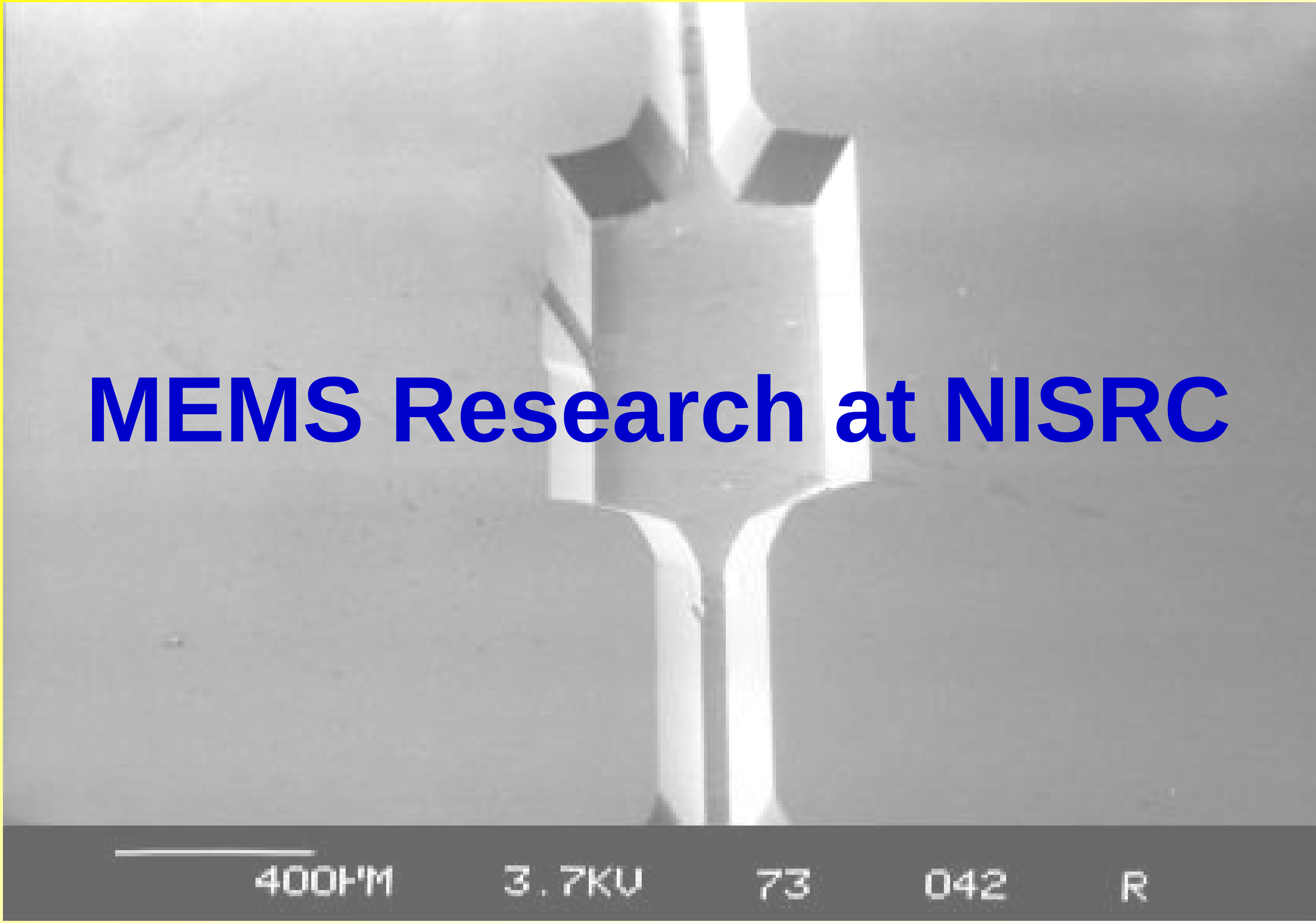
MEMS Research at NISRC



Microelectromechanical Systems (MEMS)

MEMS **are miniaturised components or devices. They may be Electrical, Mechanical or Fluidic.**

Applications :- Sensors ; Actuators

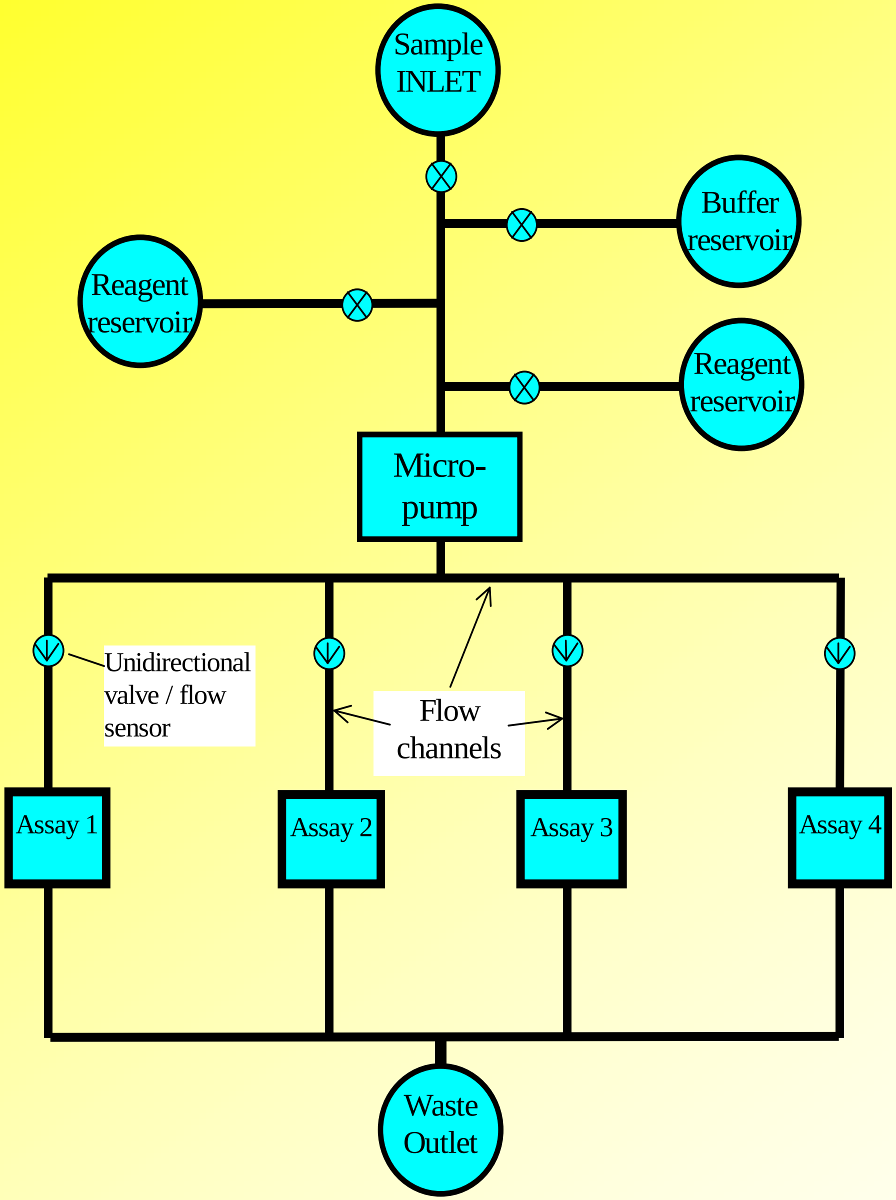
Examples :- Pressure Sensors, Accelerometers, Position Detectors, Micromotors, Chemical Microlabs.

Microfluidics, pumps, valves.

Micromachining

Micromachining is a set of processes that enables fabrication of *MEMS* devices which includes bulk or surface machining techniques.

