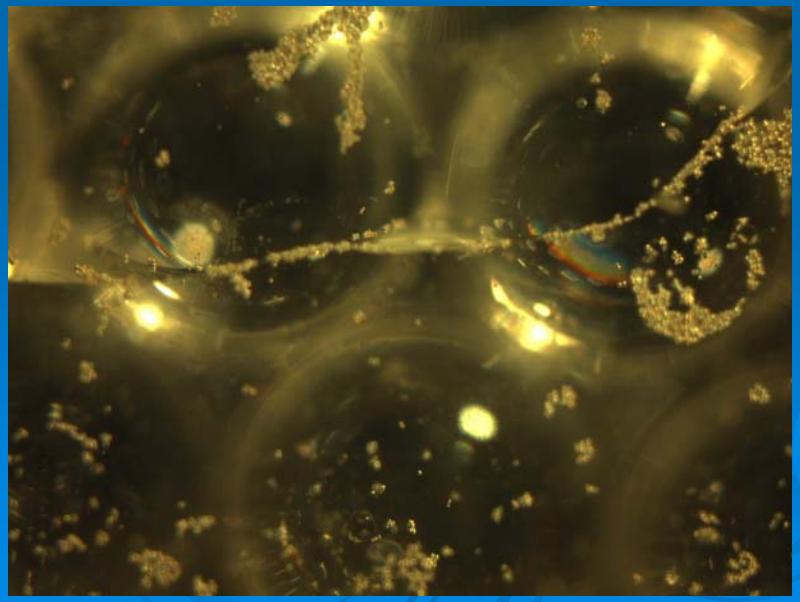
Water Wet

Building a hydrophilic, two-dimensional, micro-scale flow cell

The Goal

- To establish a technique for manufacturing 2D micro-models and for imaging porous media processes
  - To determine more accurate capillary pressures (P_c) in a multiphase (oil-water) system
  - To use these capillary pressures to better understand multi-phase flow and transport
  - Mass transfer across fluid interfaces
  - Microbial growth and transport in a porous medium
  - Velocimetry using PIV



The Theory

Laplace's Law:

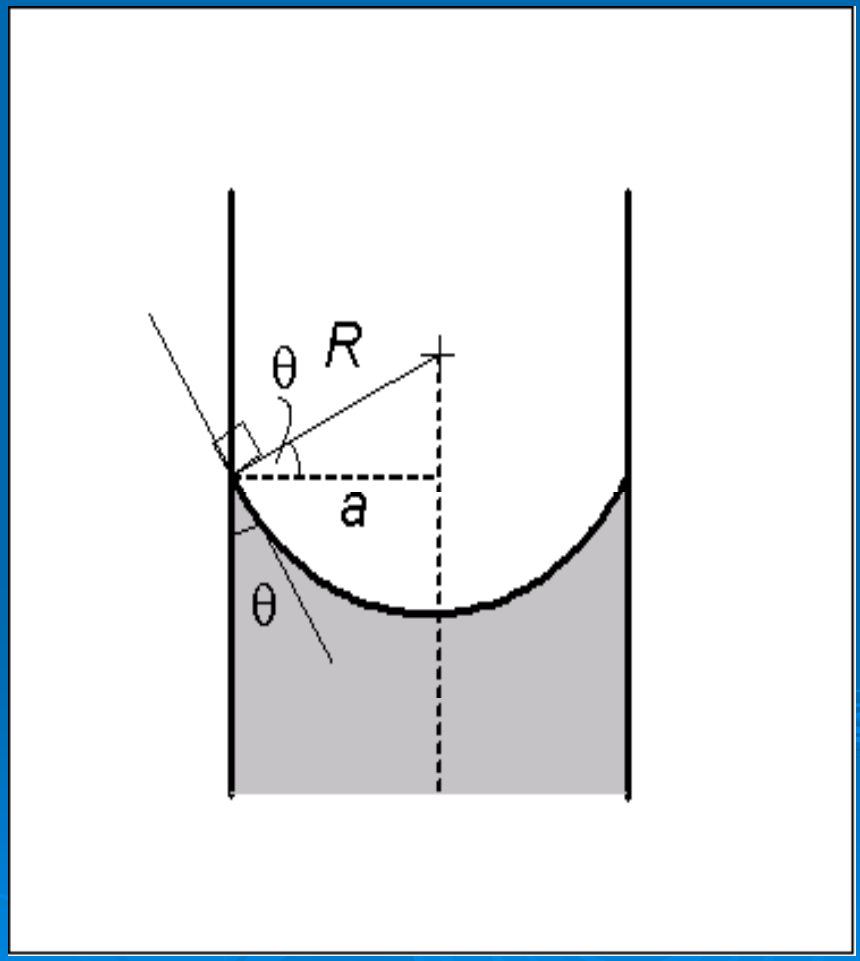
$$P_c = P_n - P_w = \frac{2\sigma \cos\theta}{R}$$

