All-glass 12-µm Ultra-thin and Flexible Micro-fluidic Chip Fabricated by Femtosecond Laser Processing

Supplementary information

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Electronic Supplementary Material (ESI) for RSC Advances

Figure List

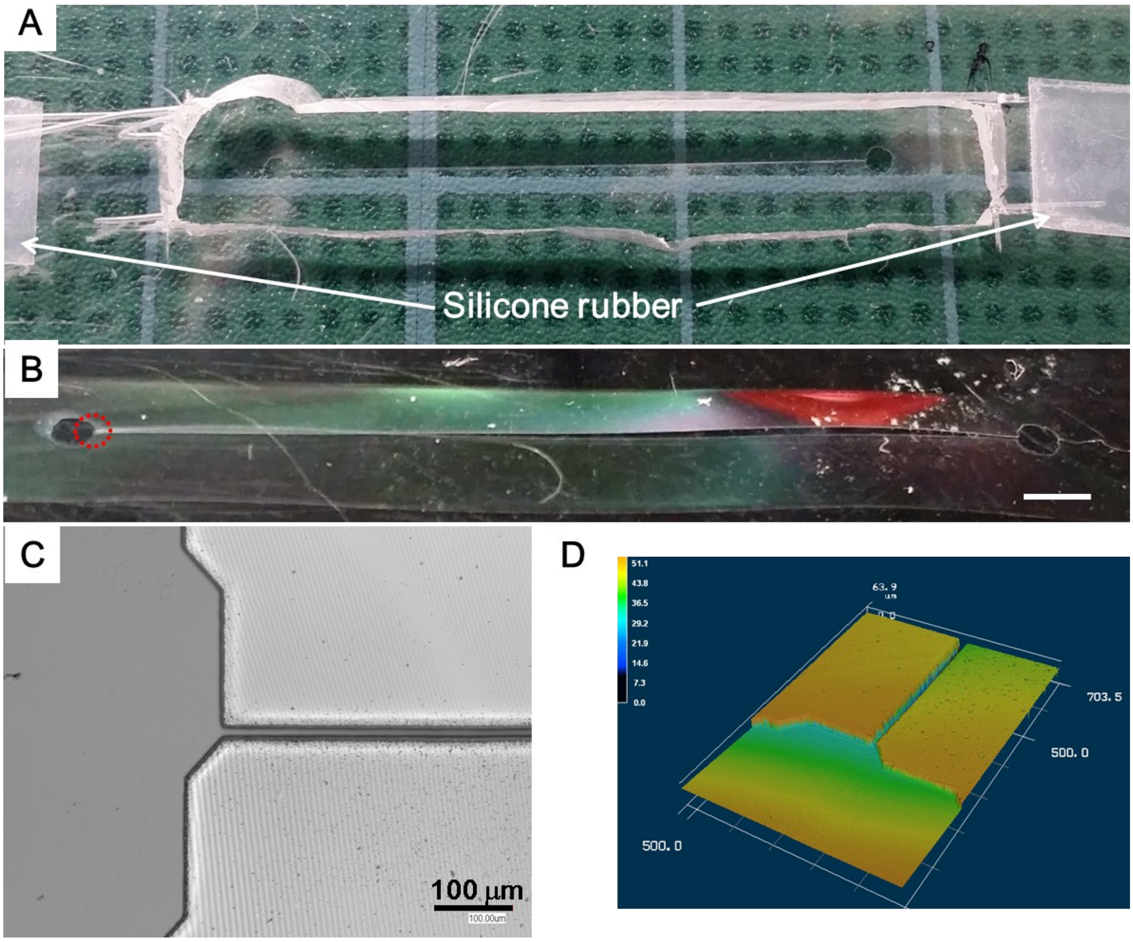

Fig. S1. Images of the fabricated layer 2 of the microchip.

