

✚ Silicone-Rubber Microvalves Actuated by Paraffin

Relative to other microvalves, these would be simpler.

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Microvalves containing silicone-rubber seals actuated by heating and cooling of paraffin have been proposed for development as integral components of microfluidic systems. In comparison with other microvalves actuated by various means (electrostatic, electromagnetic, piezoelectric, pneumatic, and others), the proposed valves (1) would contain simpler structures that could be fabricated at lower cost and (2) could be actuated by simpler (and thus less expensive) control systems.

Each valve according to the proposal would include a flow channel bounded on one side by a flat surface and on the other side by a curved surface defined by an arched-cross-section, elastic seal made of silicone rubber [polydimethylsilane (PDMS)]. The seal would be sized and shaped so that the elasticity of the PDMS would hold the channel open except when the seal was pressed down onto the flat surface to close the channel.

The principle of actuation would exploit the fact that upon melting or freezing, the volume of a typical paraffin increases or decreases, respectively, by about 15 percent. In a valve according to the proposal, the seal face opposite that of the channel would be in contact with a pistonlike plug of paraffin. In the case of a valve designed to be normally open at ambient temperature, one would use a paraffin having a melting temperature above ambient. The seal would be pushed against the flat surface to close the channel by heating the paraffin above its melting temperature. In the case of a valve designed to be normally closed at ambi-

ent temperature, one would use a paraffin having a melting temperature below ambient. The seal would be allowed to spring away from the flat surface to open the channel by cooling the paraffin below its melting temperature. The availability of paraffins that have melting temperatures from -70 to $+80$ °C should make it possible to develop a variety of normally closed and normally open valves.

The figure depicts examples of prototype normally open and normally closed valves according to the proposal. In each valve, an arch cross section defining a channel having dimensions of the order of tens of micrometers would be formed in a silicone-rubber sheet about 40 μm thick. The silicone-rubber sheet would be hermetically sealed to a lower glass plate that would define the sealing surface and to an upper glass plate containing a well. The well would be filled with paraffin and capped with a rigid restraining layer of epoxy. In the normally open valve, the paraffin would have a melting temperature above ambient (e.g., 40 °C) and

the wall of the well would be coated with a layer of titanium that would serve as an electric heater. In the normally closed valve, the paraffin would have a melting temperature below ambient (e.g., -5 °C). Instead of a heater in the well, the normally closed valve would include a thermoelectric cooler on top of the epoxy cap.

This work was done by Danielle Svelha, Sabrina Feldman, and David Barsic of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

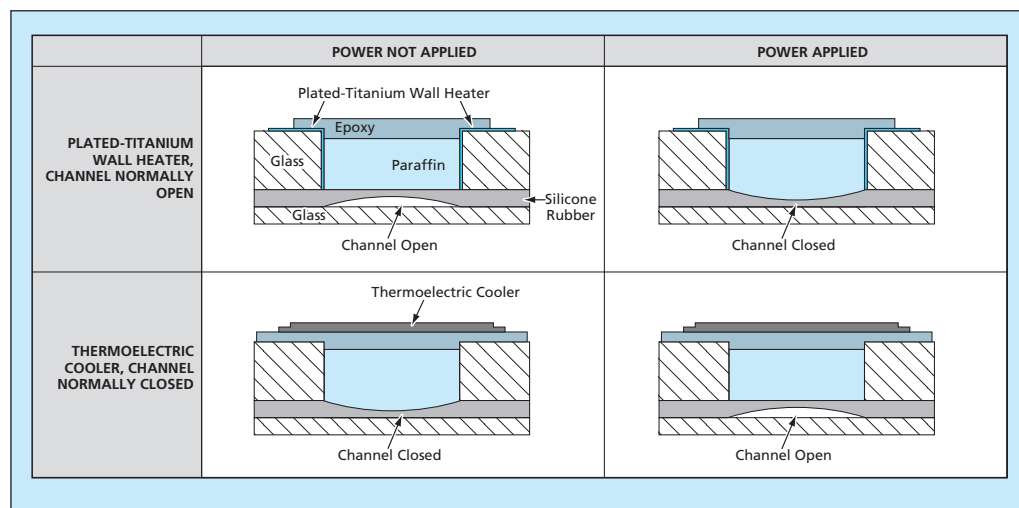
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Normally Open and Normally Closed Microvalves would both exploit the large changes in volume of paraffin that occur upon melting and freezing.