Where

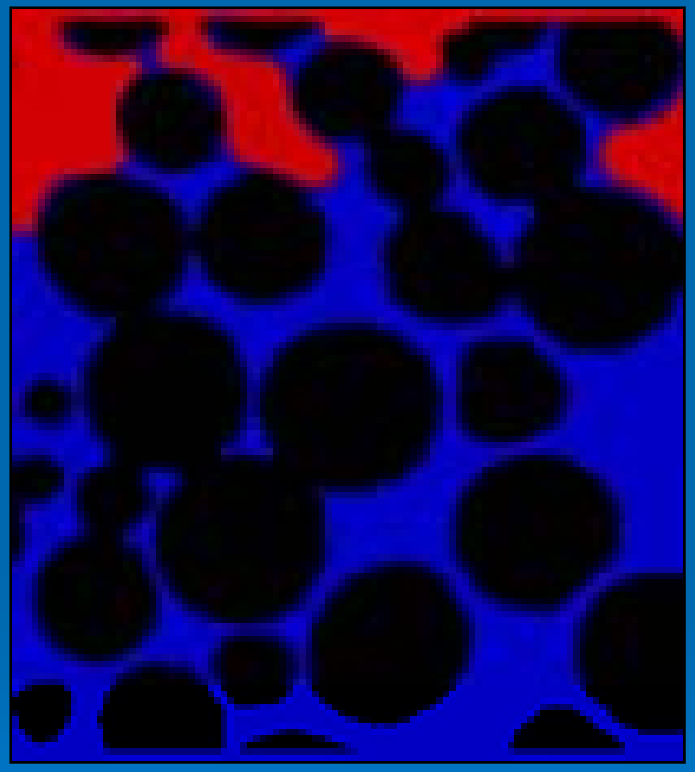
σ = surface tension

θ = contact angle

R = radius of curvature



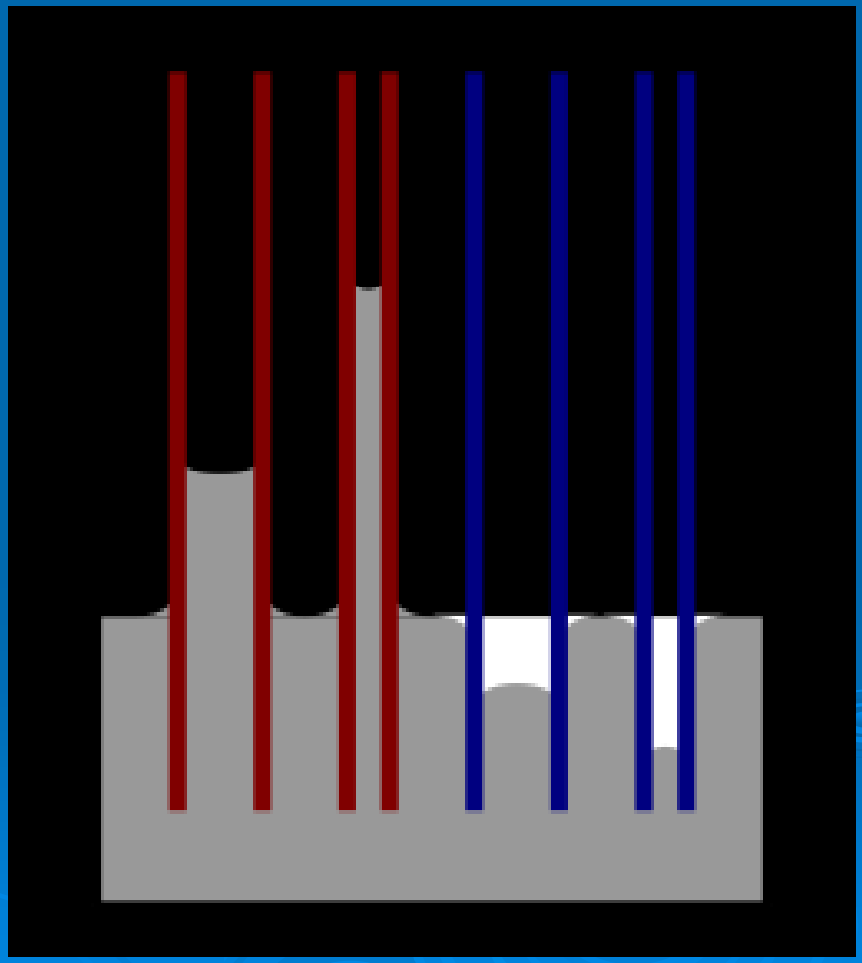
Using a 2D Model



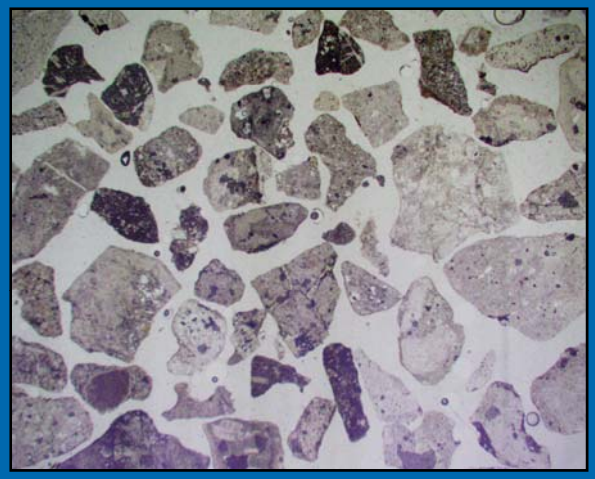
- Observing fluid flow in two dimensions will simplify interfacial measurements, allowing