(A and B) Fabricated prototype of the microchip showing the ultra-thin glass layer 2. Silicone rubber sheets on both sides of layer 2 held the layer, which otherwise tended to curl. Scale bar is 2 mm. (C) Magnified image for the area within the red dash-line circle of photograph (B) showing details of the inlet of layer 2. Scale bar is 100 μm. (D) Thickness profile (4 μm) of the prototype chip within the red dash-line circle of photograph (B). Because the glass sheet slightly curled, the maximum thickness was measured as 63.9 μm in the area of 500×703.5 μm.

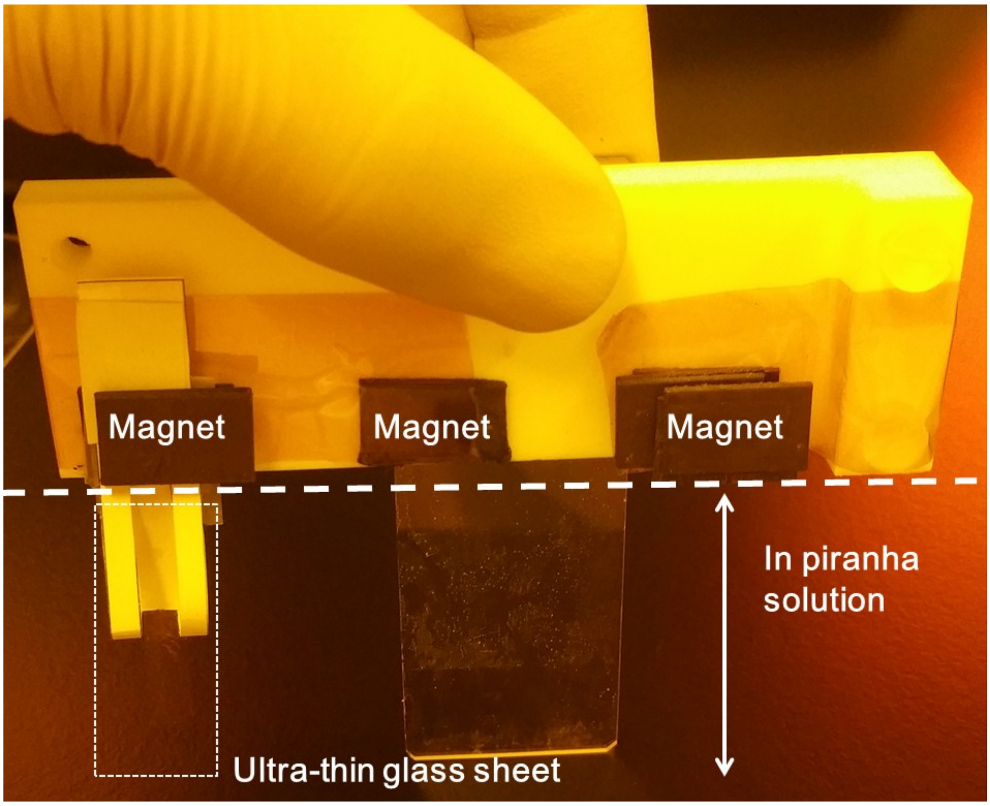

Fig. S2. Experimental jig for chemical cleaning of ultra-thin glass sheet.

A homemade jig was made for handling the ultra-thin glass sheet that uses magnets to fix the glass sheet on the upper side of the jig. The piranha solution was fed to the bottom side of the magnets. And the glass sheet was totally inserted into the solution. The glass sheet in this image was a sample to demonstrate the holding method. In the real cleaning process only the glass sheet was fixed on the upper part of the jig.

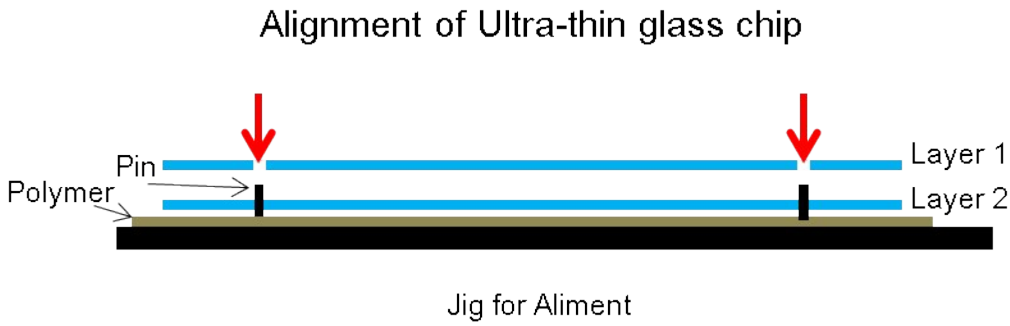

Fig. S3. The alignment jig for bonding of two layers.

