huntington MD, Odom TW. A Portable, Benchtop Photolithography System Based on a Solid-State Light Source. Small. 2011;7:3144-7.
[3] Becker H, Locascio LE. Polymer microfluidic devices. Talanta. 2002;56:267-87.
[4] Abdelgawad M, Watson MW, Young EW, Mudrik JM, Ungrin MD, Wheeler AR. Soft lithography: masters on demand. Lab on a Chip. 2008;8:1379-85.