us to better estimate the curvatures and contact angles

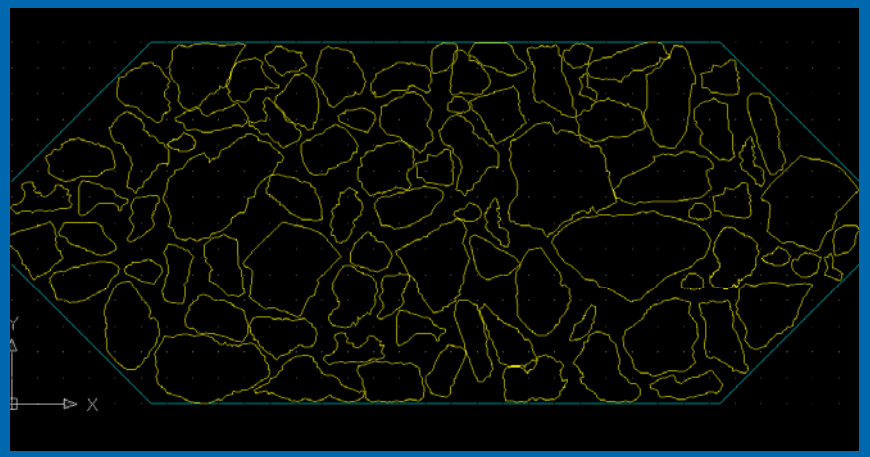
The Trick

- Building an experimental flow cell that is consistently water-wet, to ensure accurate interfacial measurements
- Right: capillary rise in a water-wet system (red) and oil-wet system (blue)



