Large-Scale Integration of Solid-State Microfluidic Pumps and Valves With No Moving Parts

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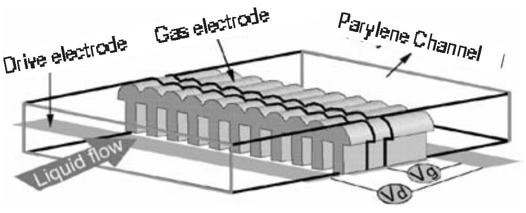

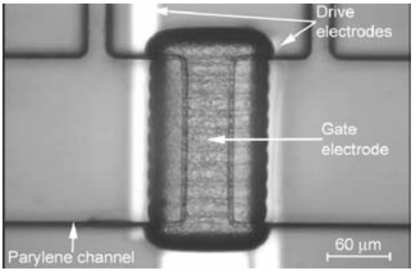

Left – Schematic of a new flow field effect transistor (flowFET). Right – Top view of a fabricated flowFET.

The large-scale integration of microfluidic components is impeded by the lack of reliable and simple pumping/valving systems. This project is aimed at developing options based on electro-osmotic pumps in a practical microfluidic platform. Current electro-osmotic pumps have two main problems: bubble generation due to electrolysis, and pressure driven flow dominance over electro-osmotic flow. Approaches based on new materials, electrode placements, and electrical drive schemes are being developed to solve these problems. A liquid bridge configuration has been developed to allow the application of DC voltages to drive porous polymer electro-osmotic pumps without any bubble generation problems. Flow rate up to 1.76nL/min with a maximum pressure head of 1673Pa have been achieved at 50V DC. A new device called flow field effect transistor (flowFET) permits high-speed unidirectional flow to be achieved with a AC drive voltage, and is consequently bubble-free. It operates by synchronously modulating the zeta potential in a “gate” region of the channel using a separate voltage signal. An initial implementation provided a flow-rate of 16nL/min with a pressure head of 2.3Pa in response to a 1KHz AC square signal with a magnitude of 17V. The development of the special materials for some of the pumps was done in collaboration with U.C. Berkeley, Chemistry Department. This project is supported by DARPA Bioflips program.