Fundamentals of rapid injection molding for microfluidic cell-based assays

Supporting Information

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LIST OF FIGURES:

CAD files for devices in Figure S10 provided.

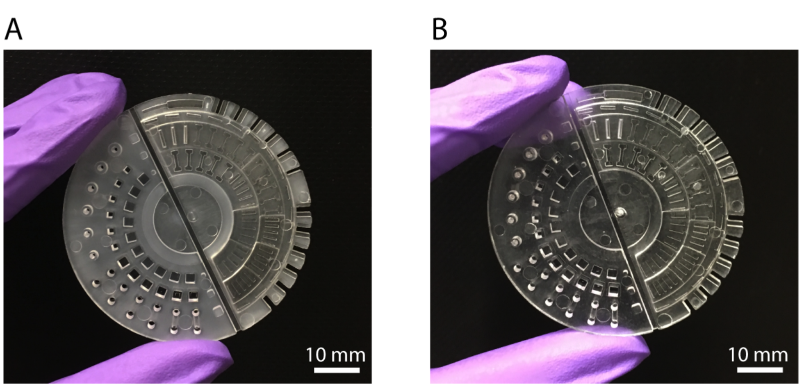

Figure S1. Image of PP device (left) and COC device (right).

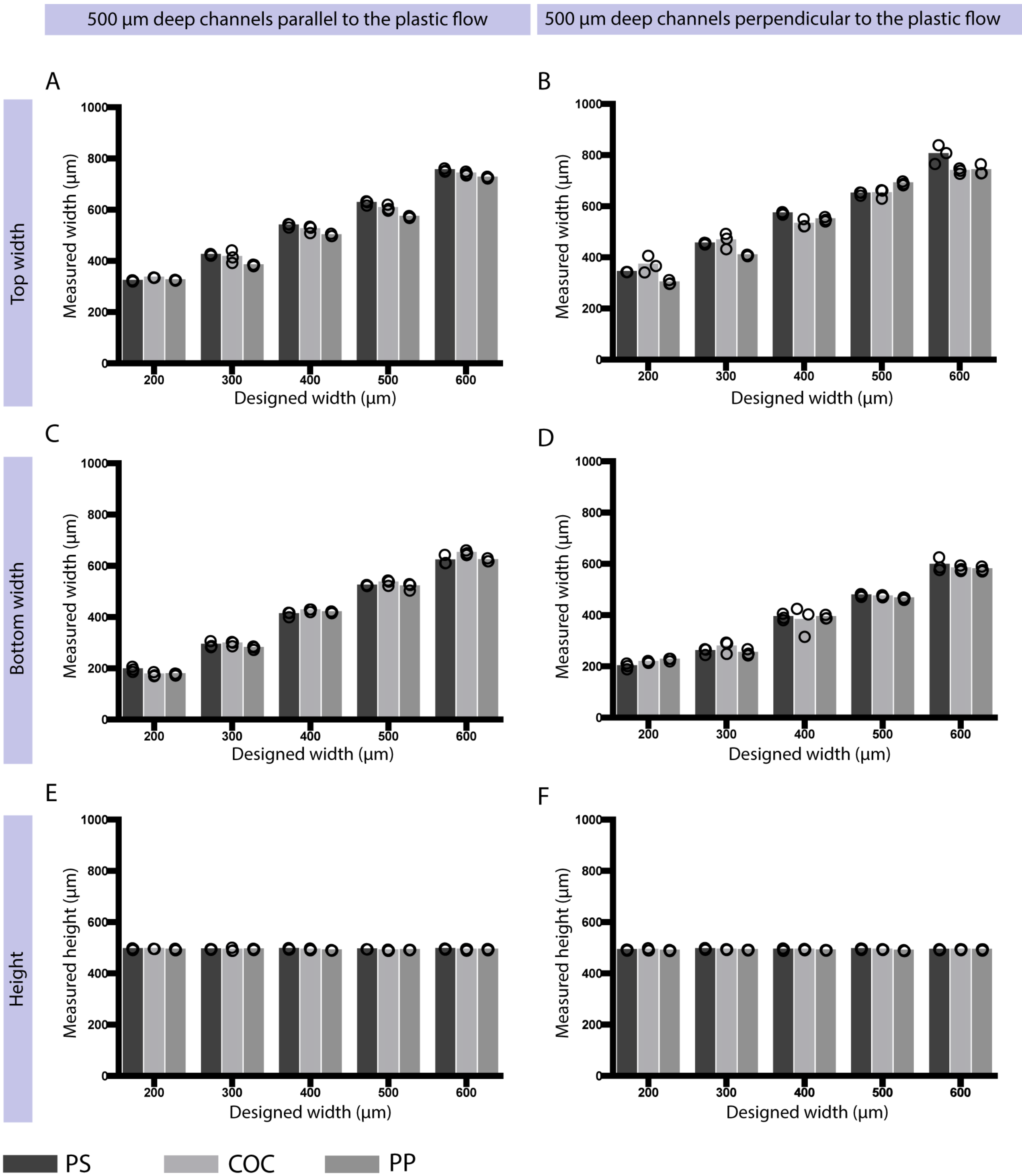

Figure S2. Measured dimensions of 500 µm deep rectangular channels in PS, COC, and PP devices. Channels are oriented parallel (left) or perpendicular (right) to the flow of molten plastic. Data points indicate three devices tested in