



Fabricating High-Resolution X-Ray Collimators

Goddard Space Flight Center, Greenbelt, Maryland

A process and method for fabricating multi-grid, high-resolution rotating modulation collimators for arcsecond and sub-arcsecond x-ray and gamma-ray imaging involves photochemical machining and precision stack lamination. The special fixturing and etching techniques that have been developed are used for the fabrication of multiple

high-resolution grids on a single array substrate.

This technology has application in solar and astrophysics and in a number of medical imaging applications including mammography, computed tomography (CT), single photon emission computed tomography (SPECT), and gamma cameras used in nuclear medi-

cine. This collimator improvement can also be used in non-destructive testing, hydrodynamic weapons testing, and microbeam radiation therapy.

This work was done by Michael Appleby, James E. Atkinson, Iain Fraser, and Jill Klinger of Mikro Systems, Inc. for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15275-1

Embossed Teflon AF Laminate Membrane Microfluidic Diaphragm Valves

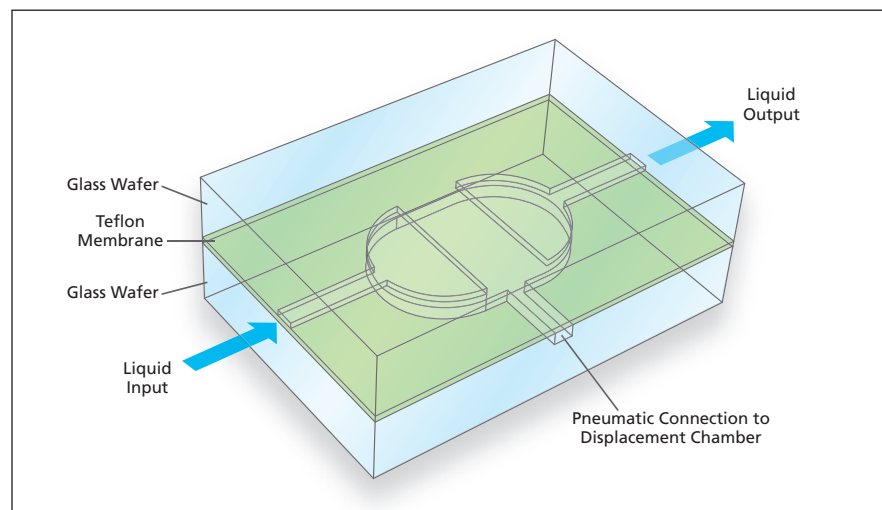
A new fabrication strategy for valve manifolds uses flexible, durable materials.

NASA's Jet Propulsion Laboratory, Pasadena, California

A microfluidic system has been designed to survive spaceflight and to function autonomously on the Martian surface. It manipulates microscopic quantities of liquid water and performs chemical analyses on these samples to assay for the presence of molecules associated with past or present living processes. This technology lies at the core of the Urey Instrument, which is scheduled for inclusion on the Pasteur Payload of the ESA ExoMars rover mission in 2013.

Fabrication processes have been developed to make the microfabricated Teflon-AF microfluidic diaphragm pumps capable of surviving extreme temperature excursions before and after exposure to liquid water. Two glass wafers are etched with features and a continuous Teflon membrane is sandwiched between them (see figure). Single valves are constructed using this geometry.

The microfabricated devices are then post processed by heating the assembled device while applying pneumatic pressure to force the Teflon diaphragm against the valve seat while it is softened. After cooling the device, the "embossed" membrane retains this new shape. This solves previous problems with bubble introduction into the fluid flow where deformations of the membrane at the valve seat occurred during device bonding at el-



The **Valve Assembly** consists of two glass wafers with a continuous Teflon membrane sandwiched between them.

evated temperatures (100–150 °C). The use of laminated membranes containing commercial Teflon AF 2400 sheet sandwiched between spun Teflon AF 1600 layers performed best, and were less gas permeable than Teflon AF 1600 membranes on their own.

Spinning Teflon AF 1600 solution (6 percent in FLOURINERT® FC40 solvent, 3M Company) at 500 rpm for 1.5 seconds, followed by 1,000 rpm for 3 seconds onto Borofloat glass wafers, results in a 10-micron-thick film of ex-

tremely smooth Teflon AF. This spinning process is repeated several times on flat, blank, glass wafers in order to gradually build a thick, smooth membrane. After running this process at least five times, the wafer and Teflon coating are heated under vacuum at 220 °C for one hour in order to drive off any residual solvent present in the composite film. After this, a second blank, glass wafer is brought down from above and the stack is held under vacuum at 3 atm mechanical pressure for ten 10 hours.

These membranes are released from the bonding stack by placing the whole stack in 49-percent HF solution, which dissolves the glass wafers completely. After thorough rinsing and drying, the membrane is ready for bonding in a device by holding it under 3 atm pressure and temperatures of at least 120 °C for 10 hours.

Microfabricated devices are mounted onto an aluminum baseplate that rests on a hot plate. The entire assembly is positioned underneath a binocular optical microscope for real-time visual inspection. Pneumatic connections are made to the valve input, output, and

displacement chamber via Tygon tubing. Air pressure of 10 psi (69 kPa) is applied to the underside of the membrane, and the device is slowly heated. A slight pressure [0.5 psi (35 kPa)] is applied to the input gas connection, and the output is directed into a beaker of water. When the temperature rises to approximately 160 °C in the membrane area, the flow rate through the valve (i.e., bubbles forming in beaker per unit time) drops sharply and shifting patterns of Newton rings can be observed in the valve seat. After cooling the device to room temperature, the single valve sealing characteristics are

drastically improved. The liquid flow rate through the device is measured as a function of pressure in the displacement chamber for a given applied input pressure of 0.5 psi (35 kPa). Flow rates are determined by measuring time required to fill a known tube volume. Embedding a higher melting temperature Teflon AF polymer core in the center of the membrane improved valve performance further.

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