A Dynamic Pore Size Tunning Approach for Manipulating In-Plane Nanopores Made in Polymer-Based Substrates

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Nanoimprint lithography (NIL) has been used to produce high throughput and low-cost nanostructures. Recently, our group has demonstrated via NIL nanofluidic devices containing in-plane nanopores in thermoplastic substrates for biosensing applications[1, 2]. Resistive pulse sensing (RPS) is a nanopore-based biosensing technique, where biomolecules translocating through nanopores are tracked by detecting a temporary decrease in the number of electrolyte charge carriers. To employ RPS, a nanopore with a size comparable to the biomolecules is essential. To produce enclosed nanofluidic devices with in-plane nanopores, NIL first produced the nanostructures, followed by thermal fusion bonding (TFB) with a thin plastic cover plate over the imprinted substrate. While this fabrication protocol has successfully demonstrated the production of sub-10 nm pore, this protocol faces two challenges. First, after TFB, the enclosed nanopore's size can only be obtained indirectly by measuring baseline current and comparing it with simulated current values with different pore sizes. Also, it is hard to control the sub-50 nm enclosed nanopores via stamp fabrication and NIL protocols.

This work reports a sub-10 nm tunning of in-plane nanopores dimension after cover plate bonding by applying external pressure on the enclosed nanofluidic device. Previously compression-based size reduction, from micro- to nanometer scale, was shown in elastomers-made nanochannels; however, this study is the first work demonstrating an active sub-10 nm pore size tunning approach employed on non-elastomer substrates. Nanofluidic devices with in-plane nanopores were created in polyethylene glycol diacrylate (PEGDA) via UV-NIL, followed by a TFB process with a PEGDA cover plate to produce an enclosed nanofluidic network. Then, uniform mechanical compression was imposed on the constructed PEGDA devices using a homemade compression stage, leading to deformation at the PEGDA-PEGDA, which results in adjustment of the pore dimensions. The modulation of the nanopore cross-section under various compression states was demonstrated by correlating transient current measurements obtained from the devices filled by 1M KCl solution and applying 1 V voltage with the simulation results given by COMSOL. Our approach provides an on-demand size control of NIL-made nanopores devices to fit the application of interest.

1. J. Choi, et al., Small, **17,** 2102567 (2021).
2. U.S. Athapattu, et al., ACS Sensors, **6**, 3133 (2021).