Nano Injection Molding for Nanofluidic Devices

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Nanofluidic devices, which refer to any devices that contain fluidic vias with at least one dimension less than 100 nm in size, have experienced significant advancement last two decades as tools to control, manipulate, and sense fluids and biomolecules using the unique nanoscale phenomena including double layer overlap, high surface-to-volume ratio, entropic barriers, and surface charge effect. Nanofluidic devices have been mostly fabricated via high end nanofabrication tools such as extreme ultraviolet lithography, electron beam lithography, and focused ion beam milling. However, the requirement of such high-end nanofabrication tools in their fabrication made it difficult to implement the nanofluidic devices beyond laboratory demonstrations. To increase the manufacturing throughput, replication methods such as nanoimprint lithography (NIL) have been used for transferring micro- and nano-patterns into polymer substrates. While NIL can produce nanofluidic devices forgoing the need for high-end nanofabrication tools to make each device, it is still a medium scale production method and as such, may not allow for the wide dissemination of nanofluidic devices into the research and commercial sectors. As seen in many commercialized microfluidic devices, injection molding of thermoplastics is a strategy with the potential to accommodate industrial-scale manufacturing requirements. However, the development of nano injection molding is still in infancy and many challenges need to be overcome.

This paper will discuss recent progresses on transitioning from NIL to nano injection molding in the fabrication of nanofluidic devices. A drawback of using injection molding in the developmental pipeline of fluidic devices is the high initial startup costs associated with the fabrication of metal mold inserts and the necessary multi-unit die. Also, to use injection molding for nanofluidic applications, much tighter tolerances are needed to ensure the continuity of fluid transfer between nanoscale fluidic vias and microfluidic networks upon assembly of devices with a cover plate. The solutions to overcome such challenges will be presented. We will also show the use of nano injection molded in-plane nanopore sensors in detecting and identifying single molecules down to mononucleotides.