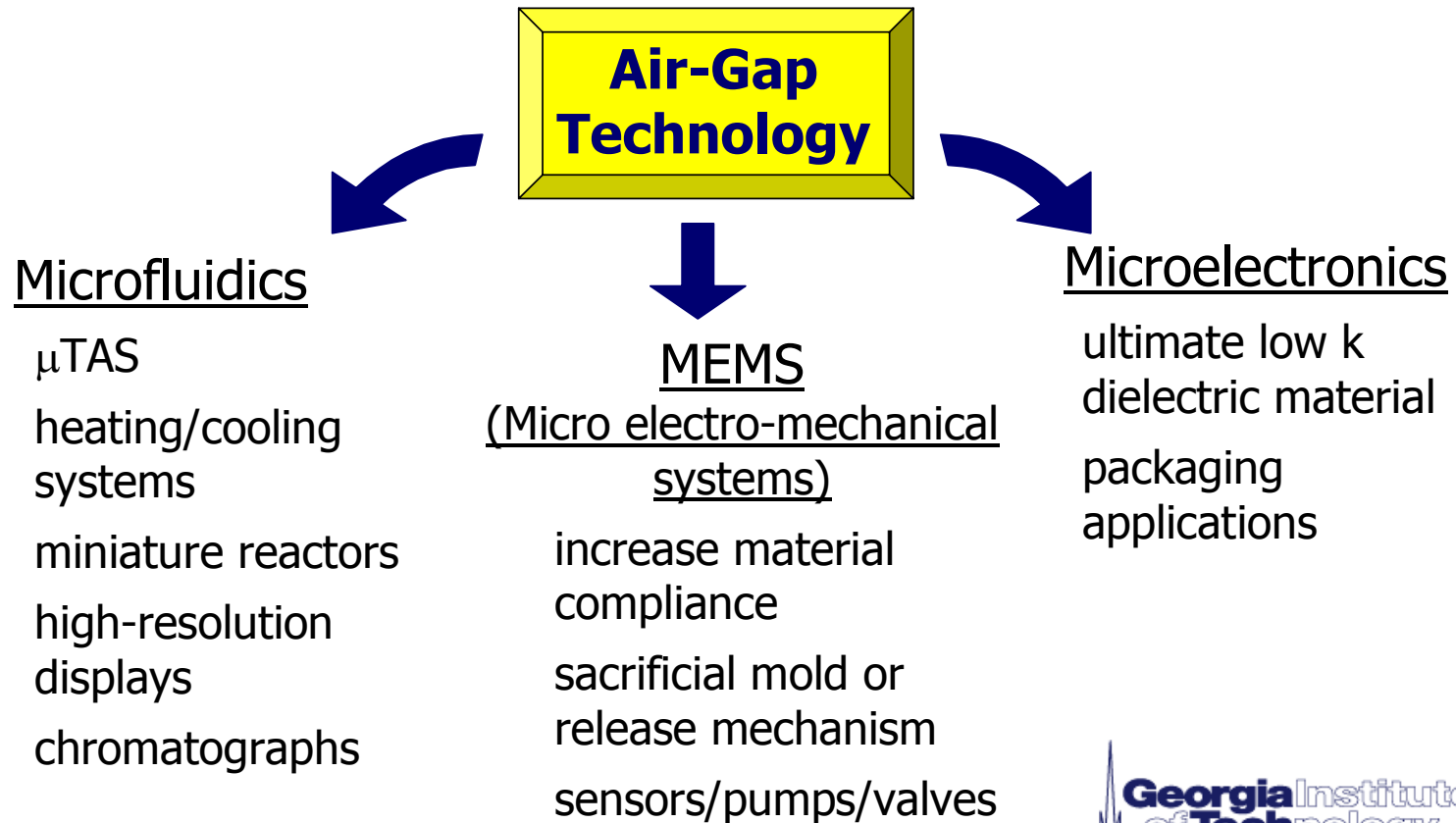


Microchannel fabrication using decomposable polymer

Li Xue

Nov 13, 2002

Applications



Advantages of this method

Glass bonding:

- flat surface, source defects and low yield

- difficulty in construction of metal lines

- modify the surface, laser ablation

Advantages of this method:

- fabrication process using current semiconductor technology

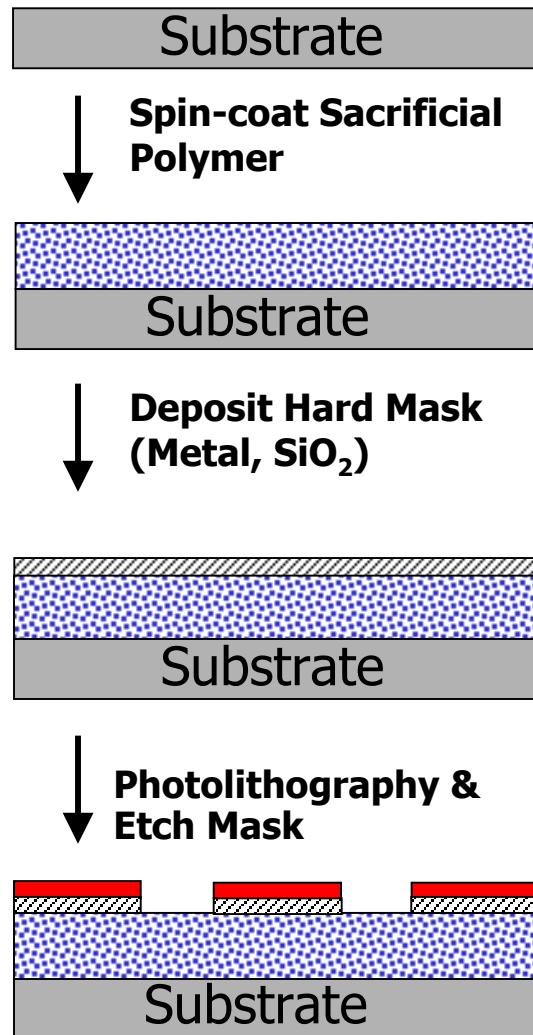
- make complete closed air-gap structures

- control over size/shape

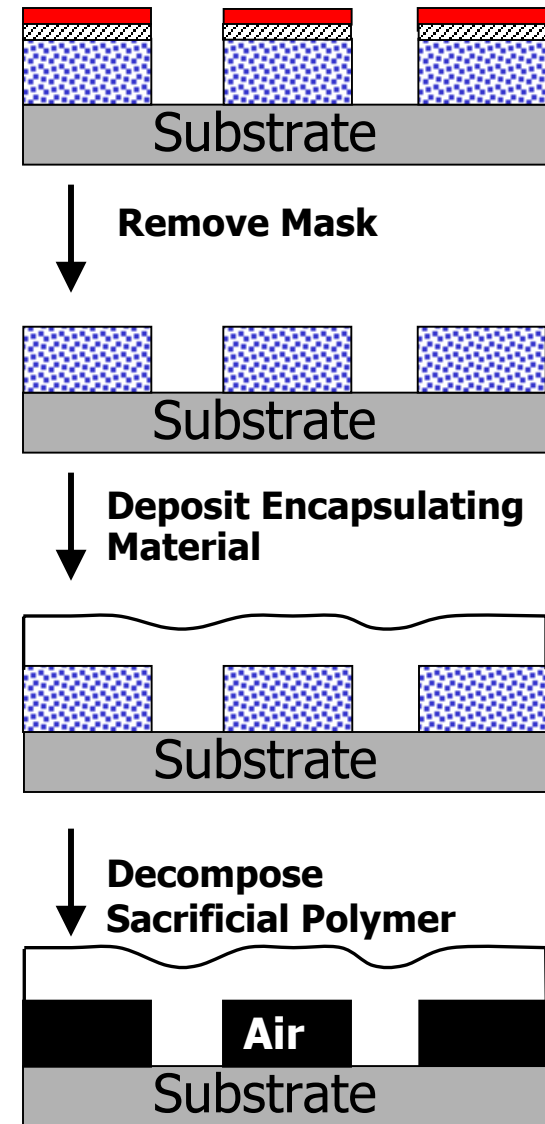
- wide range of compatible encapsulating material