each material. Data points (open circles plotted on top of bar graphs) indicate three devices measured (all from the same metal mold); bars indicate the mean.

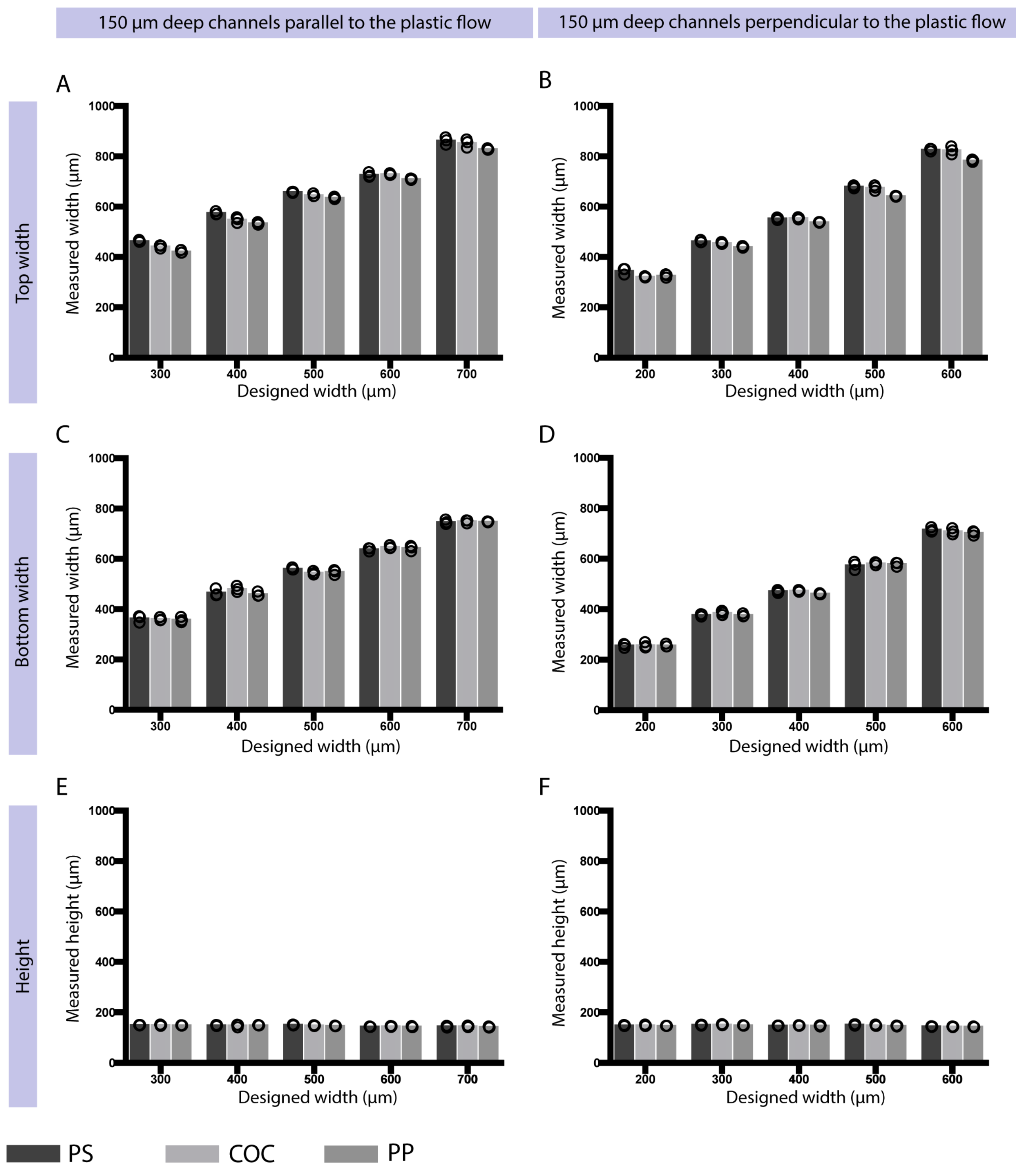

Figure S3. Measured dimensions of 150 µm deep rectangular channels in PS, COC, and PP devices. Channels are oriented parallel (left) or perpendicular (right) to the flow of molten plastic. Data points indicate three devices tested in each material. Data points (open circles plotted on top of bar graphs) indicate three devices measured (all from the same metal mold); bars indicate the mean.