The diameter of the pin was 0.5 mm, and length was approximately 2 mm. The polymer prevented the microchip contact with the substrate, which may attach to the glass chip. Also, the polymer facilitated release of the alignment microchip from the jig.

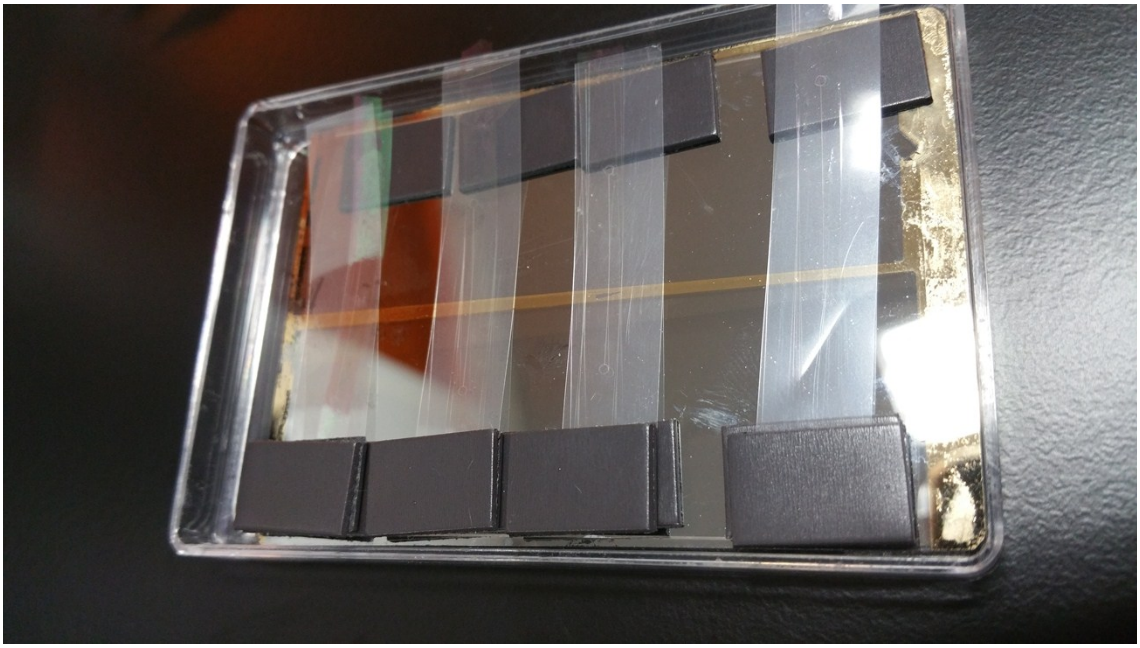

Fig. S4. Storage method for ultra-thin glass microchips.

The bonded microchips were stored between two polymer films, which prevents the microchips from attaching to a smooth surface. If the microchips contacted with a smooth surface, it was hard to pick them up because they were so thin.

