# Nanofluidic channels fabricated by e-beam lithography and polymer reflow sealing

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Nanofluidic channels are of considerable interest for many applications such as DNA analysis [1], as well as for the study of transport phenomena in the nanoscale [2]. Nano-channel fabrication consists of trench patterning and sealing [3]. Typically e-beam lithography, nanoimprint lithography (NIL), laser interference lithography and focused ion beam etching are used to fabricate the nanoscale trenches; whereas the channels are sealed by wafer bonding including anodic bonding or contact bonding using soft elastomers, material deposition onto high aspect ratio trenches [4], thermal oxidization of silicon [5] and pulsed laser melting [6]. Sacrificial polymer was also used to fabricate sealed nanofluidic channels [7].

Here we report the fabrication of nano-channels by e-beam lithography and thermal reflow of the sealing polymer, whose process is simpler than the above methods. Moreover, the current method is capable of fabricating simultaneously channels with different channel-widths, which is difficult to achieve using sealing methods of material deposition, silicon oxidation or laser melting. The process used bi-layer e-beam resists consisting of poly(methyl methacrylate) (PMMA) on top of poly(dimethyl glutarimide) (PMGI). The channels were defined in PMGI that is more sensitive than PMMA, and sealed by reflowing PMMA whose glass transition temperature is significantly lower than that of PMGI (189$^{o}$C).

The schematic fabrication process is shown in Figure 1. The substrate for e-beam lithography consists of a layer of ARC (anti-reflection coating from Brewers Sciences, a cross-linked polymer) as adhesion layer, 70 nm PMGI and 170 nm PMMA, all spin-coated on a silicon wafer and baked on a hotplate. After e-beam exposure with high dose for the holes and low dose for the channels, the development of PMMA was carried out using MIBK:IPA=1:3 for 20 sec., which resulted in a hole array with sub-50 nm diameter in PMMA. Next, PMGI channels were developed using 1:1 diluted AZ 300 MIF developer for 5 min in a ultrasonic bath. It was found that such a long development time with ultrasonic agitation was needed in order to dissolve the exposed PMGI under PMMA, presumably because of the inefficiency of developer transport through the nano-holes in PMMA. Finally, the holes in PMMA were closed and thus the channels were sealed by baking the sample on a hotplate at ~150$^{o}$C for 3 min. Figure 2 shows SEM image of two sealed nanofluidic channels with channel-width 150 nm.

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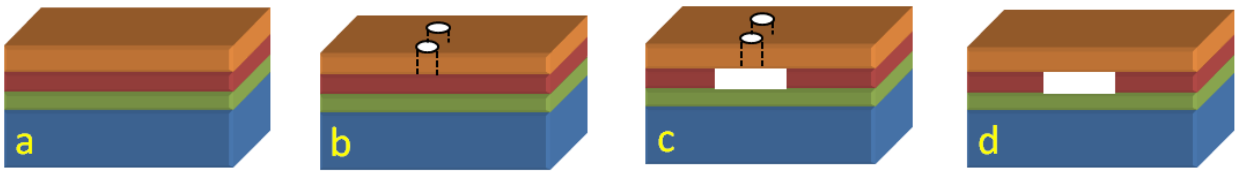


Figure 1. Schematic process for the fabrication of sealed nanofluidic channels. (a) Substrate consisting of bi-layer resists on an ARC layer; (b) e-beam exposure and development of PMMA that results in a sub-50 nm hole array along the channel; (c) development of PMGI through the holes in PMMA; (d) PMMA thermal reflow to close the holes, leading to sealed channels.

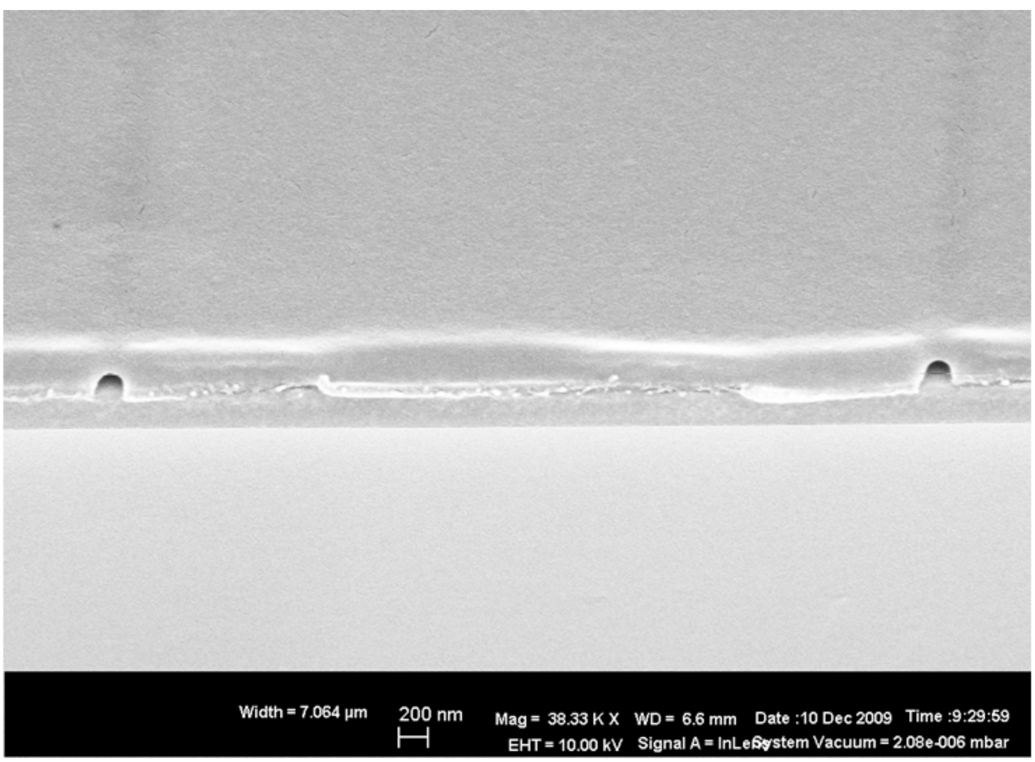


Figure 2. SEM image of two sealed nanofluidic channels in polymer with 150 nm channel width.