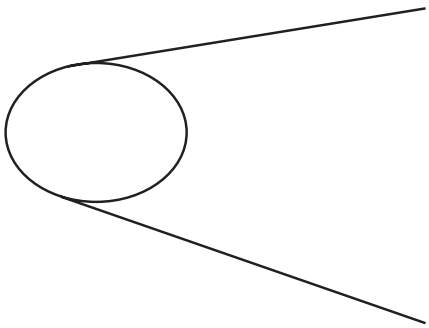

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FY2005 Accomplishments and Results

During FY2005, we reached milestones that include novel five-/seven-layer silicon/glass anodic bonding, specialized glass etching, and immiscible-fluid mixing. An overarching technical challenge was to construct a multilayer (> 4) glass/silicon structure.

Demonstration of novel processing approaches allowed for the bonding of multiple multilayered sets, such as bonding a three-layered bonded set (glass/silicon/glass) to a two-layered bonded set (Fig. 1). Fracture testing of the bond demonstrated that the glass/silicon interface was stronger than the Pyrex glass, confirming the reliability of the novel anodic bond process.

A five-layer prototype was built using acetate overlay masks for photolithography as an attempt to reduce fabrication costs and prototyping time. The devices suffered from inadequate photolithographic r esolution due to UV masking limitations, causing irregular silicon structures and fluid flow. Shifting to laser-cut polymer masking materials for glass etching and conventional glass/chrome masks for silicon etching eliminated these problems (see Figs. 2 and 3).

It is now possible to fabricate an out-of-plane modularized, multilayered, glass/silicon microdevice. Each layer performs a distinct function; therefore, simply adding additional layers can extend the functionality of the device. The packaging uses O-ring compression fitting to introduce and extract fluids to/from the device, eliminating the necessity for glue or epoxy to connect off-chip fluidic I/O (Fig. 4).

A key element of the micromixer is the ability for direct visual diagnostics during mixing. The glass/silicon structure provides a glass-viewing window of the emulsion chamber and linear-mixing channel, which affords visual confirmation of mixing (in conjunction with fluorescent/colored dyes) prior to chemical analysis of solute concentrations.

A multilayer, modular, fluidic micromixer device was fabricated and tested as a first order sample preparation/purification bio-instrument. Preliminary results of the device demonstrate good mixing of aqueous solutions (aqueous color dye solution and plain DI water) for modest-pulsed inlet pressures (~30 psi).

Related References

1. Lingeman, H., *et al.*, •Sample Preparation for Peptides and Proteins in Biological Matrices Prior to Liquid Chromatography and Capillary Zone Electrophoresis,Ž *Anal. Bioanal. Chem.* **382**, pp. 535-558, 2005.

2. Kirner, T., *et al.*, •Static Micromixers for Modular Chip Reactor Arrangements in Two-Step Reactions and Photochemical Activated Processes,Ž *Chemical Engineering Journal* **101**, pp. 65-74, 2004.

3. Lemenand, T.,*et al.*, •Droplets Formation in Turbulent Mixing of Two Immiscible Fluids in a New Type of Mixer,Ž *International Journal of Multiphase Flow* **29**, pp. 813-840, 2003.

(a) (b)

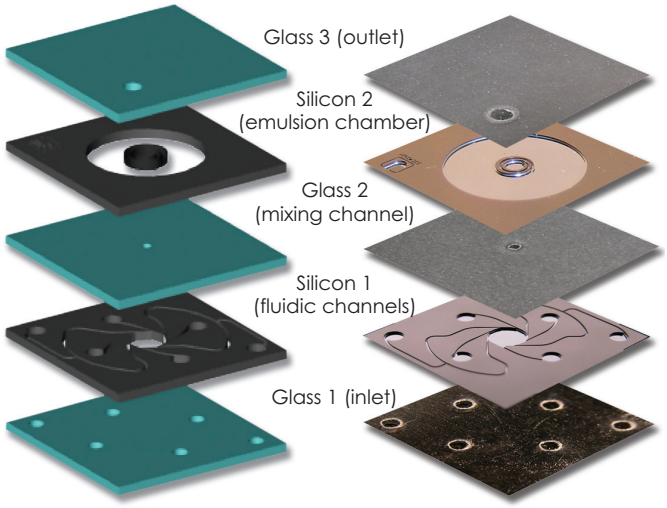

Figure 3. (a) Composite diagram and (b) photograph of five-layer mixer.

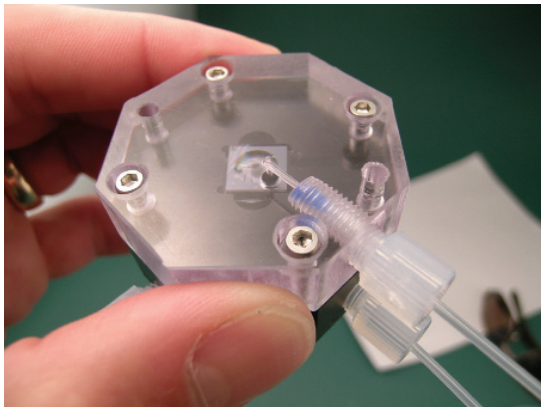

Figure 4. Photograph of custom fluidic I/O packaging with device at center.