Fabrication of Thin-Walled and High-Aspect-Ratio Microfluidic Channels

CNF Project # 1176-03
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Abstract:
Nanofluidic structures promise to solve the sample preparation problem in various spectroscopy experiments. The thickness of the sample is mostly constrained by the penetration depth of the optical probe. We have designed and successfully fabricated a nanofluidic cell which was used in a 2D-IR spectroscopy experiment to study the nature of the OH bond in water [1,2].

Fabrication:
The building blocks of the cell are two low-stress low-pressure chemical vapor deposition (LPCVD) silicon nitride membranes, created independently on separate wafers using wet etching of silicon. Plasma enhanced chemical vapor deposition (PECVD) of silicon oxide with subsequent photolithography/etching is used to create a buffer layer and the microfluidic channels between the nitride membranes.

In the first generation cell, the membrane thickness was 800 nm, and the cell was filled from the sides through the channels and sealed, trapping the liquid inside. In the latest version, an active control of the sample liquid is realized. Input and output holes are etched into the top wafer and connected to an external pump system. The previously 500 nm thick PECVD silicon oxide buffer layer is now 1500 nm thick in order to achieve a lower flow resistance. Additionally, 70 µm deep wet etched channels are used to connect the ‘thin’ channel area to the input/output holes further reducing the total flow resistance.

The etching of the oxide layer is now done with 6:1 buffered oxide etch (BOE) opposed to previously used reactive ion etching (RIE) providing cleaner and less rough nitride membranes. The BOE etching is highly selective at the nitride/oxide interface leaving almost no residue. A hydrophilic surface is created by high temperature deposition (LPCVD) of ~ 10 nm silicon oxide.

Summary:
Thin-walled fluidic cells with high aspect-ratio containers were fabricated. Active flow of water through 1.5 µm thick channels with 800 nm thick membrane walls is achieved.

References:


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• Free standing silicon nitride membranes.
• Bonded substrates with nitride windows enclosing microfluidic channels.
• High-aspect ratio containers.

Figure 1, above: Schematic of nanofluidic device for nonlinear spectroscopy on thin sample liquids.

Figure 2, below left: Nanofluidic cell filled with water. Edge thickness is ~1500 nm, center thickness is ~400 nm, window size 1 x 1 mm. The interference rings indicate the water layer thickness.

Figure 3, below right: Access hole and wet etched channel. Wet KOH etching is used to create a 70 µm deep channel connecting the access holes to the only 1500 nm thick channels in the window/membrane area.