Microfluidic Systems

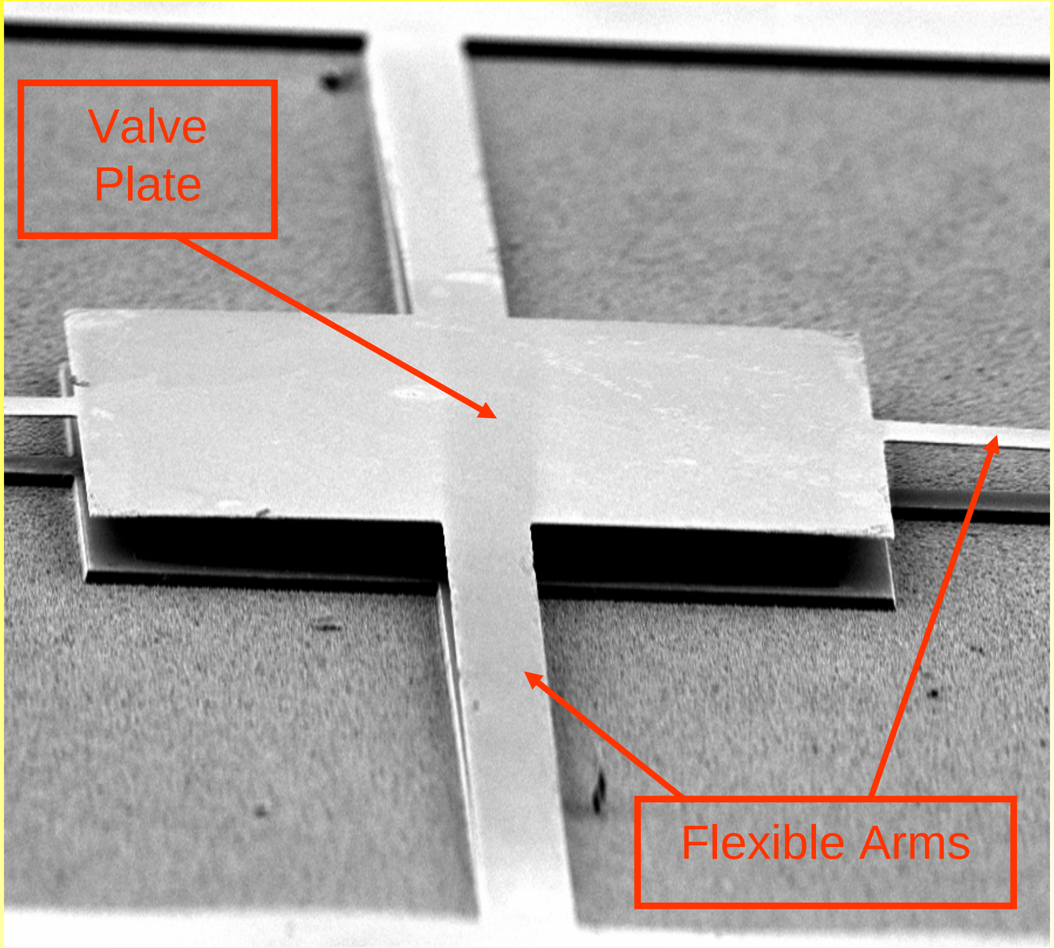


- **Integrated chemical analysis.**
- **"Lab-on-a-chip"**
- **Chemical micro-analysers.**
- **Chemical micro-synthesis.**

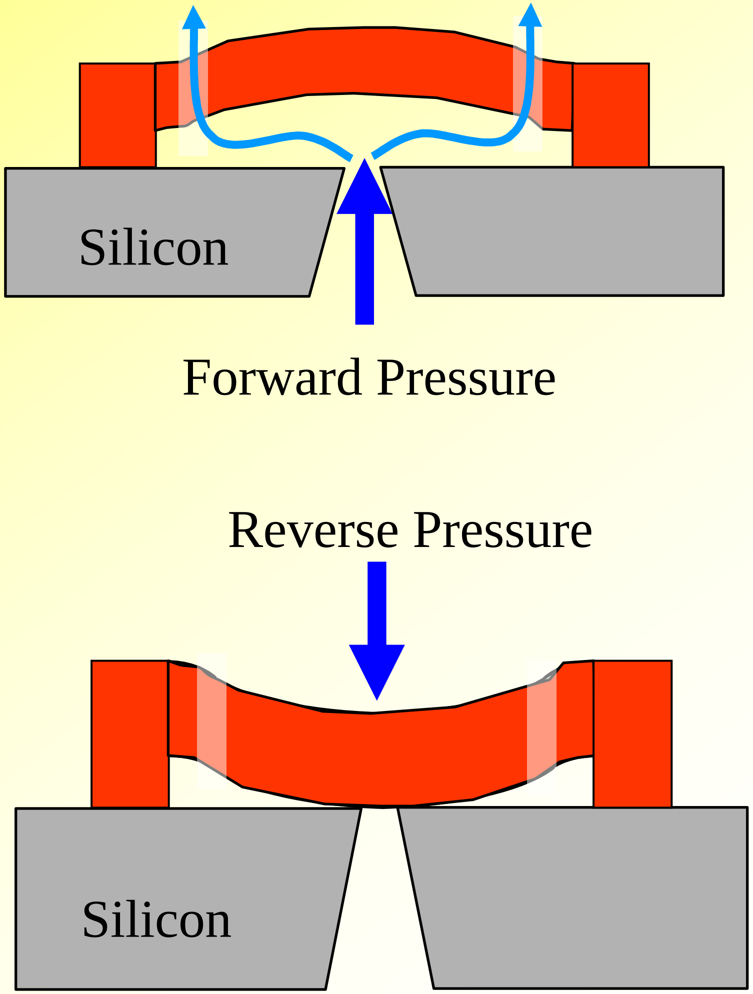
Advantages

- **Low reagent & sample volumes.**
- **Fast analysis.**
- **Portable.**
- **High surface area to volume ratio.**
- **Good Heat transfer.**

