# Process Flow Design Challenge: Thermal Pneumatic Actuator

A thermal pneumatic actuator consists of a sealed cavity bounded on one side by a deformable, corrugated (wavy) membrane and on the other side by a surface with an ohmic heater. When the heater is turned on, the air inside the cavity heats up, expands, and makes the deformable membrane bulge out. Your team's job is to design a fabrication process flow to create such a device. The cross sections are shown below.

The membrane is 2 μm thick, 4 mm on a side, and is patterned out of a 450 μm thick silicon wafer. The cavity depth is 5 μm. You may choose the detailed cross-sectional profile of the corrugations, but they should be concentric circles with a wavelength of 250 μm and a depth of 10 μm. The heater should be made of gold and patterned on a Pyrex wafer.

With your team, first sketch out a process flow and mask set; then fill in the details as far as possible. After each team has a chance to work on the process flow, a team or teams will be chosen to present their solution(s) to the class. If your team is not chosen to present its design, your job will be to critique the process that is presented.
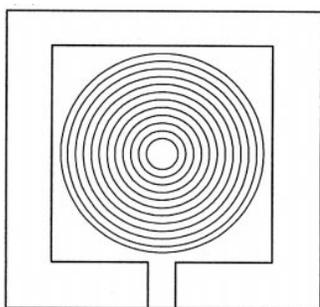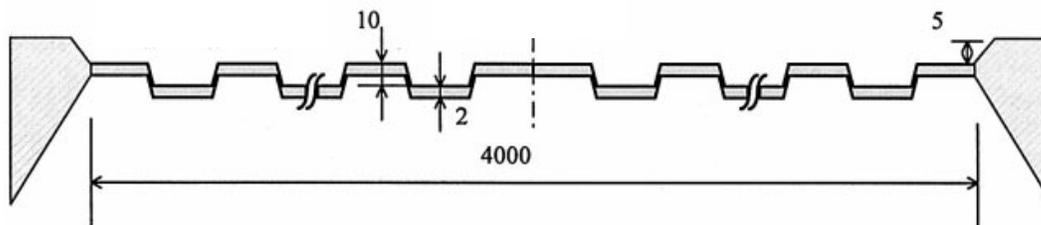

Top view of silicon wafer containing corrugated membrane
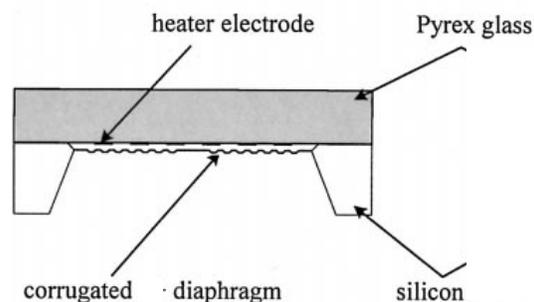
Cross section of complete device

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Figure 1a) on p. 63 in: Jeong, O. C., and S. S. Yang. "Fabrication of a Thermopneumatic Microactuator with a Corrugated p+ Silicon Diaphragm." *Sensors and Actuators A: Physical* 80, no. 1 (2000): 62-67.

Close up cross-section of silicon wafer containing corrugated membrane

(unit : μm)

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Figure 2 on p. 63 in: Jeong, O. C., and S. S. Yang. "Fabrication of a Thermopneumatic Microactuator with a Corrugated p+ Silicon Diaphragm." *Sensors and Actuators A: Physical* 80, no. 1 (2000): 62-67.

This problem is based on a real device written up in the following paper; the cross sections are from the paper as well.