Electronic Supplementary Material (ESI) for Lab on a Chip.

Supporting Information

High Process Yield Rates of Thermoplastic Nanofluidic Devices using a Hybrid Thermal Assembly Technique

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Assessment of device replication fidelity. All devices were fabricated using an approach previously reported by our group.[1] In general, the procedure involved producing a Si master possessing the nanofluidic structures that was used to fabricate a UV curable resin stamp from which nanofluidic devices were generated using thermal embossing. In this work, the replication fidelity was assessed using a device with a single nanoslit that was 140 nm deep. Figure S1 shows an AFM line scan of the depth of the nanoslit in the Si master (red trace) and height of the positive tone in the UV-resin stamp (black trace). A single Si master was used to fabricate >20 resin stamps and the replication fidelity (%) was evaluated using;

$$\frac{\text{Height of nanostructure in stamp (nm)}}{\text{Depth of nanostructure in Si (nm)}} \times 100\% \quad (1)$$

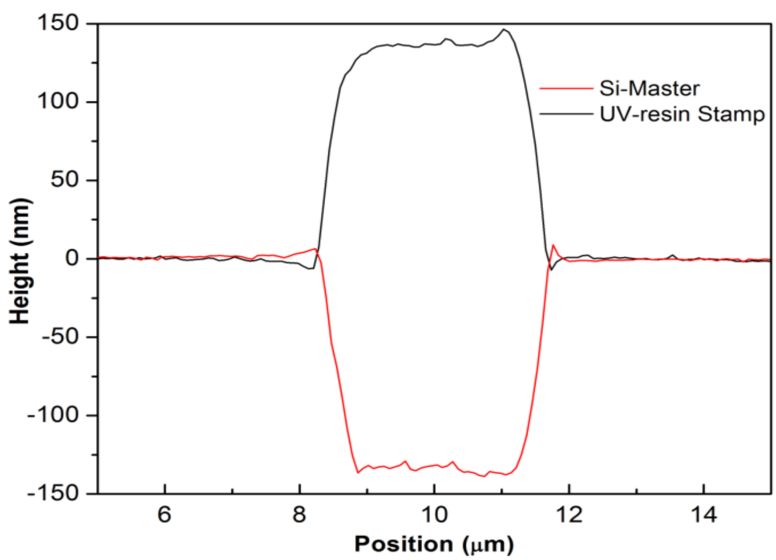

Figure S1. AFM profile of a nanoslit in a Si master (red trace) and positive structure in the UV resin stamp (black trace) showing the replication fidelity in the structure.

The upper panel of Figure S2a shows an AFM image of the first stamp of the replication process and the lower panel shows a box plot for the dimensions measured at 10 different positions along the structure length with the average number plotted and the variation in the 10 different positions represented as the error bars. As can be seen, we obtained a replication fidelity of ~100% without any significant reduction in the height even after 20 transfers (Si master → resin stamp).