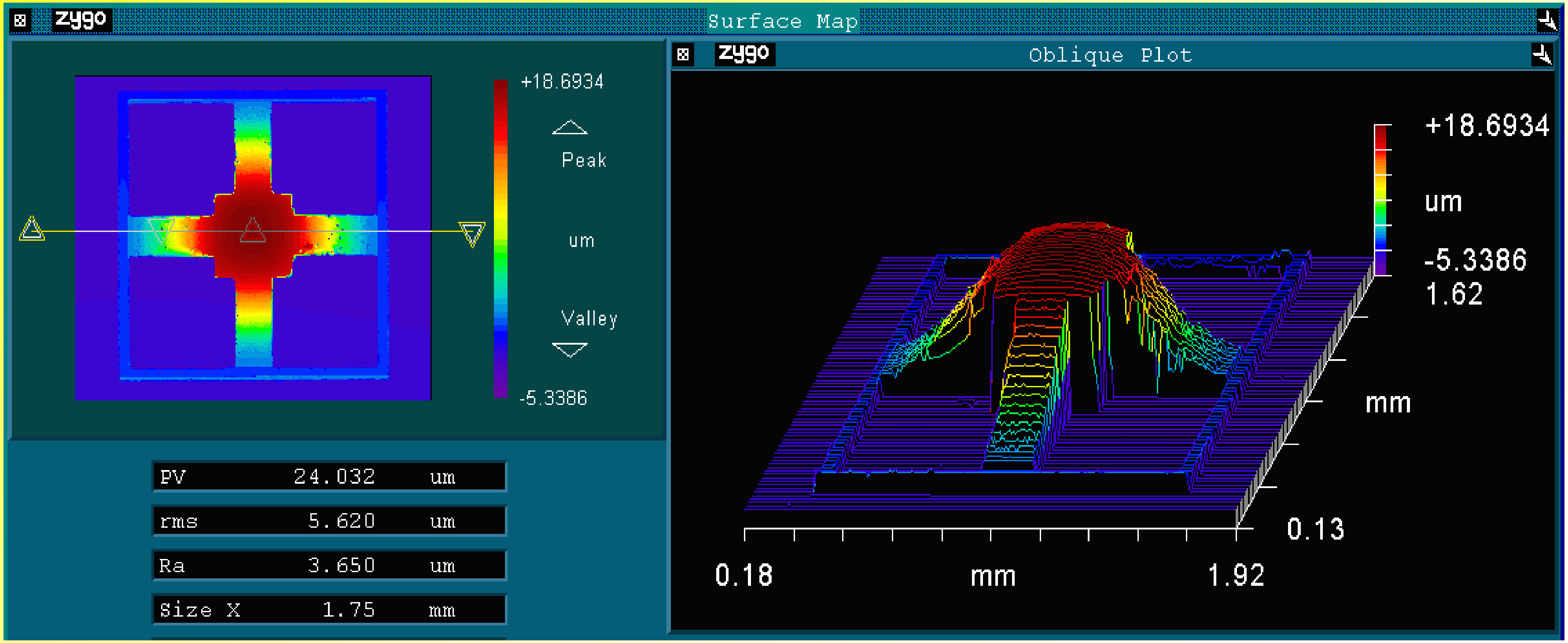
Polysilicon Micro-valves



Electron Microscope Image



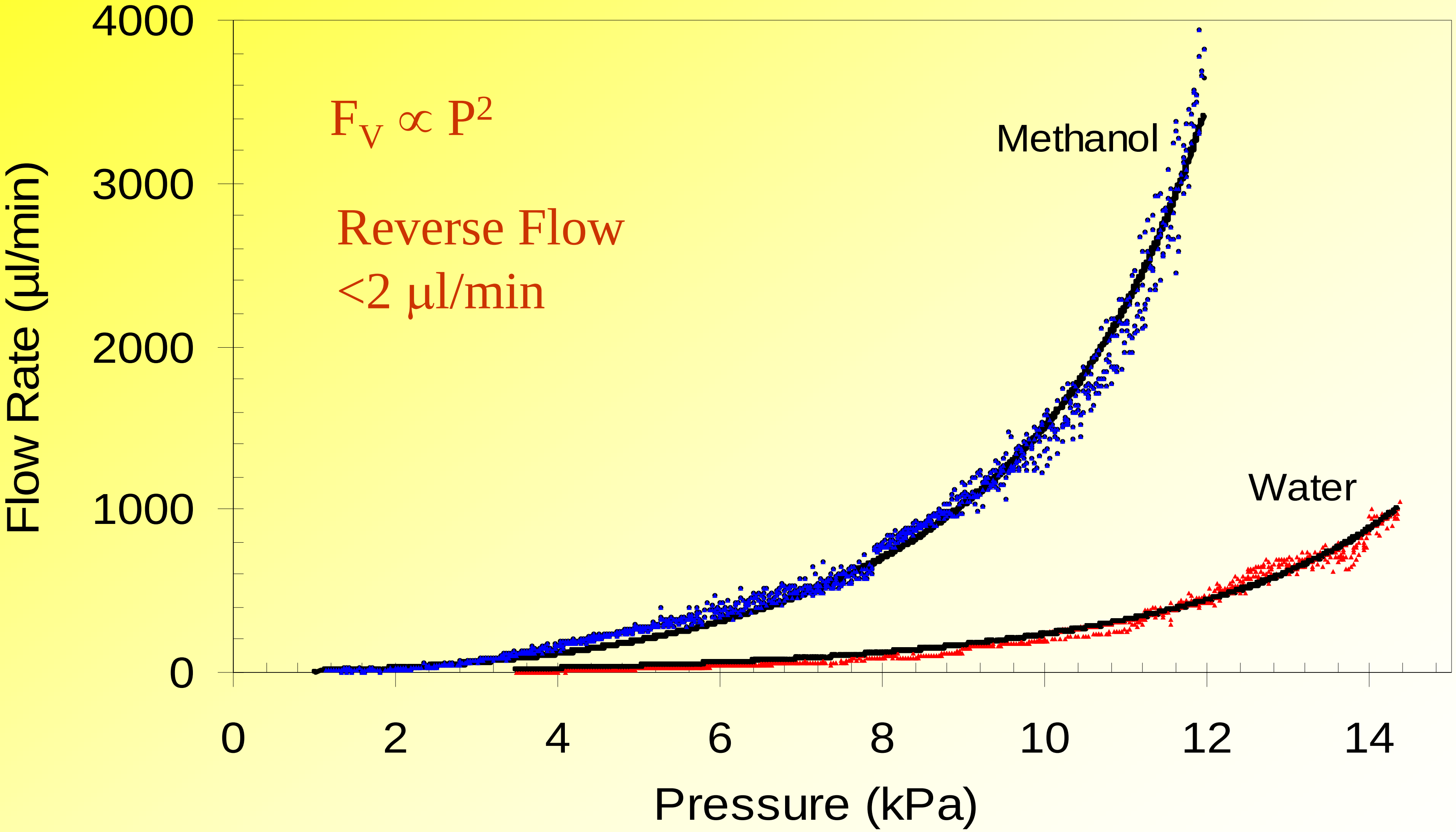
Surface profile of microvalve.



Surface view of relaxed microvalve measured using a ZYGO optical profile instrument.

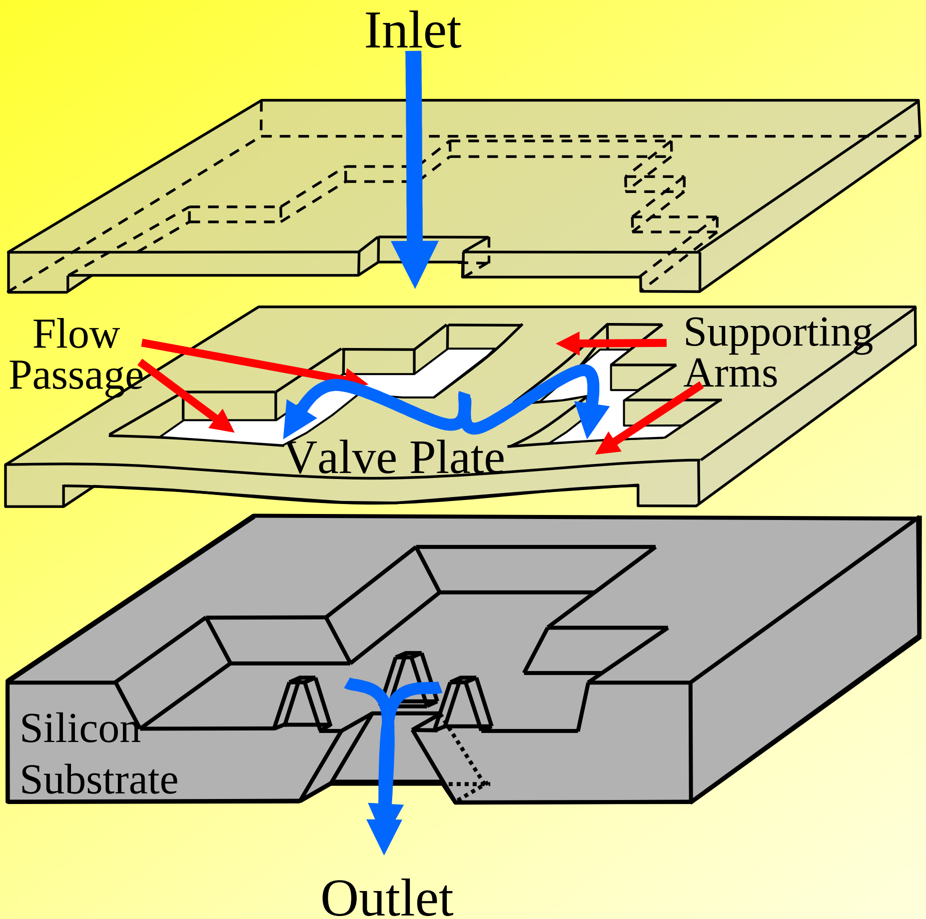
Compressive stress in polysilicon ~ 120MPa

Microvalve Forward Flow Results



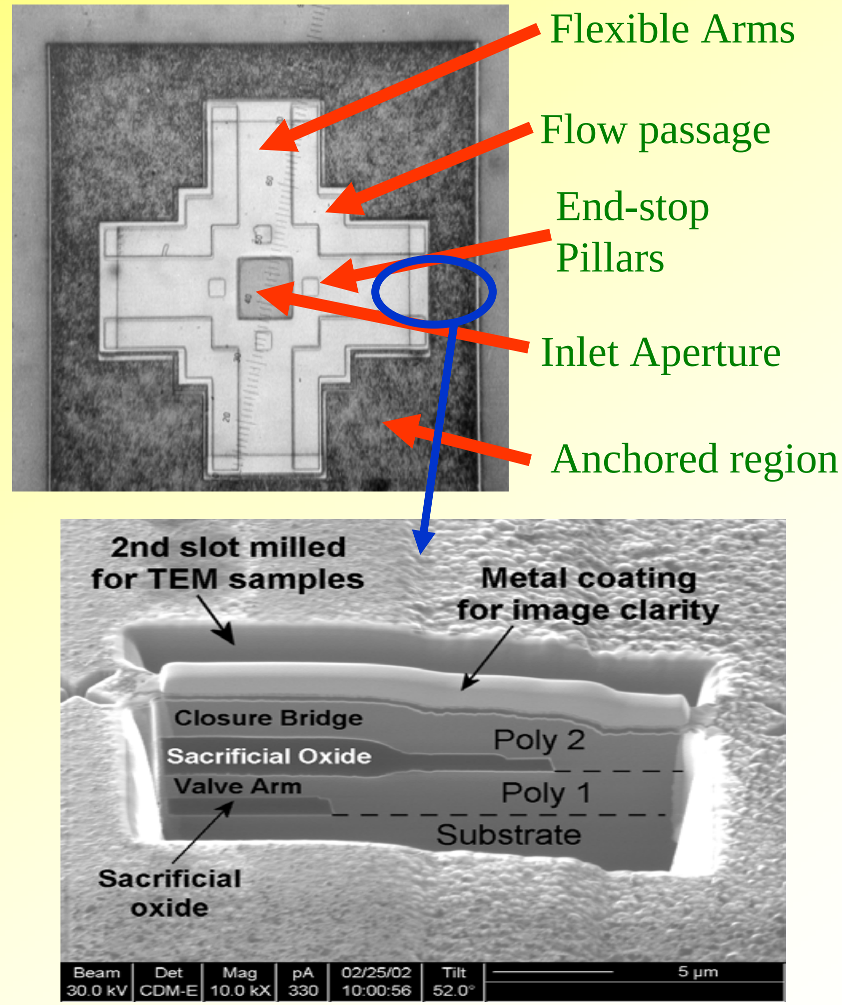
Valve dimensions : 400 µm arm length.
100 µm square inlet hole.

