Nanofluidic Single DNA Sorter and Analyzer Fabricated by Nanoimprint and Wafer Bonding

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Real-time DNA sequencing with ultra-fast speed and low cost has great significance in biology and medicine. One promising approach is the "nanogap detector" built inside a nanochannel [1], which stretches a DNA molecule and measures the base-pair signals at the same time. A key step in fabricating such a device is the successful sealing of the fluidic channel with metal detectors. However, a conventional direct wafer bonding technique requires smooth surfaces and high bonding temperatures (800~1000ºC), and a polymer-based sealing suffers from poor reliability such as fast degradation, making a perfect sealing very challenging to realize.

Here, we present a method to fabricate perfectly sealed nanofluidic device for DNA sorting and analysis using air cushion based nanoimprint lithography [2] and a room-temperature wafer bonding based on sodium silicate [3], and the results of successful DNA flow in a single 55 nm wide nano-fluidic channel.

Our fabrication method includes the steps (Fig.1): (a) nanochannel was fabricated by UV nanoimprint lithography with a smooth single-channel mold fabricated by anisotropic wet etching of crystalline silicon, conformal deposition of mold material and RIE [4], (b) the microchannel was aligned to the single nanochannel and access holes were drilled, (c) the Pt/Ti (12/3 nm) electrodes were patterned by photolithography, (d) device and cover slip were cleaned and sealed by sodium silicate (2%) using NX 2000 Imprinter (200PSI, 5mins, 90ºC) and then anneal the device at 90ºC for 2 hours. The NX 2000 Imprinter, which has an air cushion press for ultra-uniform pressure [2]**,** facilitates a good sealing with large area uniformity**.**

Figure 2 shows the SEM images of the nanochannel (120μm length, 55nm width, 100nm depth) and part of the microelectrodes after nanoimprint and photolithography. The EMCCD images show the fluorescent signal of a DNA molecule stretched and moved in the single nanochannel under electrophoresis (Fig. 3).

Using this sealing method, we fabricated nanochannel devices with multiple electrodes in it (Fig.4). Multiple parallel electrodes in a single nanochannel allow us to apply different voltage at different electrodes to manipulate and analyze a single DNA. It also provides a good chance to study the mobility and length of DNA molecules.

Reference

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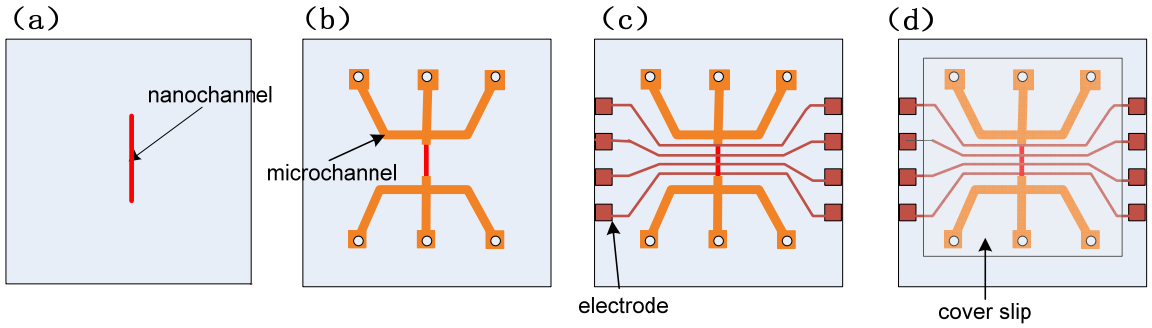

Fig.1 Schematics of fabrication process (a) nanochannel fabricated by UV imprint, (b) microchannel was aligned to the nanochannel and drill holes, (c) multiple electrodes was patterned by photolithography, (d) cover slip was placed on top and sealed by sodium silicate.