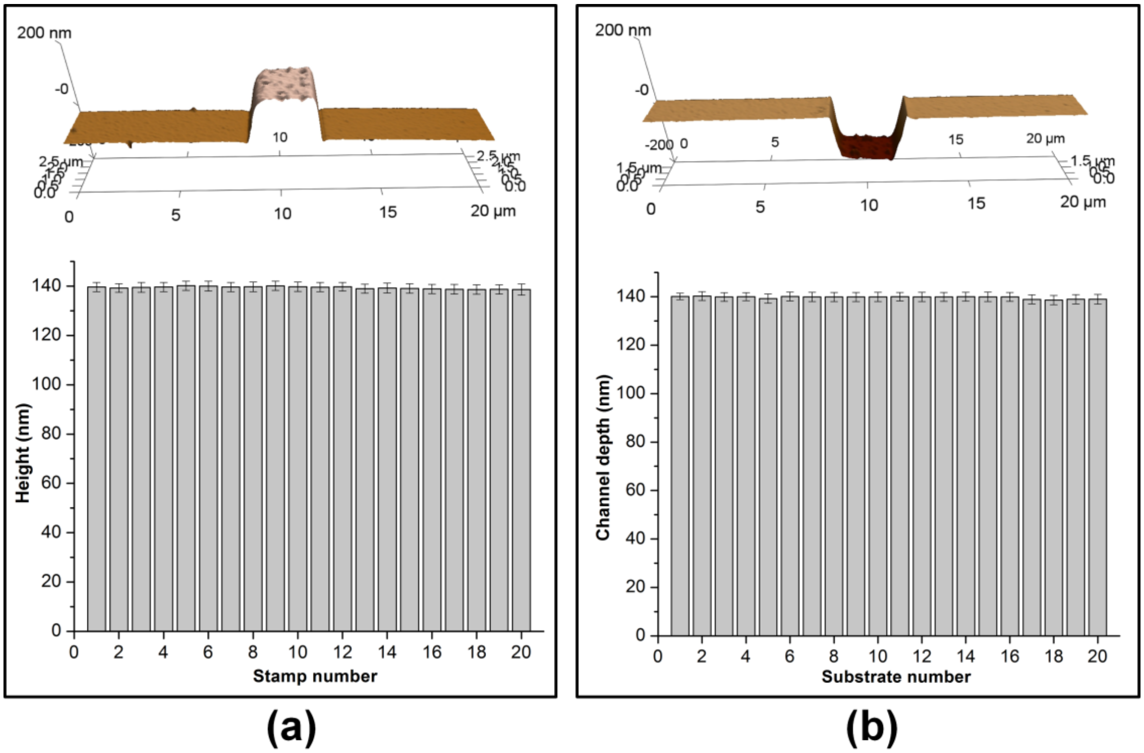

Figure S2. (a) Upper panel - AFM image of the first UV resin stamp produced from the Si master. Lower panel – Box plots of the stamp height measured with the AFM from 20 stamps produced from a single Si master. (b) Upper panel – AFM image of the first PMMA device generated after thermal imprinting using a UV-resin stamp. Lower panel – Box plots of the nanoslit depth measured with AFM from 20 substrates produced from a single UV-resin stamp. Both images reveal ~100% replication fidelity of nanostructures from the master to stamp to substrate. For the box plots, the value plotted represents the mean of 10 measurements made along the structure with the variance shown as the error bars.

Next, the rigidity of the UV resin stamp and the reproducibility of thermal imprinting were evaluated by measuring the depth of the nanoslit in a PMMA substrate relative to the height of the nanostructure in the stamp. The upper panel in Figure S2b shows an AFM image of the first imprinted nanoslit. As can be seen in Figure S2b, there was no significant reduction in the channel depth even after 20 transfers (resin stamp polymer → substrate).

Fabrication of sub-50 nm nanochannels. For the 35 nm 2D nanochannels, a 50 nm Al film (sputtering yield = 0.30 $\mu m^3/nC$) was sputtered onto the Si wafer possessing access microchannels. The type and thickness of the conductive film were chosen based on a previous report.[2] After FIB milling, the Al layer was removed using an Al etching solution, cleaned with water and dried with N_2 gas. Figure S3 shows SEM images of the Si master, UV-resin stamp and the nanochannel embossed in the thermoplastic substrate.

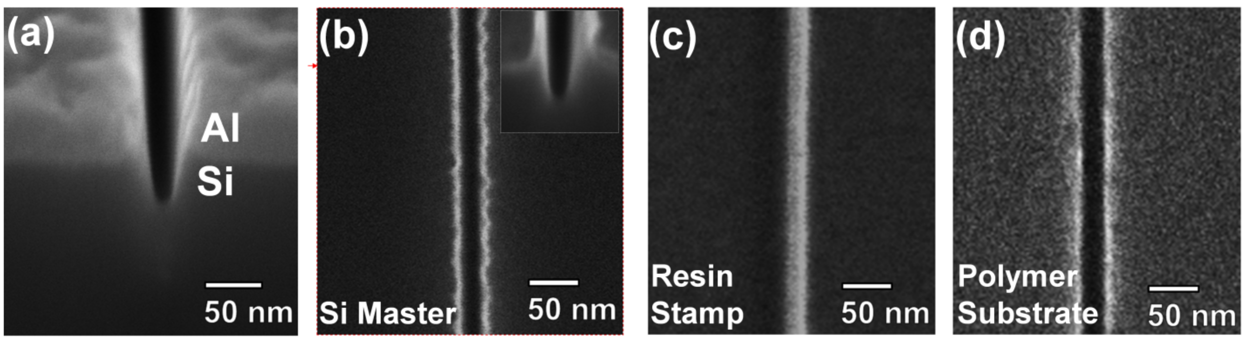

Figure S3. SEM images of the Si Master (a) with and (b) without Al layer (insert shows the cross-section image), (c) UV-resin stamp and (d) embossed polymer device for the 35 × 35 nm nanochannel.

REFERENCES

1. F. I. Uba, S. Pullagurla, N. Sirasunthorn, J. Wu, S. Park, R. Chantiwas, Y.-K. Cho, H. Shin and S. A. Soper, *Analyst*, 2014, 139.

2. L. D. Menard and J. M. Ramsey, *Nano Letters*, 2011, 11, 512-517.