The Process

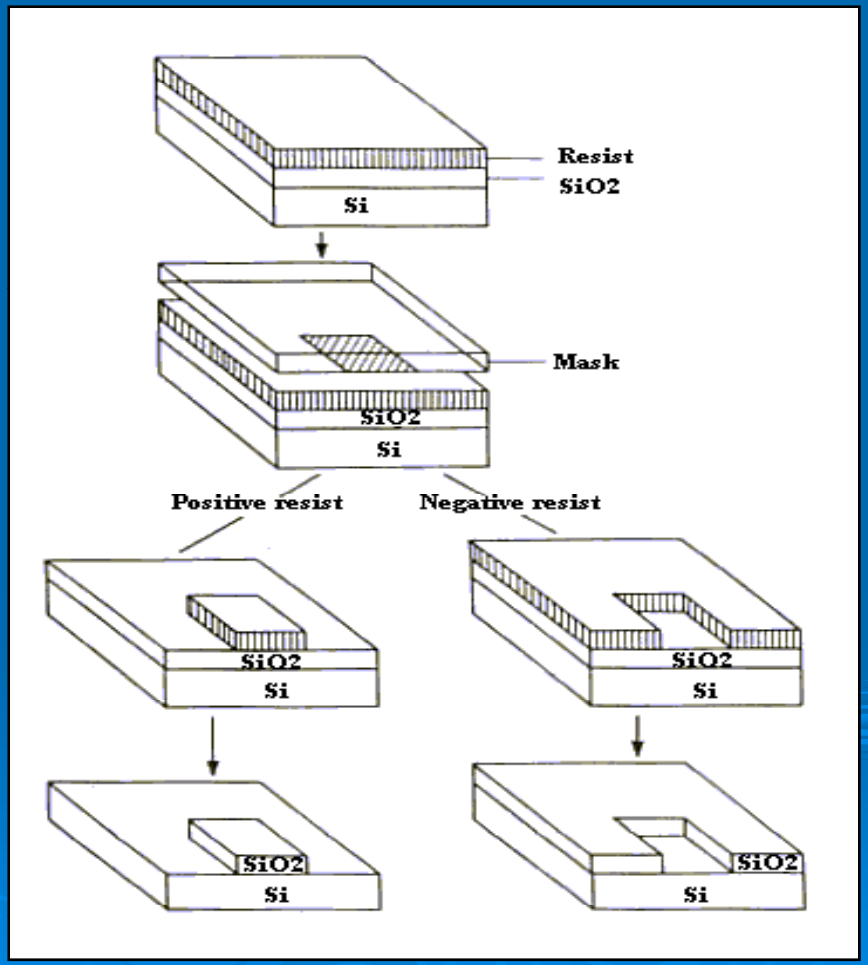




- Create photomasks from images of sand grains and glass beads

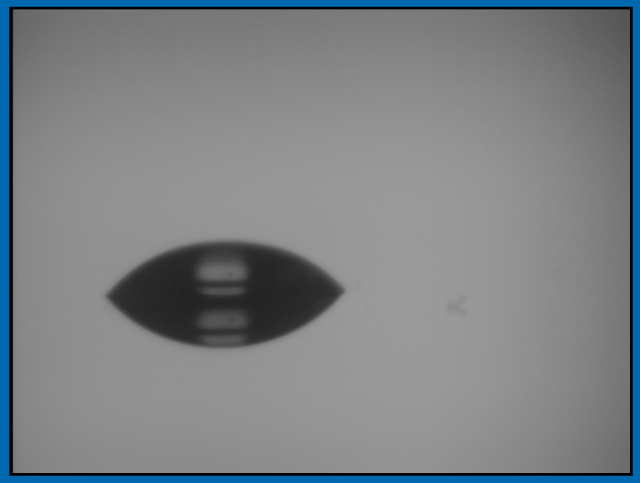
The Process (cont'd)

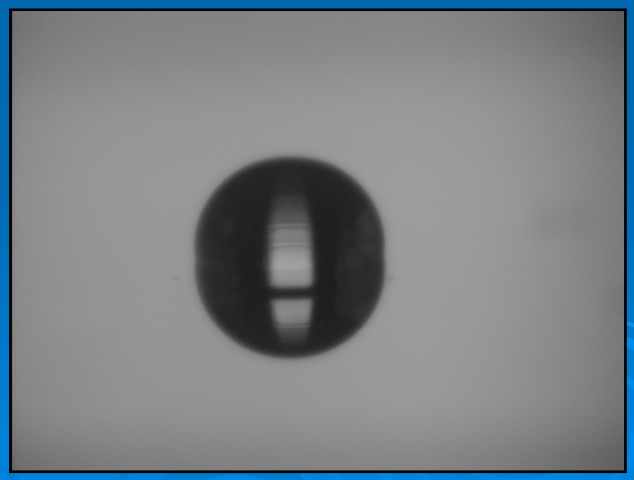
- Use photolithography to etch the desired channel pattern into a silicon wafer



The Process (cont'd)

