Combining Shape Memory Alloys and Microfluidic Chips on Printed Circuit boards

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Integrated multi-layer fluidic chips, with hundreds of elastomeric valves, are useful in immunoassays, protein crystallization, cell culture and several other applications. Although the devices are micro-scale, because valves are actuated pneumatically, each chip requires a relatively large pneumatic control system for operation. Fulfilling the great promise of microfluidics, for instance building throwaway, portable, massively parallel, point-of-care diagnostic systems is unlikely until there is a solution for actuating micro-valves electrically. We introduce a combination of materials—shape memory alloys (SMAs) and elastomersto solve this problem. SMAs offer among the highest work per unit volume of any actuator, and elastomers have the ability to absorb the energy and return the SMA to its original configuration, while providing electric and thermal insulation. Using this marriage of materials, with PDMS (elastomer) and Ni/Ti wires (SMA), we built electrically activated micro-fluidic valves, peristaltic pumps and multiplexers. The first generation valve design needs 50 to 250 mA current in the on state, with power requirements of about 0.5 W. It can hold back >1 atmosphere of pressure and run for thousands of cycles, actuating at sub-second speeds. The dead volume is <1 nano-liter. Crucially, these devices are assembled on printed circuit boards, like conventional electronic components. Thus, the technology used in assembling electronics is applicable to assembling fluidic chips, and both electronics and fluidics can be integrated on one platform for biomedical applications.