MEMS Vacuum Pump

V. Sharma, M.A. Schmidt
Sponsorship: DARPA

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.

There has been a great deal of research 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 constructed accurate computer models for all aspects of the pump’s operation: a compressible mass flow model of the flow rates, the pressure, the density, and the Mach number in the different parts of the pump in both the sonic and subsonic regimes [4], and a nonlinear plate deformation model of the stresses experienced by the pistons, tethers, and walls of the pump during operation [5], for any chosen dimensions and material properties.

Using these models we have defined a process flow for our first-generation MEMS vacuum pump designed to meet our first-term goals. A schematic of this pump that we started fabricating is shown in Figure 1 below. For ease in testing we have decided to fabricate only Layers 1-3 and constructed a testing platform that will drive the pistons pneumatically. This will allow for rapid characterization of pumping performance as well as chamber and valve designs for several dies at once without having to incorporate piezos in each case. The final device will be driven using low-voltage, low-loss, piezoelectric-stacks incorporated into Layer 4 and will include Layer 5 for structural support.

Figure 1: Schematic of the MEMS vacuum pump. Layers 1 and 4 are glass, Layer 2 forms the chambers and channels using double-side polished silicon, Layer 3 forms the pistons and tethers being silicon-on-insulator, and Layer 5 is single-polished silicon. For testing and characterization, only Layers 1-3 are being fabricated.

REFERENCES