Stacked Microvalve



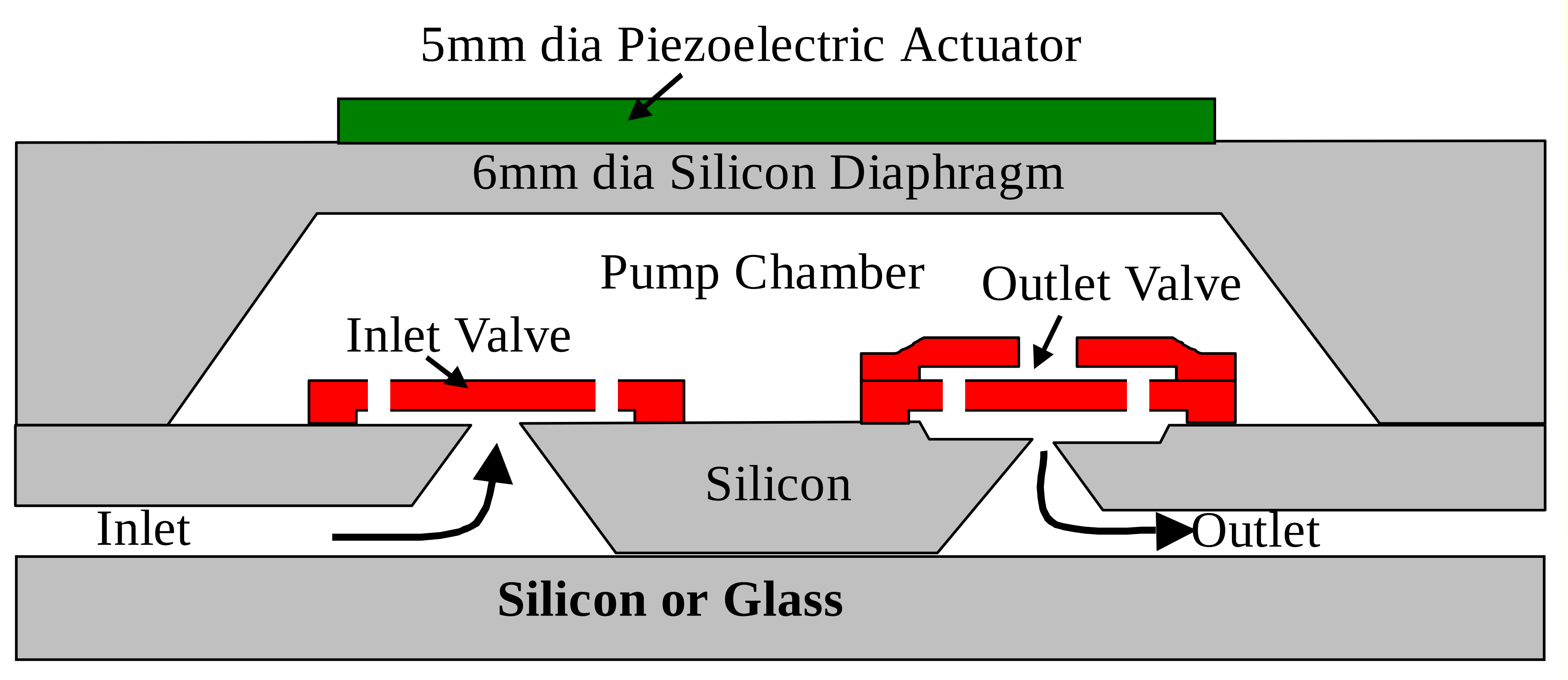
Fluid Flow under Forward Pressure

Overall dimensions 1.2mm square



Surface and Cross Sectional View Across Arm

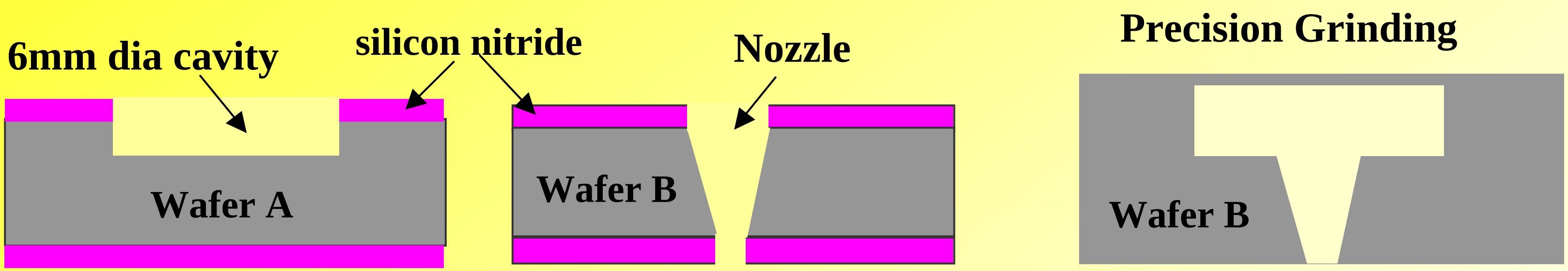
Piezo-electrically Actuated Micropump

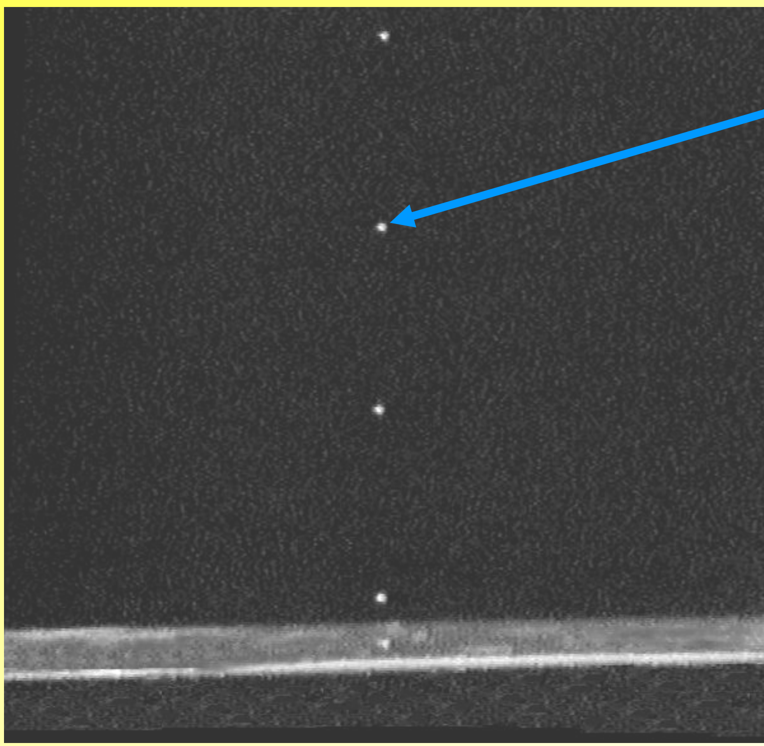


Micromachined pump incorporating the stacked microvalve.

Pump rate at 5Hz:- 0.5μl/min

Nano-litre Dispensers



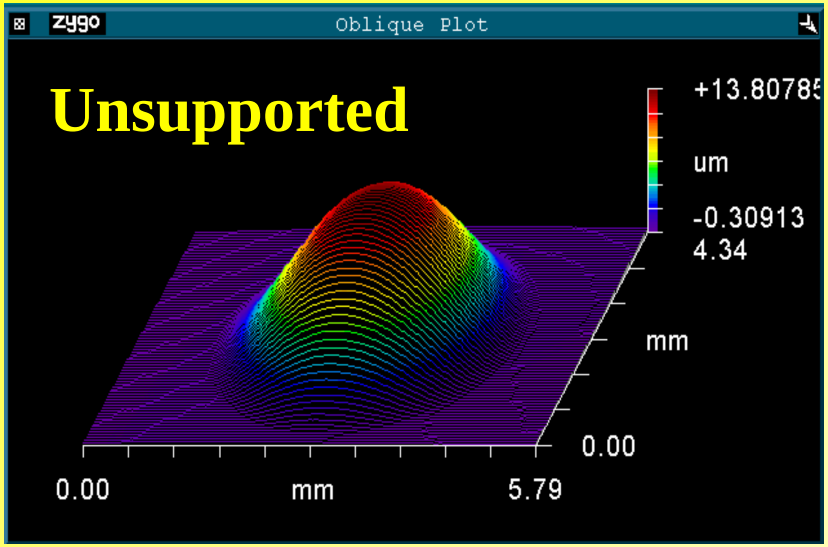


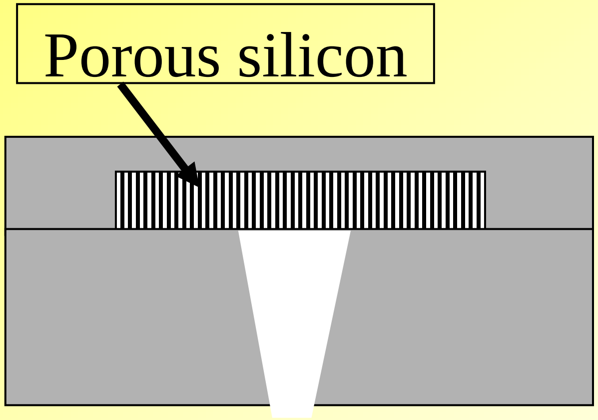
Droplets ejected from a dispenser using piezoelectric actuation.

Droplet volume: 0.3 – 10nl; depending on device dimensions and driving signals.

Dr. Andrzej Prochaska

Diaphragm Distortion





Diaphragms produced by grinding without support exhibit convex distortion.

Support can be provided by forming sacrificial porous silicon in the region where the cavity is to be formed.

Deflection during grinding is reduced and post grind distortion minimised.

After grinding, the porous silicon can be selectively etched.

Distortion is suppressed by a factor of up to 300.