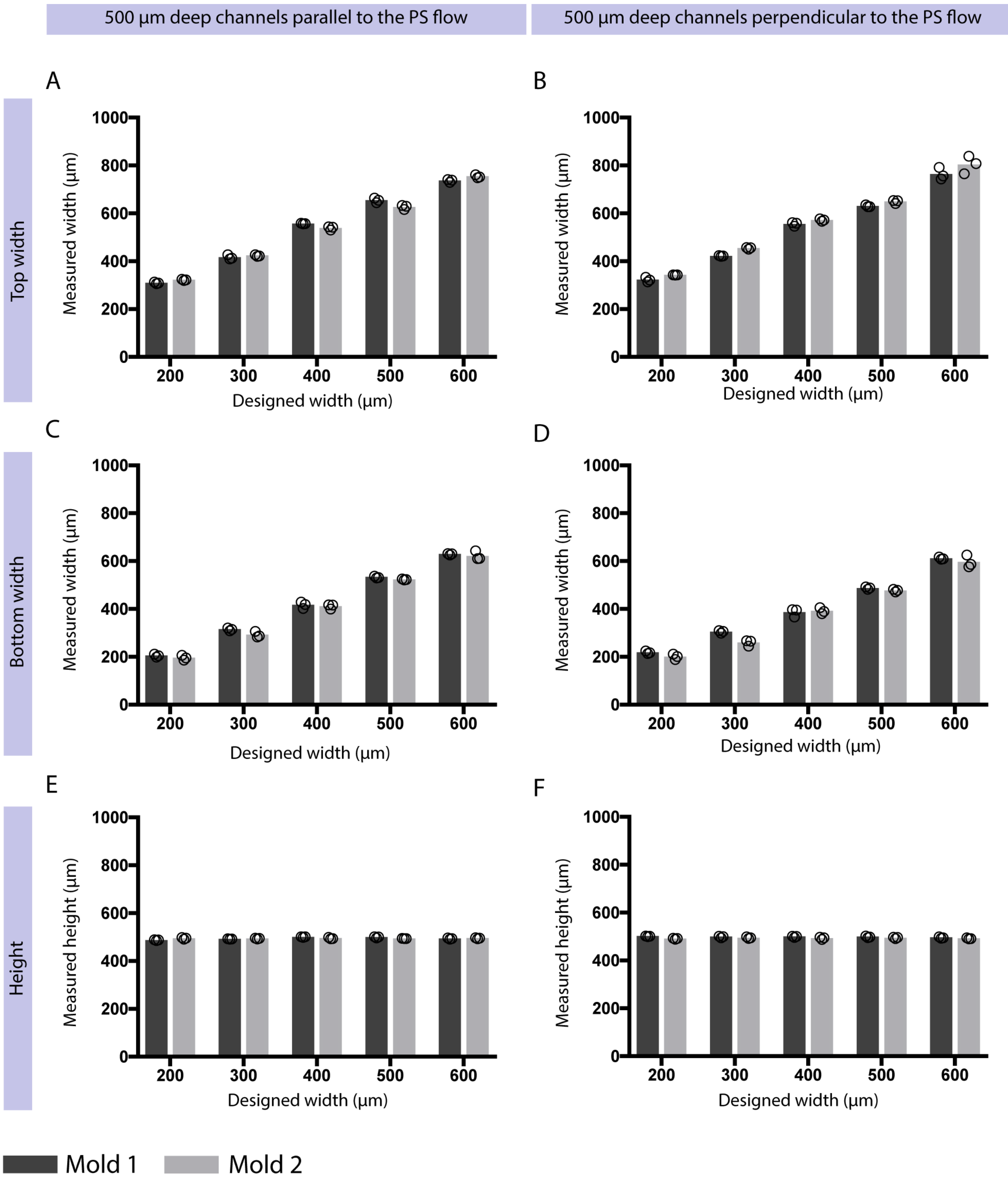

Figure S4. Quantification of channel dimensions from devices injection molded out of two identically designed molds. Graphs of mold 1 and mold 2 for 500 µm deep rectangular channels parallel (left) and perpendicular (right) to molten PS flow. Data points (open circles plotted on top of bar graphs) indicate three devices measured (all from the same metal mold); bars indicate the mean.

