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Valving and Sensing Technologies for Microfluidics: Electrostatic Microvalves

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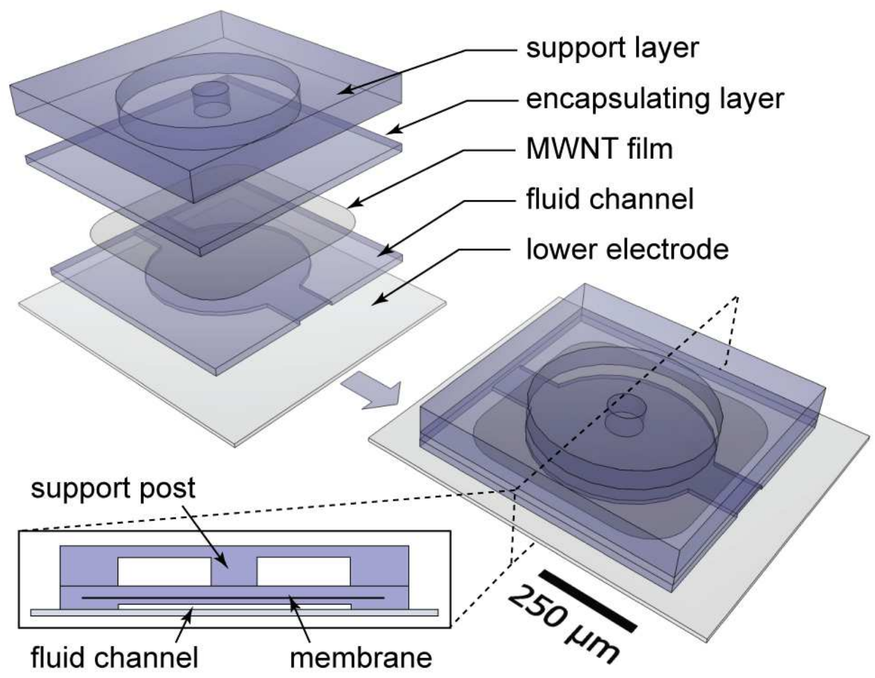
Goals

Develop and characterize a microvalve that is actuated with electrostatic forces and easily integrated into microchemical systems.



Mapping to Center's Objectives

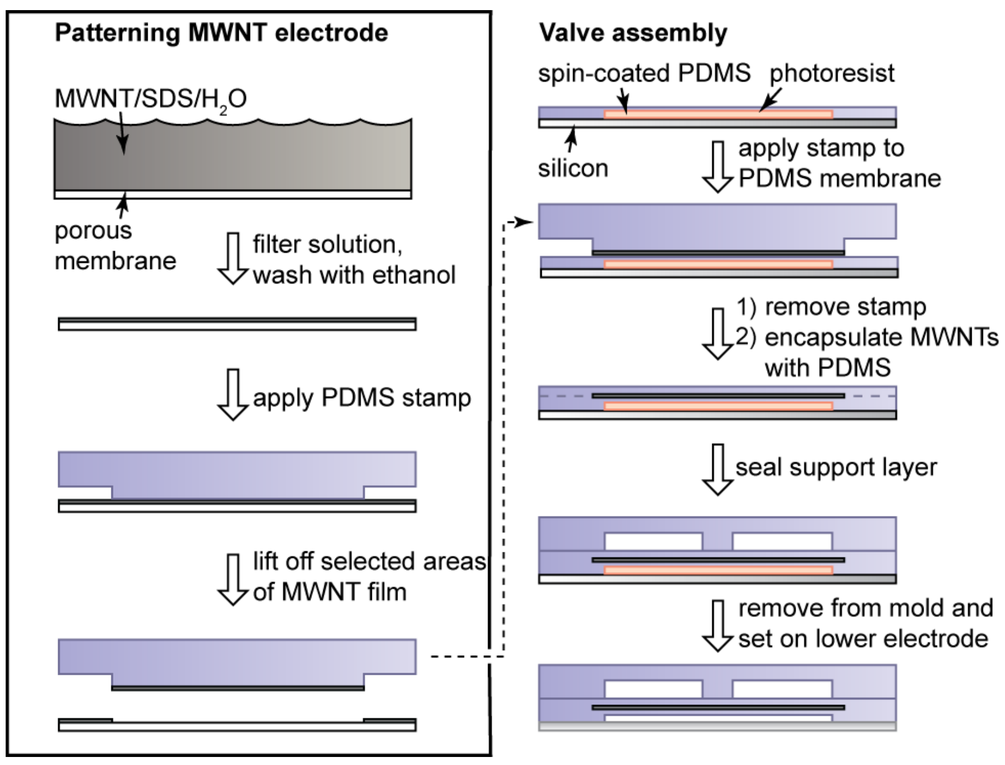
- Enable fluid routing and pumping on nano-manufacturing toolbit.
- Simplify ancillaries and interfacing needed to operate toolbit.