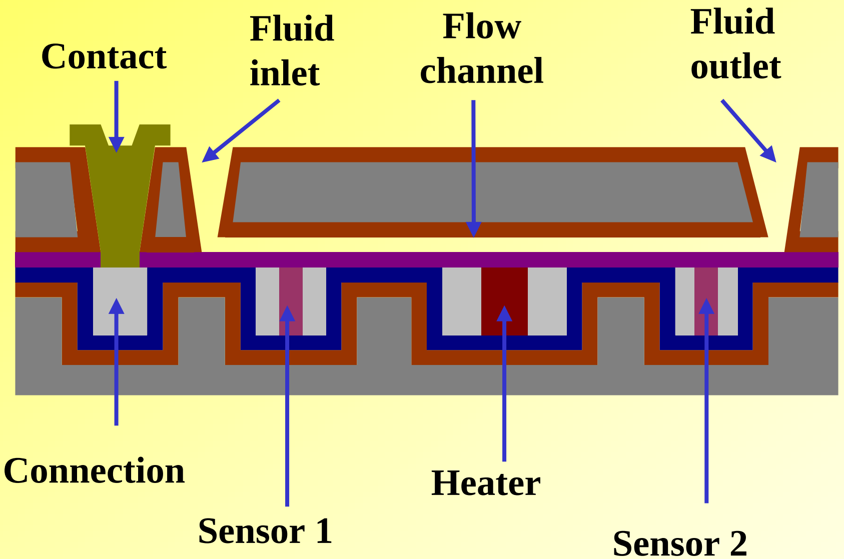
Integrated microfluidic flow sensor

Heat transfer used to determine flow rate.

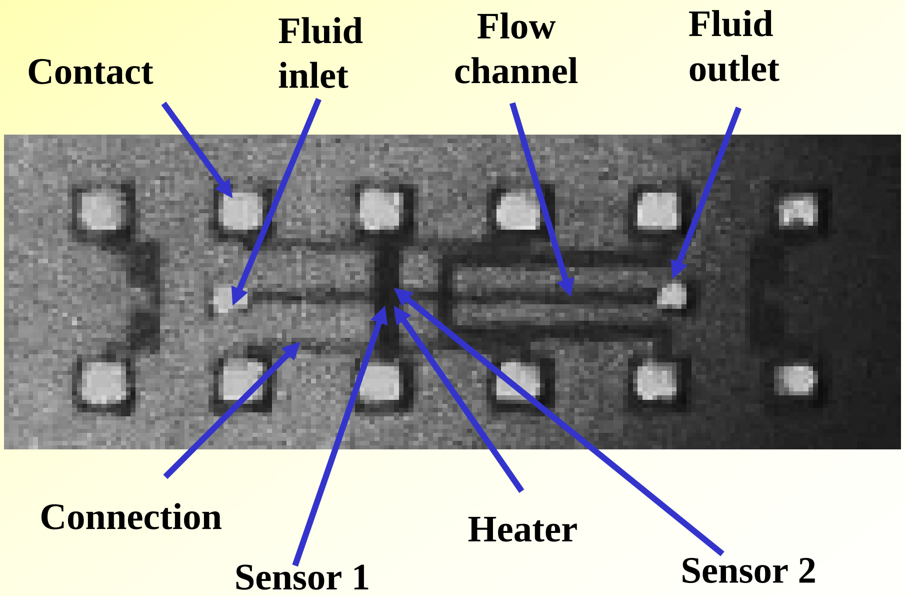
Polysilicon resistors – high thermal coefficient of resistance.

Resistance difference between sensors 1 & 2 increases with flow.

Cross-sectional view



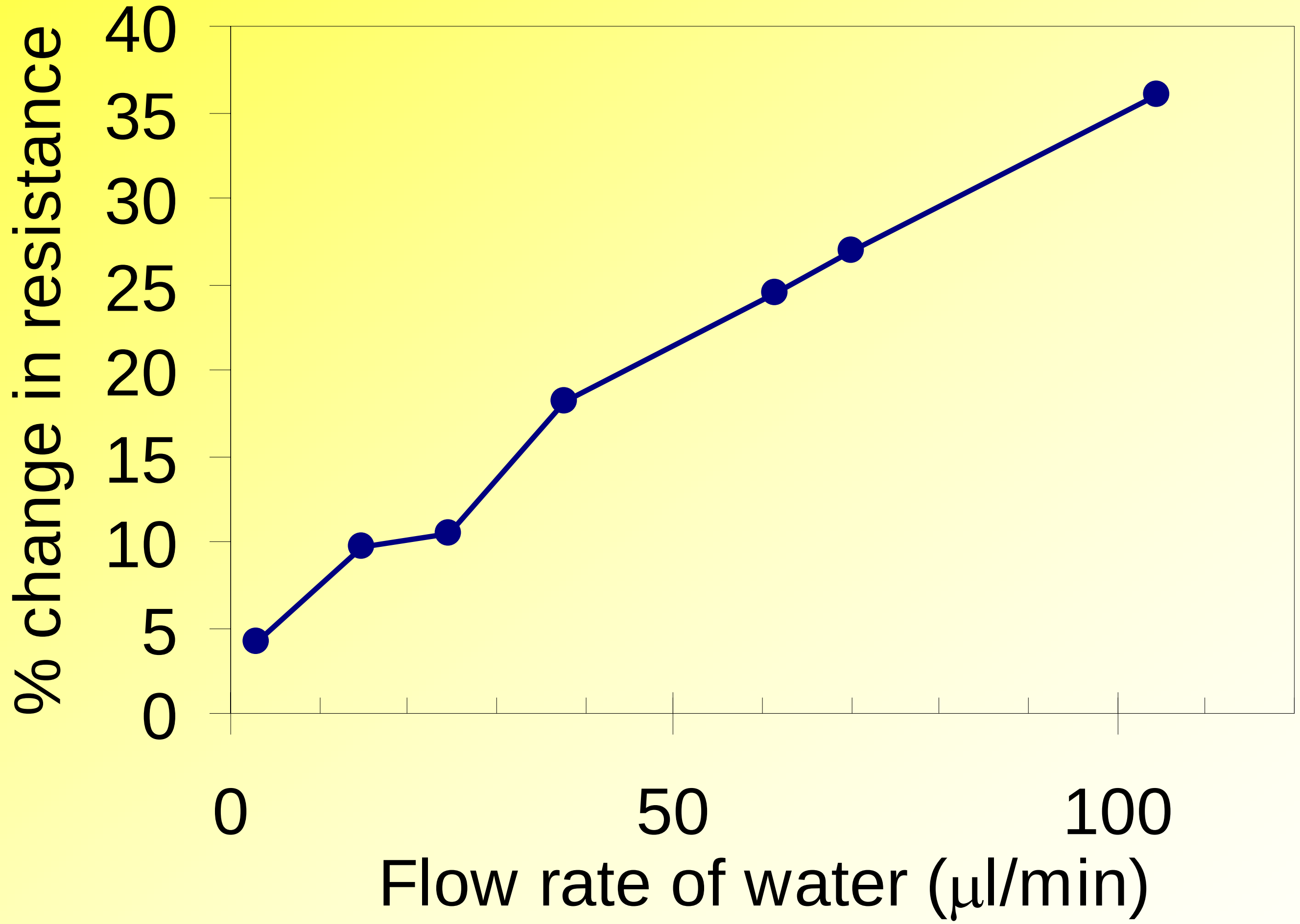
Plan view – optical micrograph



100μm wide, 10-20μm long resistors.