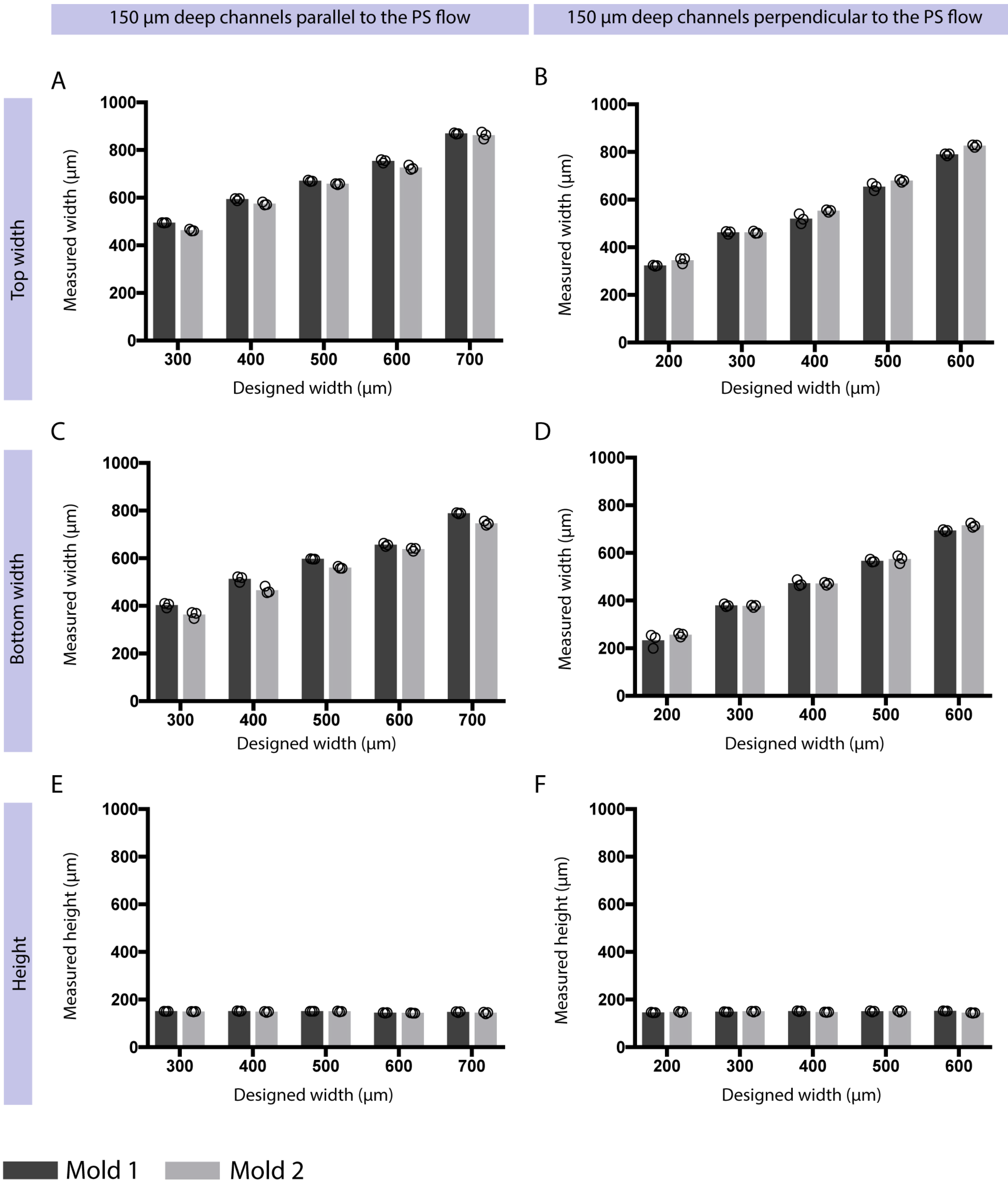

Figure S5. Quantification of channel dimensions from devices injection molded out of two identically designed molds. Graphs of mold 1 and mold 2 for 150 µm deep rectangular channels parallel (left) and perpendicular (right) to molten PS flow. Data points (open circles plotted on top of bar graphs) indicate three devices measured (all from the same metal mold); bars indicate the mean.

