MEMS Micro-vacuum Pump for Portable Gas Analyzers
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There are many advantages to miniaturizing systems for chemical and biological analysis. Recent interest in this area has led to the creation of several research programs, including a Micro Gas Analyzer (MGA) project at MIT. The goal of this project is to develop an inexpensive, portable, real-time, and low-power approach for detecting chemical and biological agents. Elements entering the MGA are first ionized, then filtered by a quadrupole array, and sensed using an electrometer. A key component enabling the entire process is a MEMS vacuum pump, responsible for routing the gas through the MGA and increasing the mean free path of the ionized particles so that they can be accurately detected.

A great deal of research has been done over the past 30 years in the area of micro pumping devices [1, 2]. We are currently developing a displacement micro-vacuum pump that uses a piezoelectrically driven pumping chamber and a pair of piezoelectrically driven active-valves; the design is conceptually similar to the MEMS pump reported by Li et al. [3]. We have constructed an accurate compressible mass flow model for the air flow [4] as well as a nonlinear plate deformation model for the stresses experienced by the pump parts [5]. Using these models, we have defined a process flow and fabricated five generations of the MEMS vacuum pump over the past years and are currently working on improving the overall design.

Figure 1 shows a schematic of the pump. For ease in testing we have initially fabricated only layers 1-3 and have constructed a testing platform which, under full computer control, drives the pistons and monitors the mass flows and pressures at the ports of the device. The lessons learned from the first four generations of the pump have led to numerous improvements. Every step from the modeling, to the etching and bonding, to the testing has been modified and improved along the way. The most recent fifth generation pump test data appears in Figure 2. Figure 2a shows the measurements of the vacuum being generated in an external volume (5.6cm³) by the micropump operating at 2Hz. The pump was able to reduce the external volume pressure by 163 Torr. Figure 2b shows the micropump-generated flow rate as a function of pumping frequency (driven in a 6-stage cycle by a controlling microprocessor to move the gas from the input to the output). The performance of this pump compares very well with that of other similar scaled micropumps in the literature. Next, we plan to fabricate and test an improved overall design and develop a final set of models to fabricate any future micropumps to the desired specifications.

REFERENCES