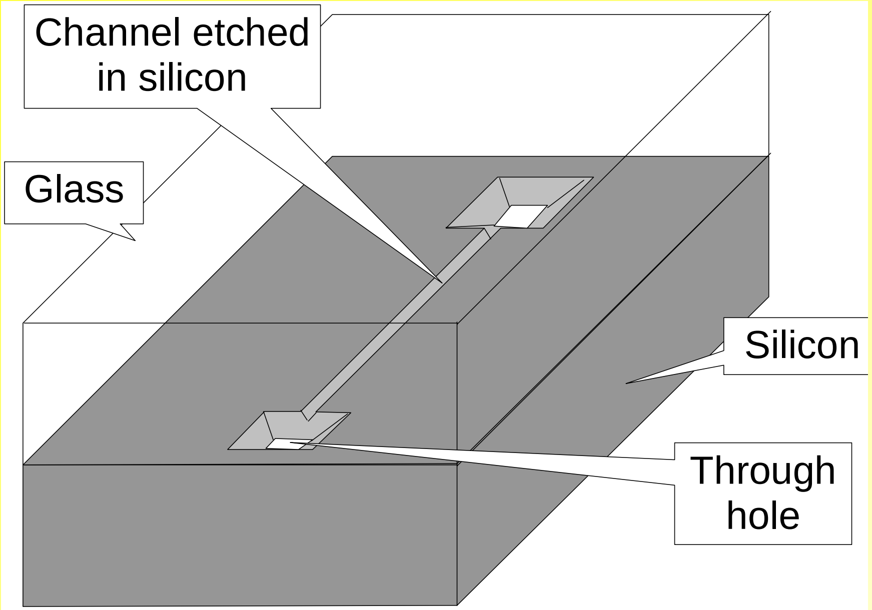
Dr. Hao Zhao

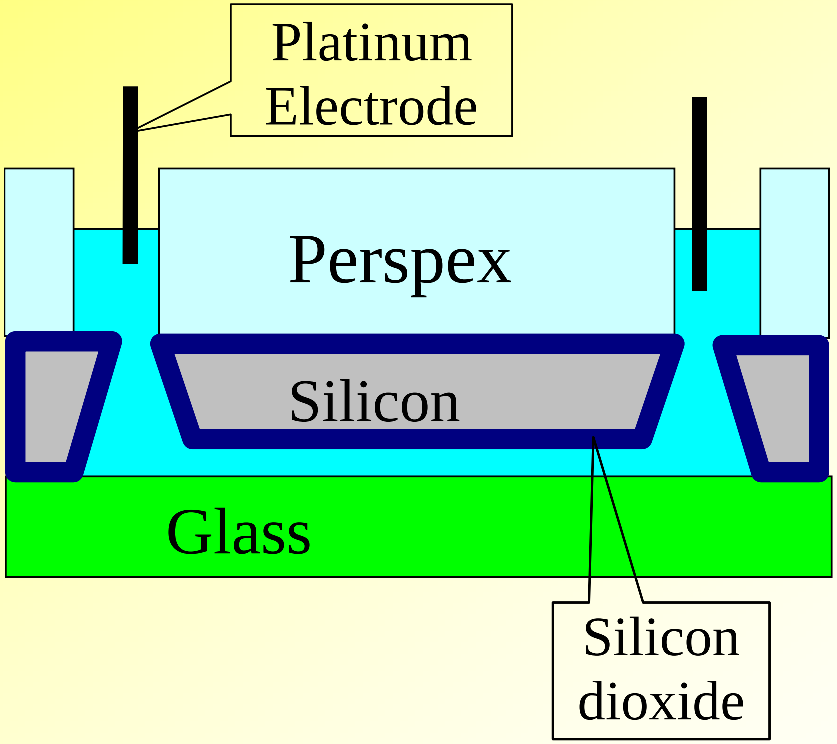
Polysilicon Resistor Temperature Sensors



Single resistor as ‘hot-wire’ anemometer.

Electro-osmotic pumping -Test structure



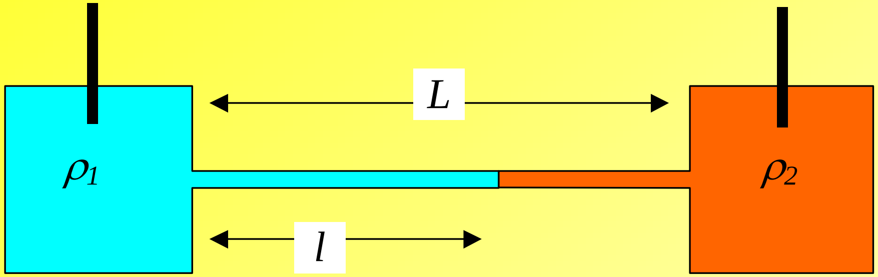


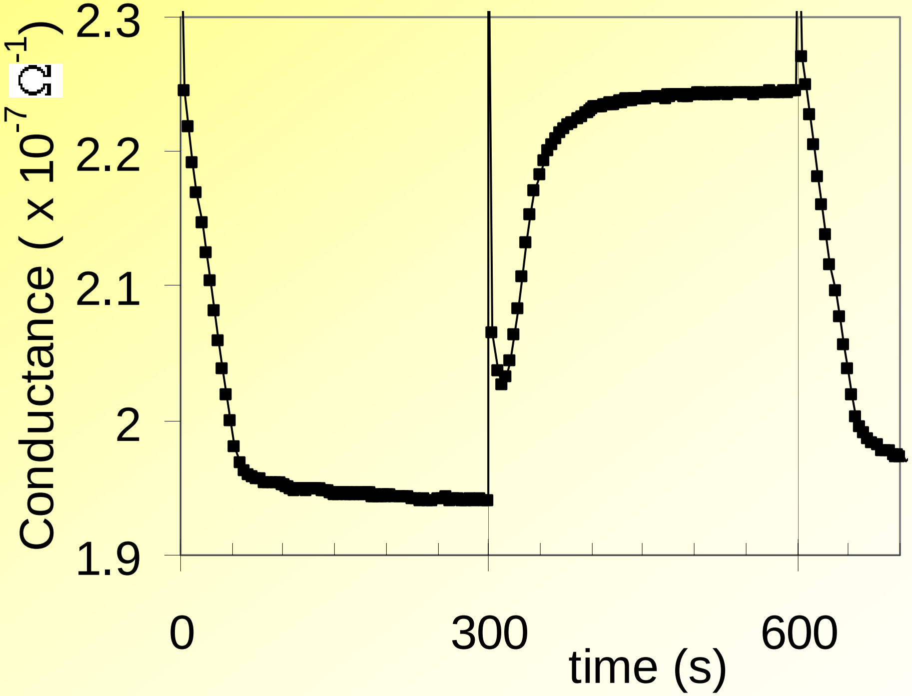
- **75-100μm wide, 9mm long channels.**
- **Oxidised channels in silicon bonded to glass.**
- **Through-etched inlet/outlet holes.**
- **Glued perspex reservoirs.**
- **Platinum wire driving electrodes.**

Electro-osmotic Pumping

Liquid being electrically 'pumped' along a 100μm wide pipe fabricated in the surface of a silicon wafer.

Conductivity Monitoring in Silicon Channel.



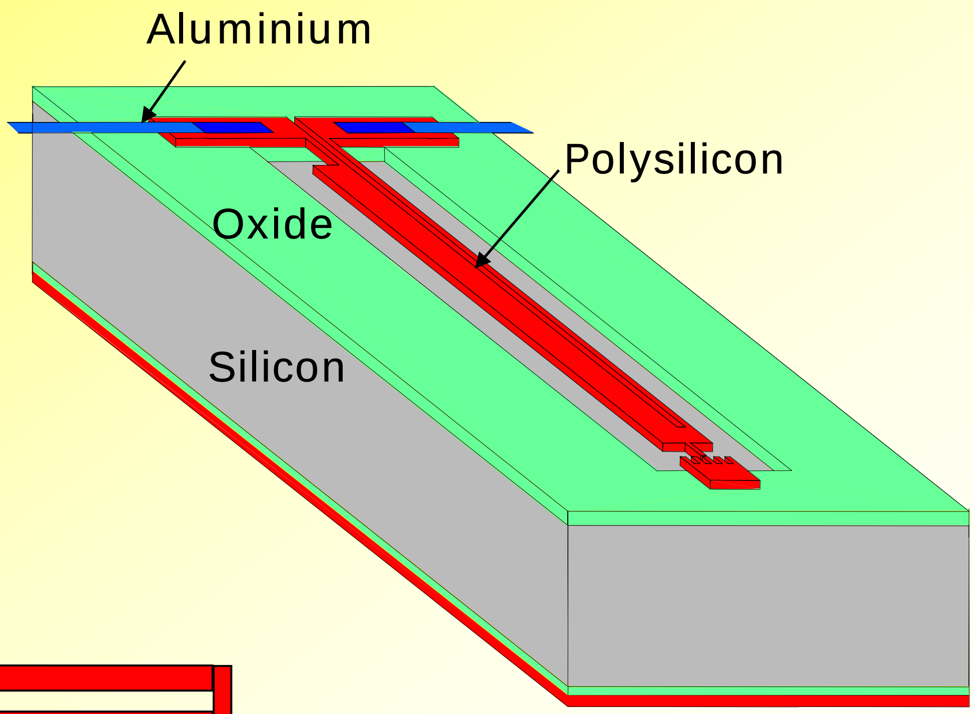


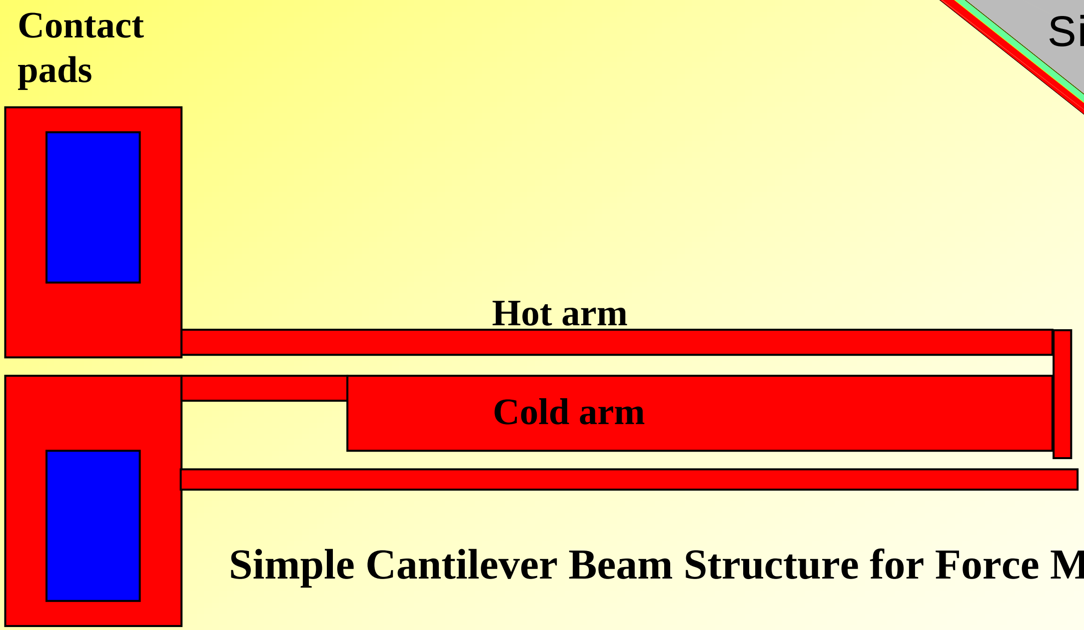
- **Flow rates can be determined by monitoring conductance in the channel when two liquids of different conductivity are present.**