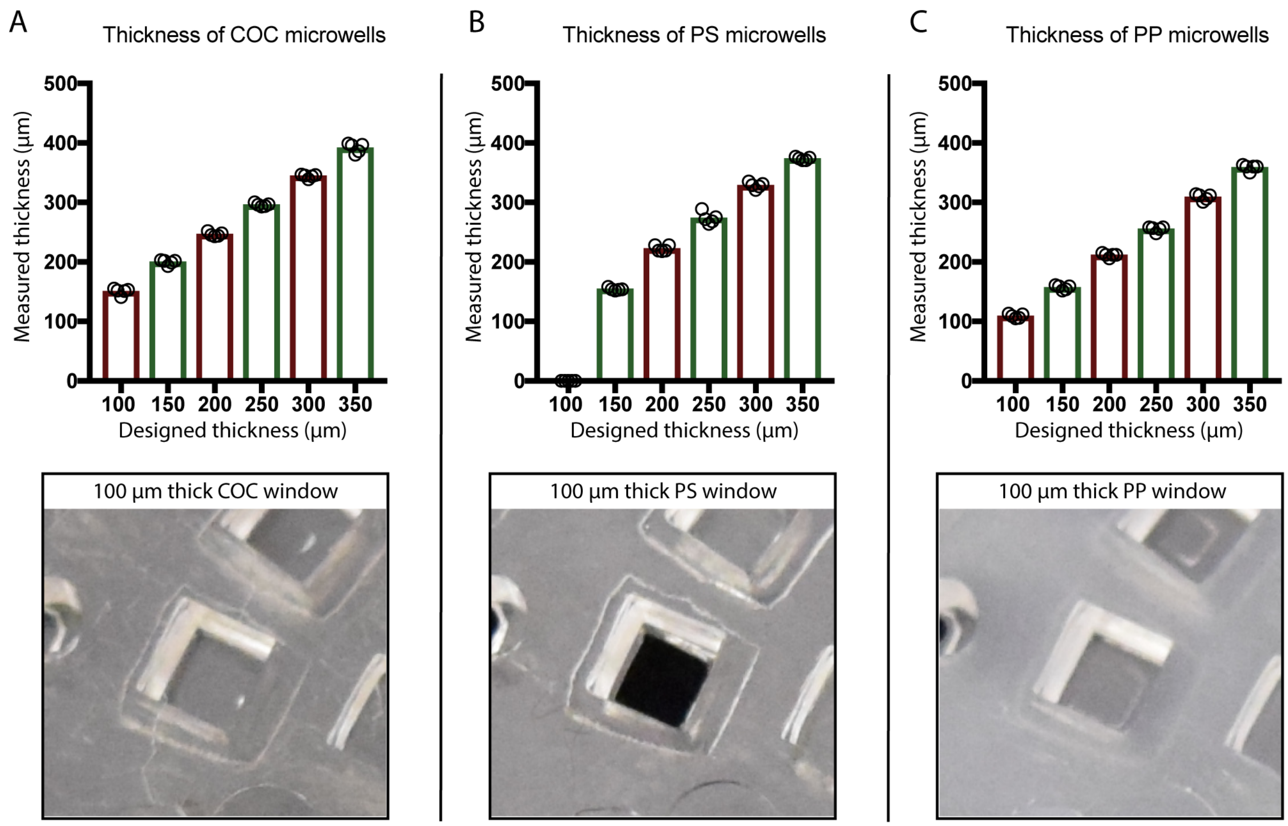

Figure S6. Measured microwell thicknesses (top) and photo of 100 µm thick microwell (below) for (A) COC (B) PS (C) PP. Red bars indicate SPI_A2 polishing level, and green indicates SPI_B1 polishing level. Data points (open circles plotted on top of bar graphs) indicate five devices measured (all from the same metal mold); bars indicate the mean.