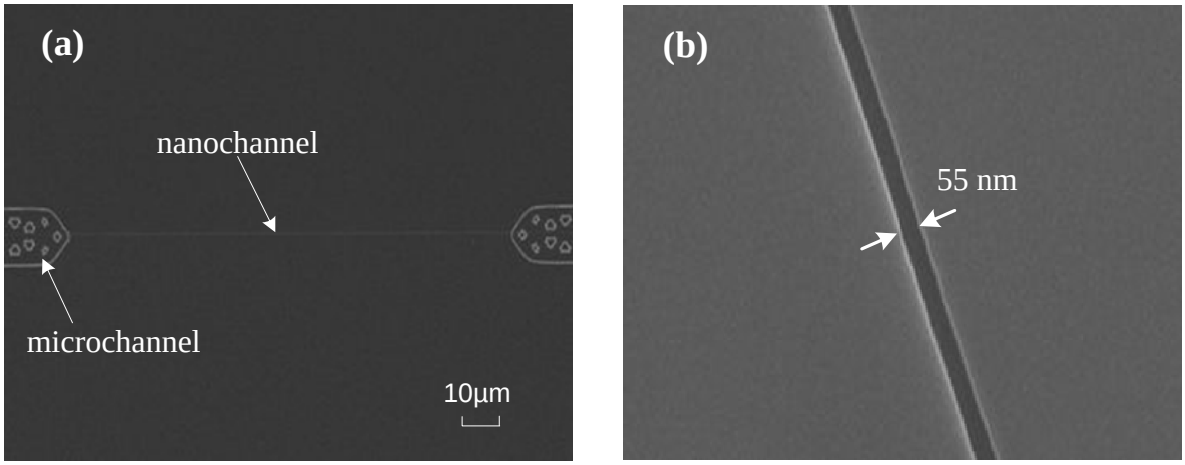

Fig.2 SEM images of (a) single nanochannel aligned and connected to the microchannel, and (b) a high-magnification image showing the 55 nm wide single-channel.

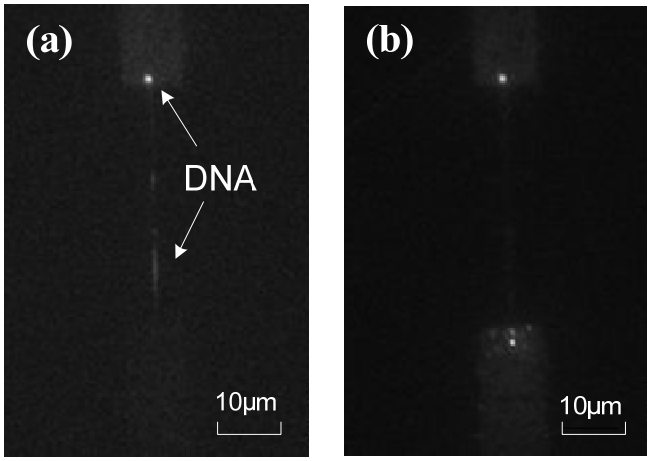

Fig.3 CCD images of fluorescent DNA molecules in single nanochannel (a) and both ends (b).

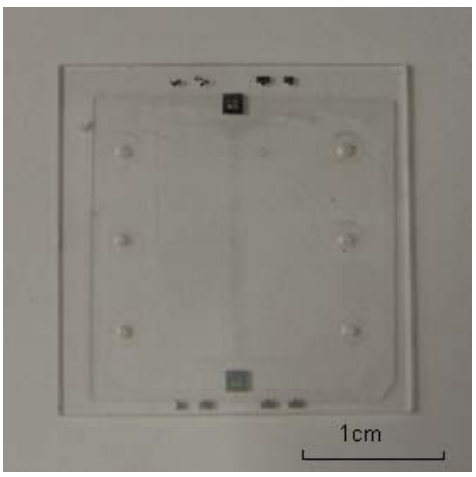

Fig.4 Optical image of a nanofluidic DNA analyzer after sealing using sodium silicate.