Flow velocity 0.16 - 0.23 mm/s, in 9mm long, 75µm wide channel at 100V. (~ 25nl/min)

Electrothermal Actuator

Mechanical actuation via resistive Joule heating of polysilicon cantilever beams

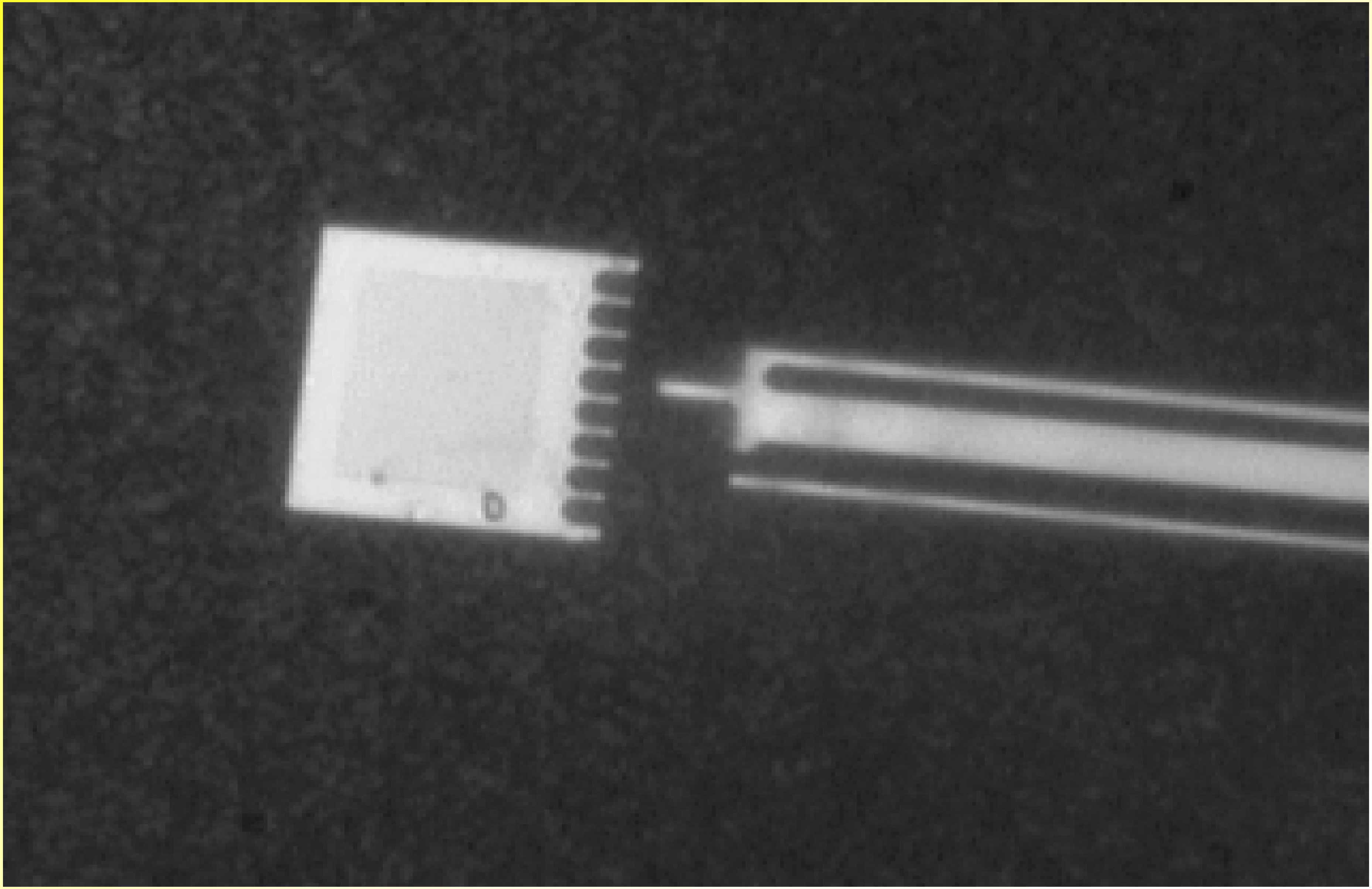




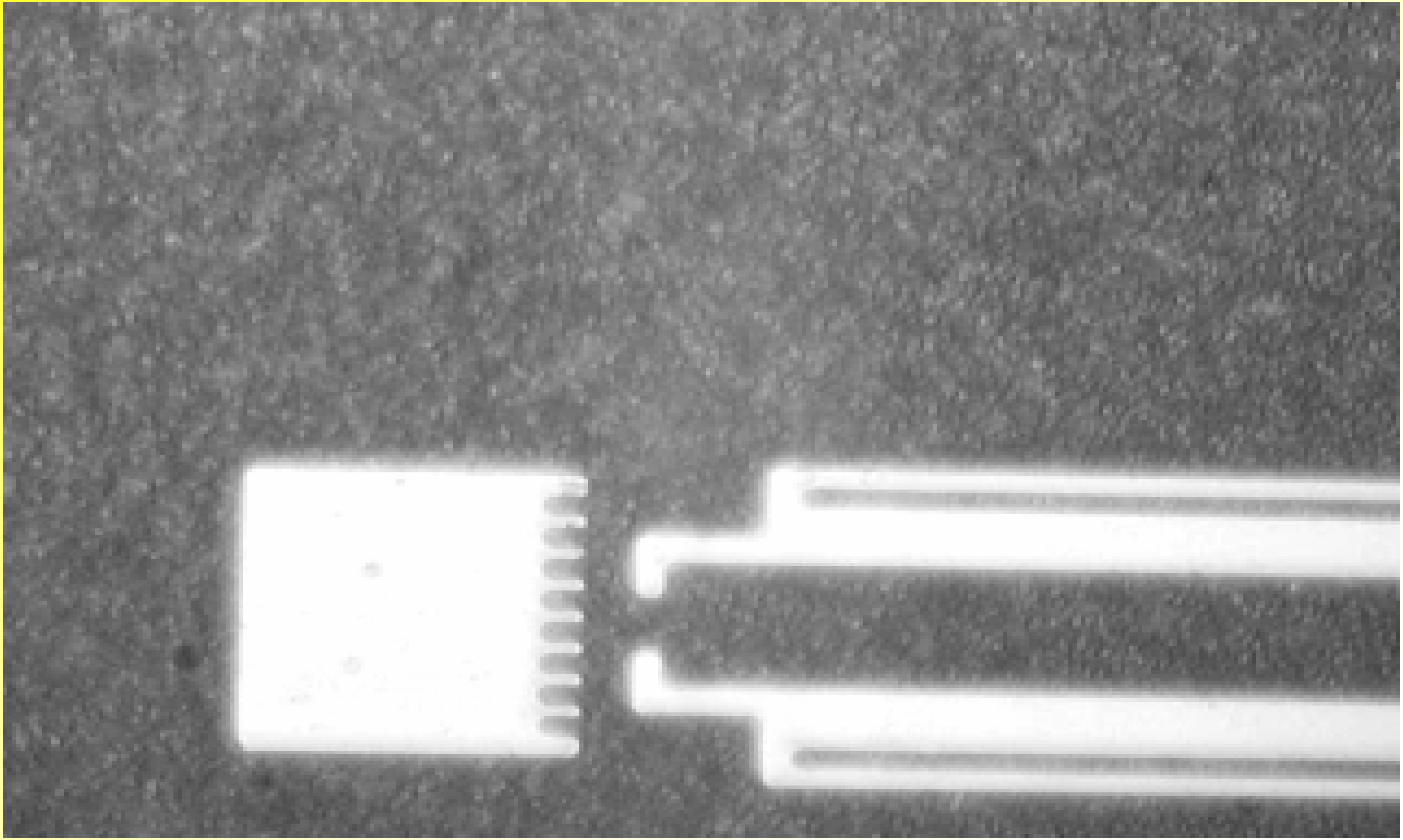
Simple Cantilever Beam Structure for Force Measurement