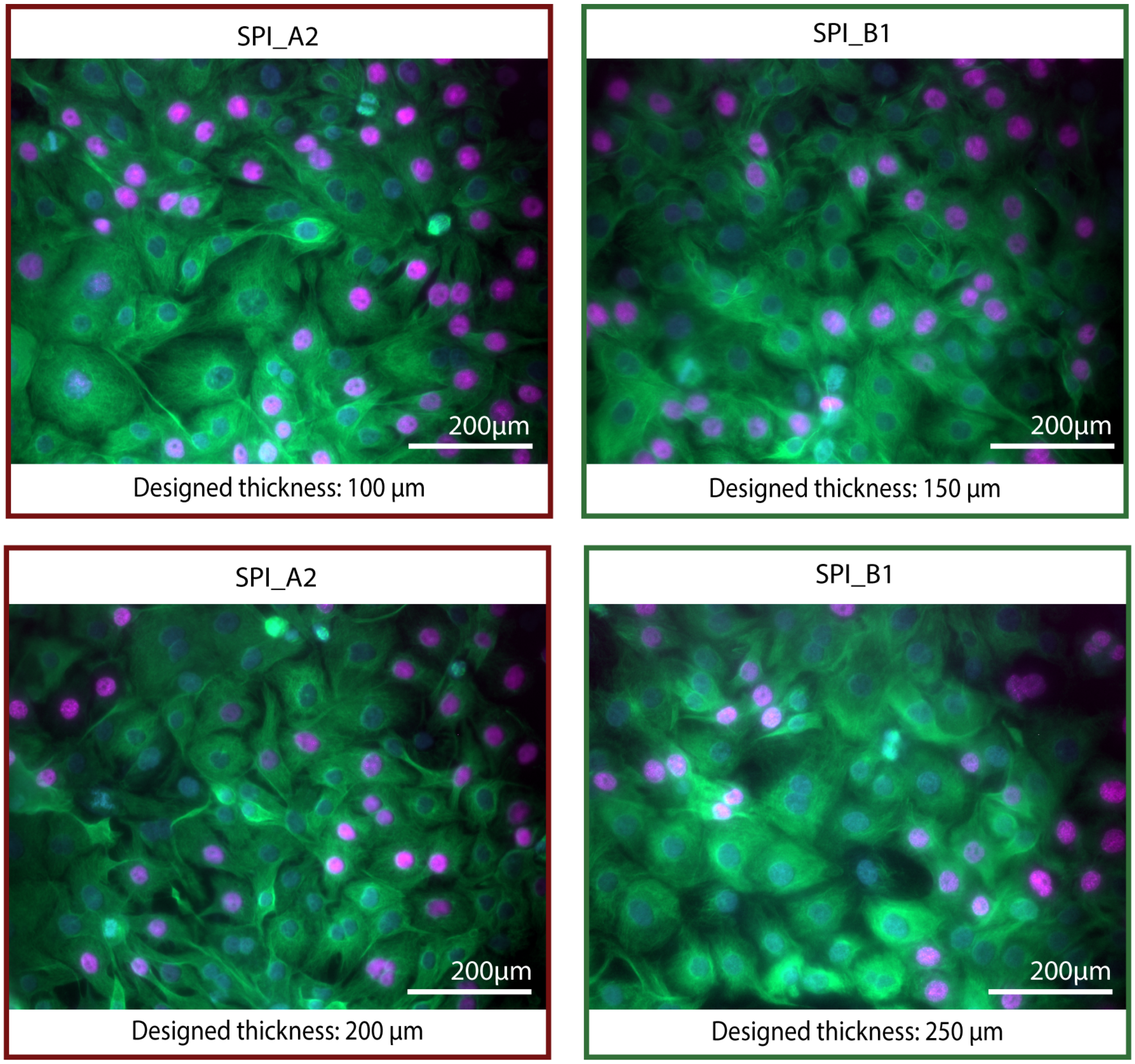

Figure S7. Unmodified fluorescence images of BHPrE1 cells in COC microwells of varying thickness and surface roughness. Images taken at 20x (0,40 NA) magnification with nuclear staining (DAPI, blue), proliferating nuclei (EdU, red), and tubulin (green). Red borders indicate SPI_A2 as highest level of polishing provided by Proto Labs® (left) and green indicates SPI_B1 as second highest level of polishing (right). Raw TIFF files available in the ESI.

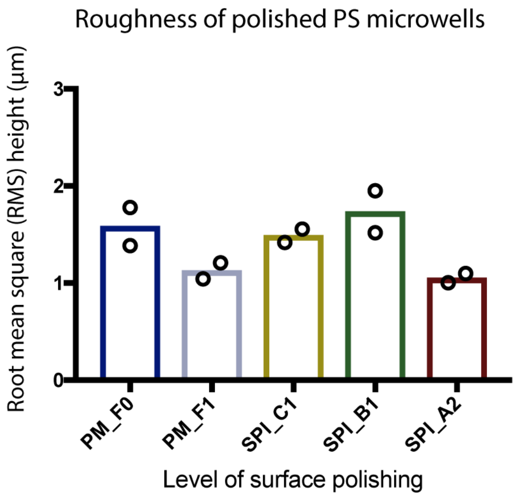

Figure S8. Root mean square height for PS microwells. Points represent measurements from two microwells of the same polishing in one device.

