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

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Abstract
Nanofluidic structures promise to solve the sample preparation problem in various spectroscopy experiments where the thickness of the sample is usually constrained by the penetration depth of the optical probe. We have designed and successfully fabricated a nanofluidic cell which was used in a two-dimensional infrared (2D-IR) spectroscopy experiment to study the nature of the OH bond in water [1, 2]. The fabricated structure employs a system of access holes and channels used for sample delivery and active thickness control.

Summary of Research
The building blocks of the nanofluidic cell are two free standing membranes of low stress silicon nitride back-etched on separate wafers using potassium hydroxide (KOH). A silicon oxide spacer deposited on one wafer was used to define a gap between the silicon nitride membranes when the matching pieces of the structure are bonded together. The etching of the silicon oxide layer to create the actual gap is done with 6:1 buffered oxide etch (BOE). In the first generation cell, the thicknesses of the silicon nitride windows were 800 nm, and the cell was filled from side channels, then sealed, trapping the liquid inside. In such a passive approach, the instability of the thin silicon nitride membranes leads to a poorly defined sample thickness.

In recent designs, input and output access holes were etched into the surface of the structure as shown in Figure 1, then connected to an external pump system. The active control of the gap thickness was realized using the transmitted intensity of an IR beam through the cell as feedback signal. In addition, a 70 µm deep KOH etched channels were used to connect the narrow gap to the access holes therefore restricting the high flow resistance region to the sample area. Lastly, a hydrophilic surface is created by high temperature deposition (LPCVD) of ~ 10 nm silicon oxide [3] in order to enhance the filling of the cell. An assembled cell filled with water is shown in Figure 2. The variation in sample thickness is most apparent from the interference rings.

References
**Figure 1:** Schematic of nanofluidic device for nonlinear spectroscopy on thin sample liquids.

**Figure 2:** Nanofluidic cell filled with water. Edge thickness is ~1500 nm, center thickness is ~400 nm, window size 1 x 1 mm.