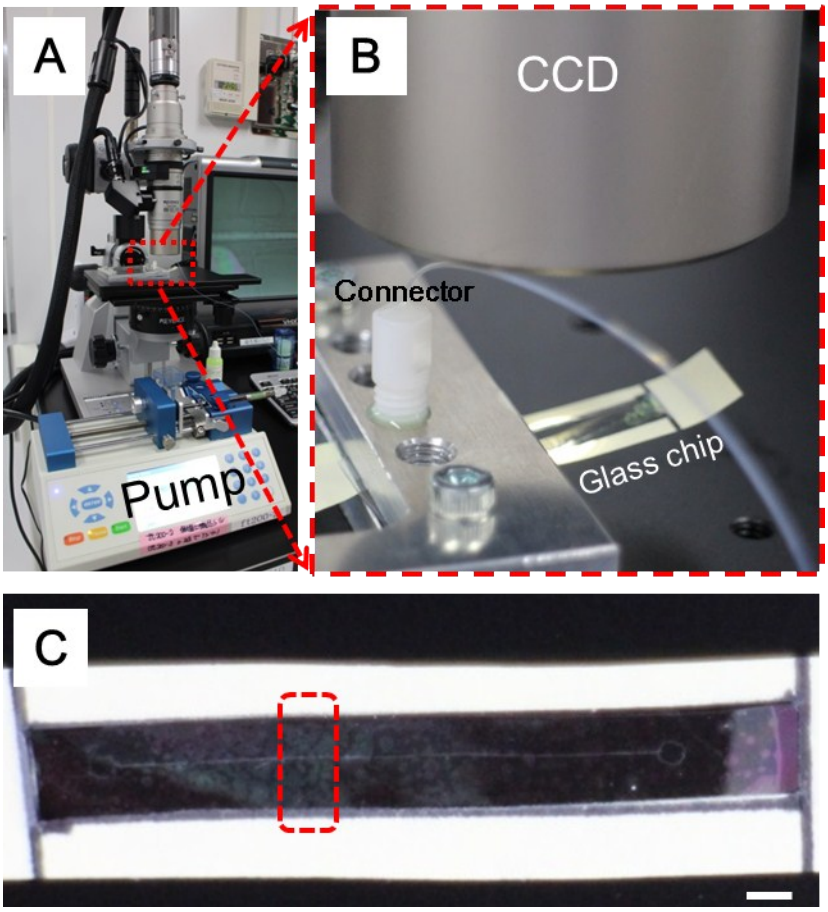

Fig. S5. Experimental setting.

(A) The experimental setup had a syringe pump and a microscope. The glass microchip was held on the microscope stage. (B) Image showing details of the area within the red dash-line square of photograph (A). The chip was connected to the syringe pump with a silicone tube and a metal jig. (C) Observations of the micro channel were made within the red dash-line rectangular area of the micro-fluidic chip. Scale bar is 2 mm.

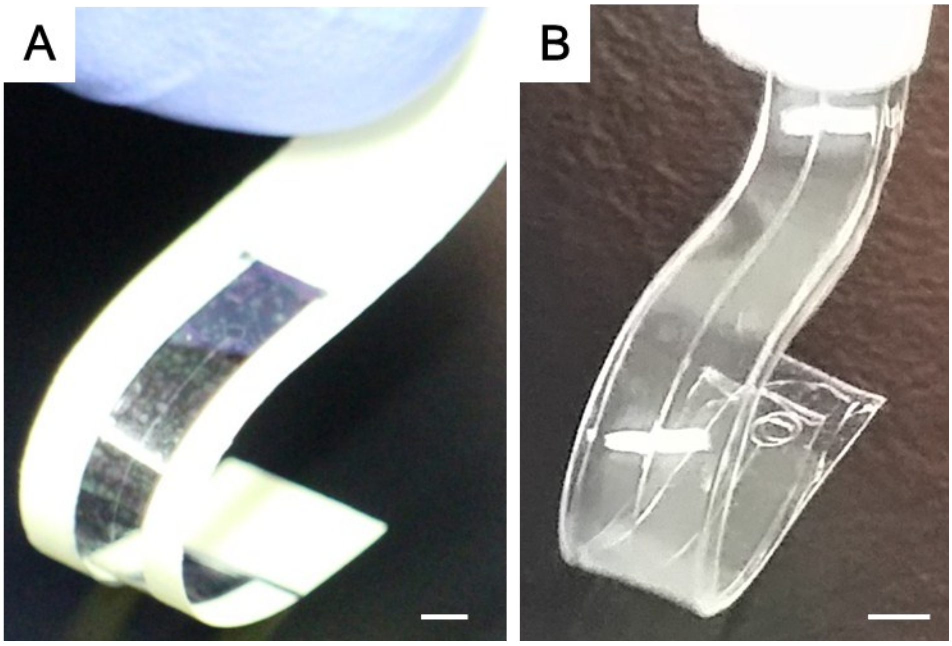

Fig. S6. Specimens for the flexibility experiment to evaluate fragility.