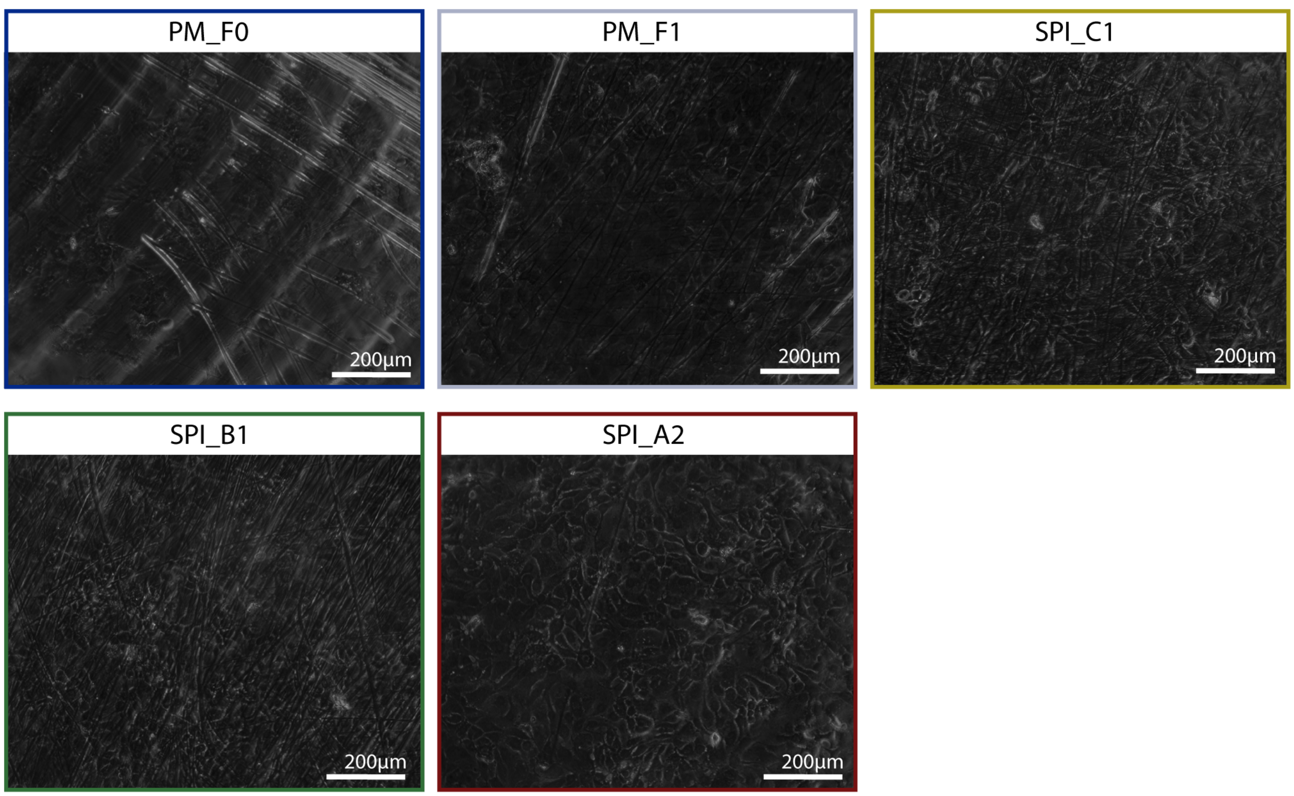

Figure S9. Unmodified phase contrast images of BHPrE1 cells on COC microwells of varying surface roughness taken at 10x magnification. Images are representative of two replicate microwells from one device. Raw TIFF files available in the ESI.