Research Plan

- Model microvalve to identify critical design parameters and predict effective design space to minimize actuation potentials.
- Develop a fabrication process utilizing soft-lithographic techniques.
- Optimize microvalve for operation in nano-manufacturing toolbit.

Fundamental Questions / Challenges

How to integrate electrodes into microvalve architecture using only simple fabrication techniques at ambient pressure / temperature?



Research Results

Modeling using semi-analytical approach:

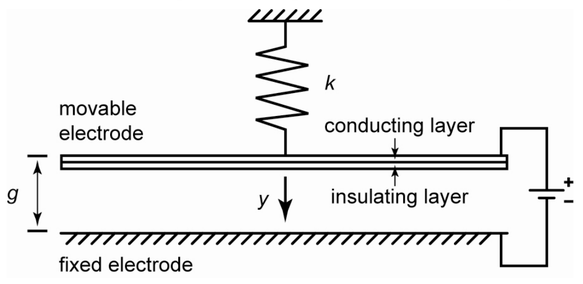
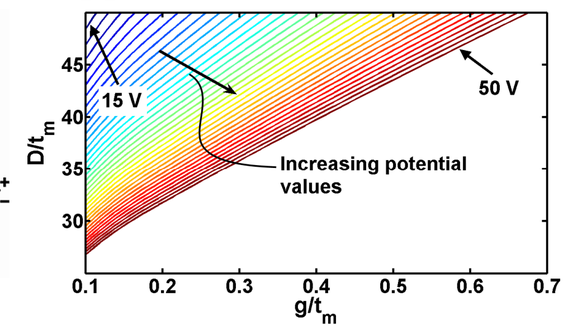


Diagram of parallel-plate actuator used as model

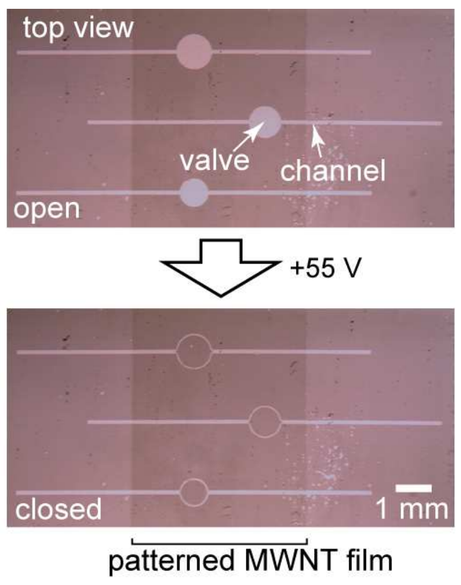


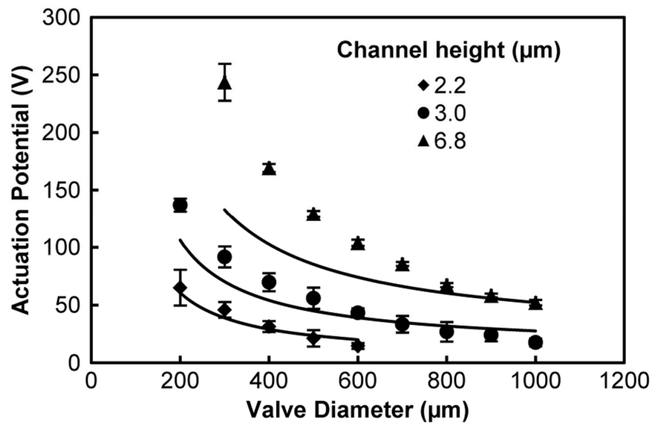
Predicted design space for microvalves actuated with < 50V

Parameter	Order of dependency		Design range
	Stable region	*Snap-in*	
Diameter, D	-2	-2	300-1000 µm
Membrane thickness, t_m	2.5	3	10-50 µm
Electrode gap, g	0.5	1.5	1-15 µm
Dielectric constant of fluid, ε_{fluid}	0.5	1	--

Parameters identified by model with greatest effect on actuation potentials.

Microvalve actuation and characterization:

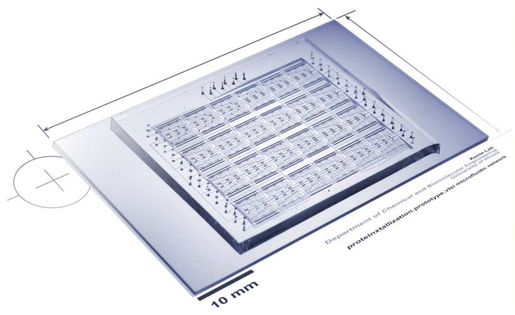




Left: micrographs of microvalves in the open and closed state. Above: actuation potentials for microvalves compared with model predictions.

Broader Impact

- Point-of-care diagnostics
- Portable lab-on-a-chip
- Automated high-throughput screening
- Wireless chemical monitoring



Interaction with Other Projects

- Microfluidic interface for E-Jet printing.
- Fluidic components integrated with optical sources for sensing.

Future Efforts

- Test valve with relevant printable fluids.
- Construct microvalve array to pump and route fluids on print head.

Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems

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