Gary O'Neill – MEng. Project Student

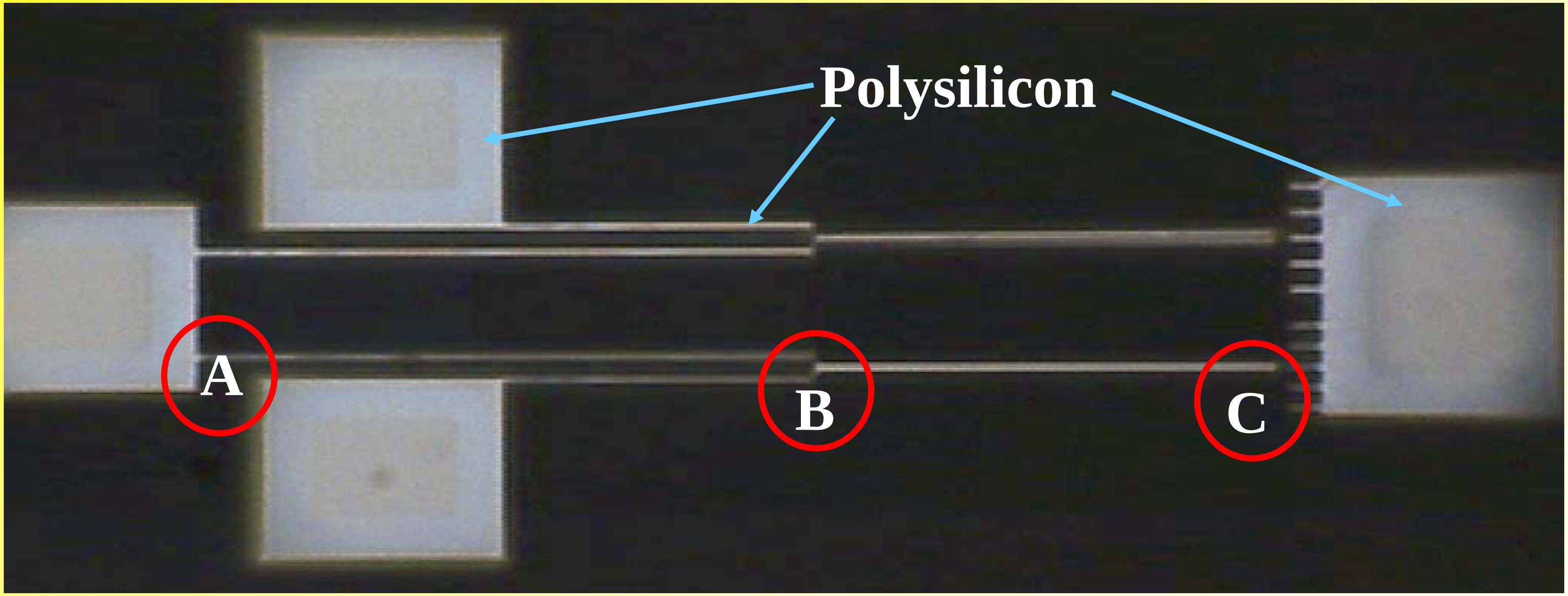
Electrothermal Actuator

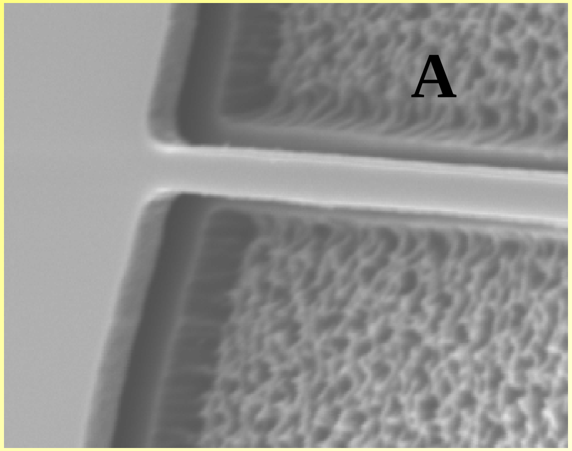


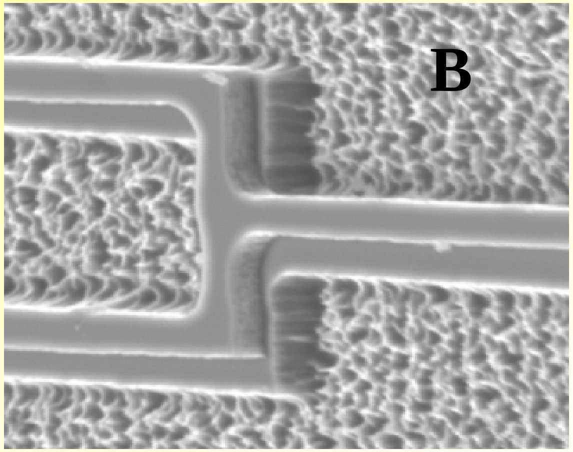
Polysilicon Micro-Tweezers

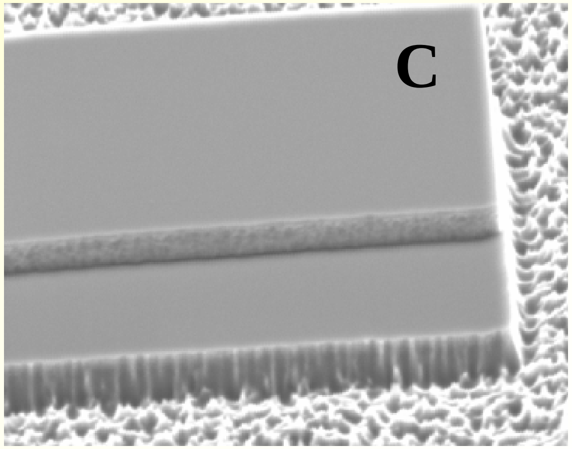


Polysilicon Cantilever Strain Gauge





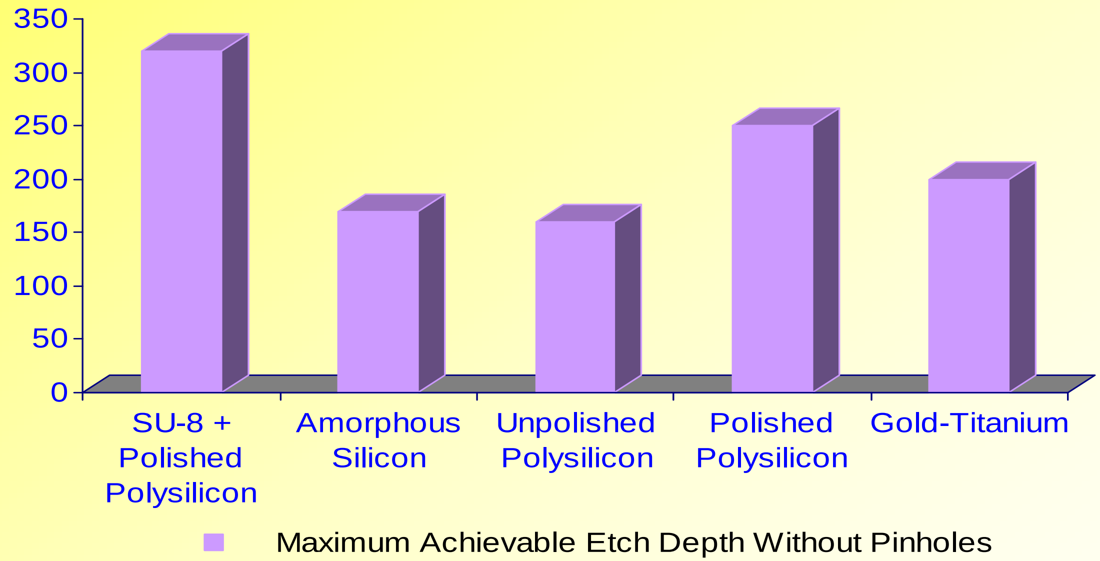


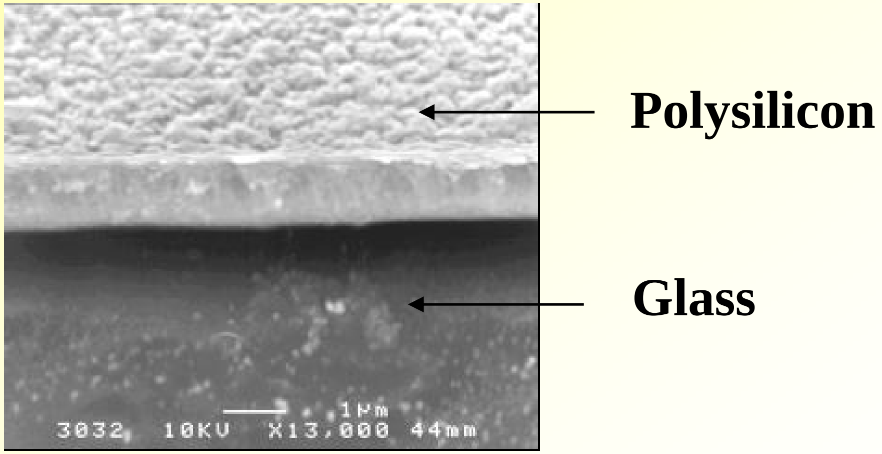


Ailbhe McCarthy - BEng. Project Student; Uday Kiran Mannan - MSc. Project Student

Deep Wet Etching of Glass

- In many areas of MEMS, glass is an attractive alternative substrate to silicon due to its optical properties, chemical inertness and relative cost.
- For deep wet etching, using HF-based solutions, the challenge is to find a suitable masking layer.





“Characterisation of masking materials for deep glass micromachining”, D.C.S. Bien, P.V.Rainey, S.J.N.Mitchell, H.S.Gamble, *Journal of Micromechanics and Microengineering*, Vol.13, No.4, July 2003, ppS34

Silicon Micromachining

- **Anodic Bonding.**
  - Silicon to Glass
  - Silicon Dioxide to Glass
  - Silicon Nitride to Glass.
- **Silicon Direct Bonding.**
  - Silicon to Silicon
  - Silicon Dioxide to Silicon
  - Silicon Nitride to Silicon.
- **Aligned Silicon Bonding.**

- **Double-Sided Photolithography.**
- **Precision Grinding.**
- **Thick-film Piezoelectrics.**
- **Porous Silicon.**
- **Thick Photoresist (SU-8).**
- **Polyamide.**