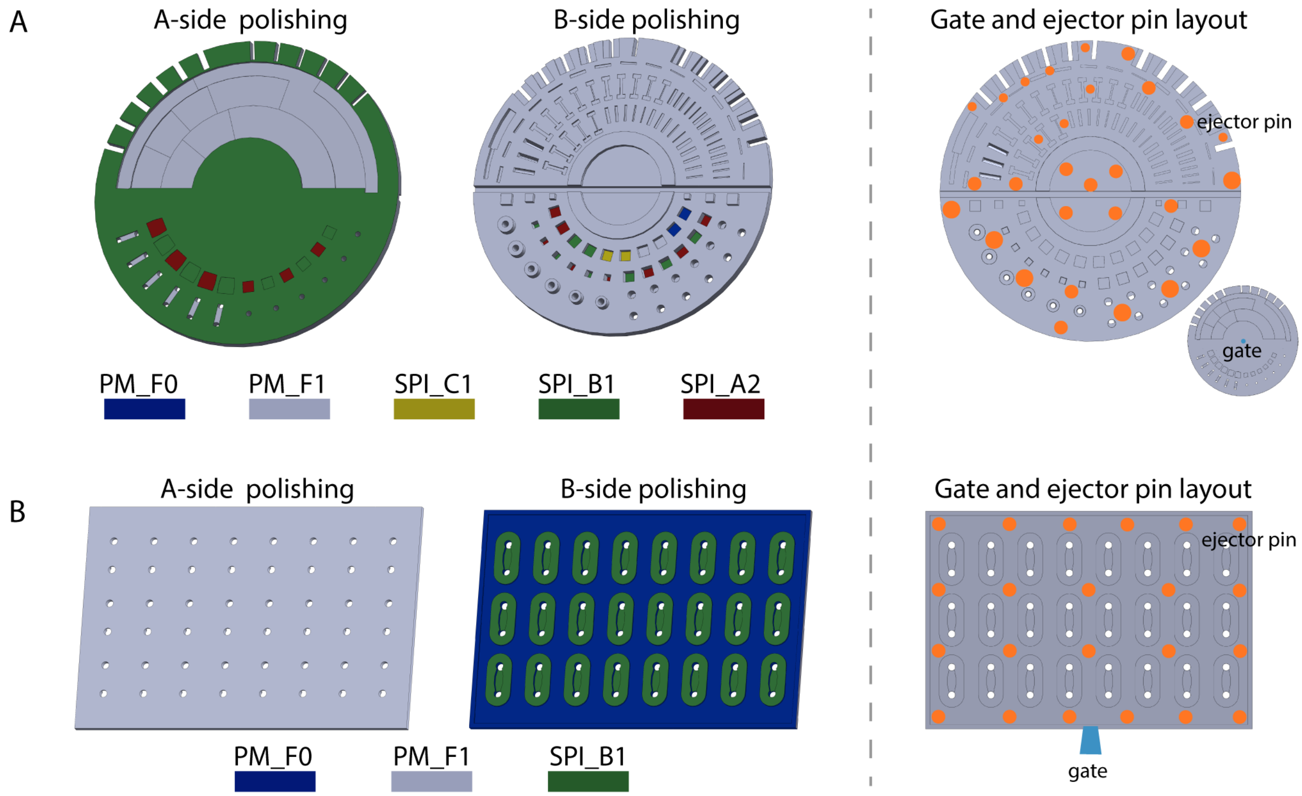

Figure S10. Polishing levels applied to both sides of the mold for all devices. Ejector pin and gate layout on molds. (A) test device and (B) closed cell culture channels. Five levels of polishing offered by Proto Labs®: PM-F0: Non-cosmetic, finish to Proto Labs® discretion; PM-F1: Low-cosmetic, most toolmarks removed; SPI-C1: 600 grit stone; SPI-B1: 600 grit paper; SPI-A2: Grade #2 diamond buff.

Appendix 1: Considerations when working with and choosing rapid injection molding companies

The following is a list of questions and considerations that may be useful to ask when choosing a rapid injection molding company.

Questions to consider when calculating price comparisons

1. The metal mold used to manufacture plastic parts is typically retained by the rapid injection molding company. Companies typically will not release the mold to customers because it contains aspects of their proprietary process technology (such as the way the mold configures with their injection molding system to enable rapid work flows). Molds are typically stored indefinitely or for an agreed upon period of time, and the customer can request additional parts at a later date. Some questions to ask include:

a) How long are the metal molds stored? Is there a fee for storing the mold (some, but not all, companies charge a storage fee)?

b) What is the 'setup fee' for making a new batch of devices? (Some, but not all, companies charge a fee to take the mold from storage and set it up for subsequent batches of devices.)

2. Is there a 'material change fee' if parts in different materials are desired from the same mold? Typically the material change fee is less than the 'setup fee' discussed in 1 b. (For example, it may cost $500 to setup a new batch of devices and $100 to change materials within a batch, so if parts are desired in PS, COC and PP it may be advantageous to combine all three materials in a single order to avoid multiple 'setup fees'. However, some companies may not charge a fee for either setup or material changes.) Note: switching materials may result in different dimensions and tolerance, since plastics have different properties (e.g., shrink rates, flow properties, melting temperatures).

3. How many parts can be produced from the mold? The metal mold wears over time, and different companies guarantee the mold for different numbers of parts (Proto Labs: ~10,000 parts in an aluminum mold).

Additional technical questions

1. What metal are the molds made of? Aluminum is typically used for rapid injection molding, but some companies may use soft steels that provide results more typical of production scale injection molding.

2. Are the parts inspected for accuracy by the manufacturer? If so, how are the parts inspected?

3. Is the shrinking of the part accounted for in the design of the mold? Is the mold specifically designed for a certain material with a determined shrink rate?

4. Can the designer choose the tolerances? What are the highest tolerances achievable? (Proto Labs has a predetermined tolerance for most uploaded parts and thus tolerances cannot be specifically chosen.)