(A) The ultra-thin and flexible chip fabricated in this study. (B) The flexible conventional material chip of polydimethylsiloxane (PDMS) used as the control. The chips are being bent by a finger pressing onto them. The scale bars are 2 mm.

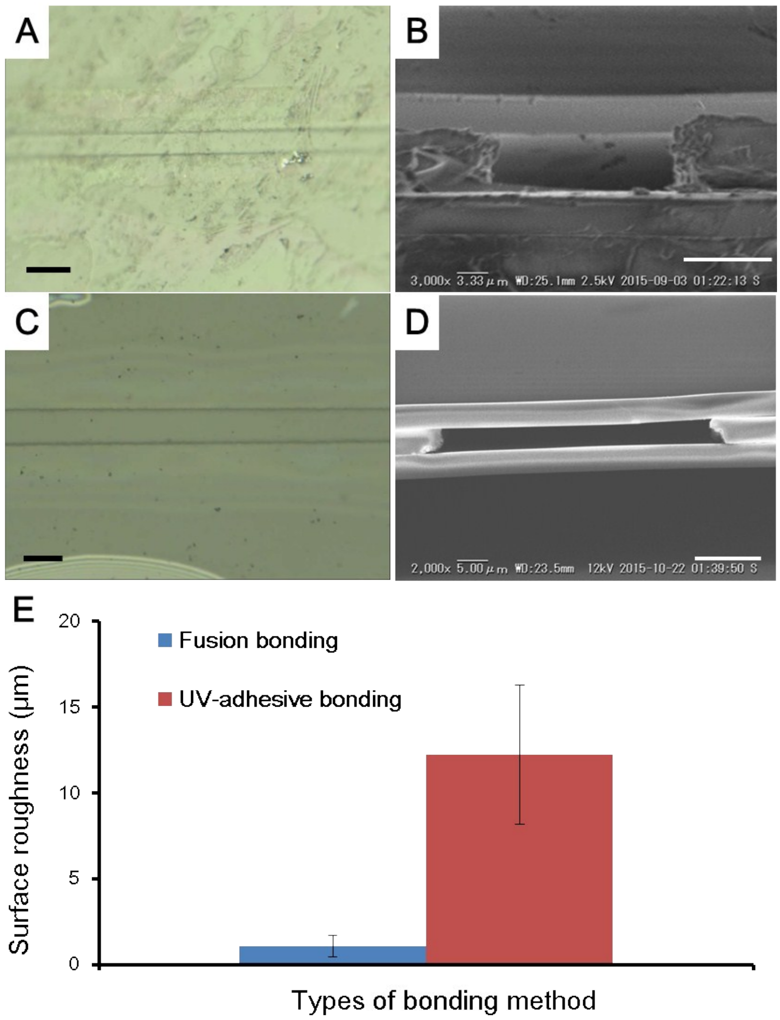

Fig. S7. The surface roughness of chips made by different bonding methods.

(A) The surface of the chip made by the UV-adhesive bonding method. (B) Cross-sectional view of the chip in (A). (C) The surface of the chip made by the fusion bonding method. (D) Cross-sectional view of the chip in (C). (E) Surface roughness comparison between the fusion bonding method and UV-adhesive bonding method. The surface roughness of 8 fusion bonded microchips and 4 UV-adhesive boned chips was measured. The black scale bars are 20 μm. The white scale bars are 10 μm.

Video List

S1. Demonstration of the fabrication process for the ultra-thin glass sheet by a femtosecond laser.

S2. Channel leakage confirmation by movement of the air-liquid interface.

S3. 1 μm bead particles flowing in the microchannel.

S4. 2 μm bead particles flowing in the microchannel.

S5. Flexibility of the ultra-thin glass microchip