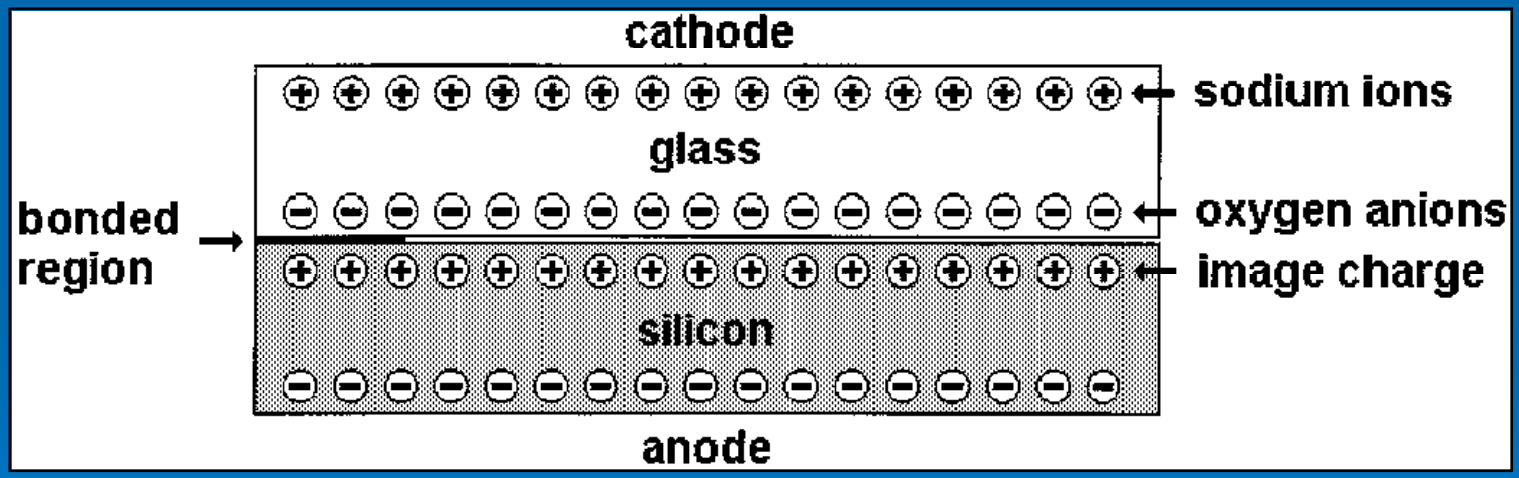
- Grow silicon dioxide into the silicon surface to achieve proper wettability
- Right: water bead on silicon dioxide surface (top) and silicon surface (bottom)



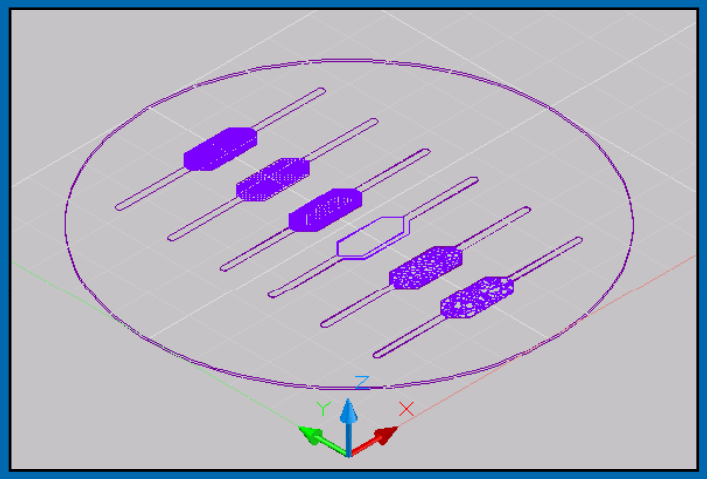


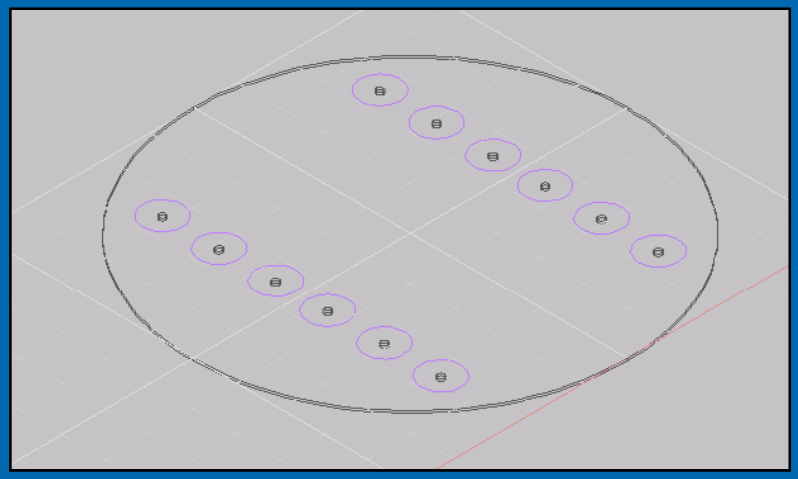
The Process (cont'd)

- Anodically bond the silicon wafer to a glass-plate cover



The Final Design





- The silicon wafer etched with six channel patterns (left)
- The glass-plate cover with inlet and outlet ports (right)

Next Steps…

- Run experiments through the flow cells under an epifluorescent microscope
- Take snapshots of fluid interfaces
- Estimate curvatures and contact angles

- Observe biofilm growth
- Observe transfer of biocolloids across oil-water interfaces

Acknowledgements

- A big thank-you to Chris Tasker, EECS
  - Instruction in the photolithography
  - Assistance with setting up anodic bonding