- no wet chemicals to remove sacrificial

Fabrication via Non-photosensitive Sacrificial Polymer

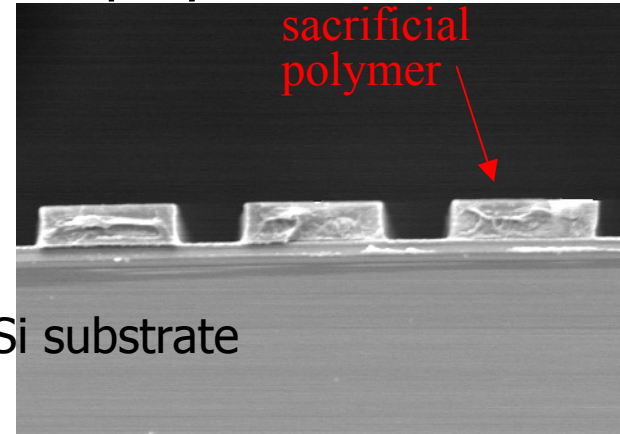


Plasma Etch polymer

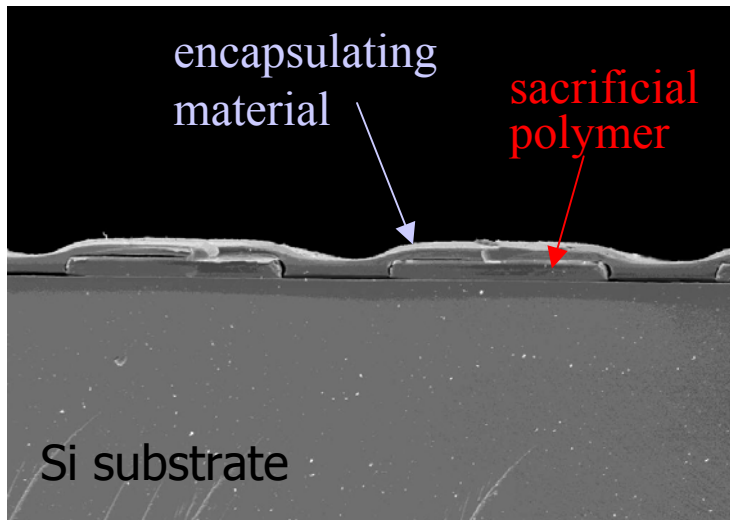


Microchannel Fabrication via Sacrificial Polymer

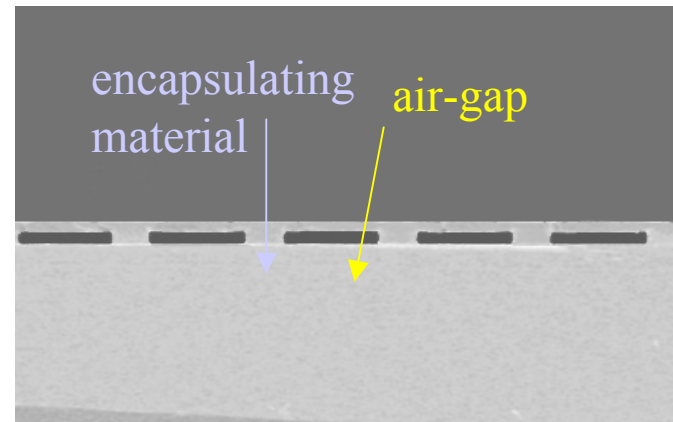
Patterned polymer film



Deposition of encapsulating material before decomposition



Completed air-gaps



Si substrate

Material Property Requirements

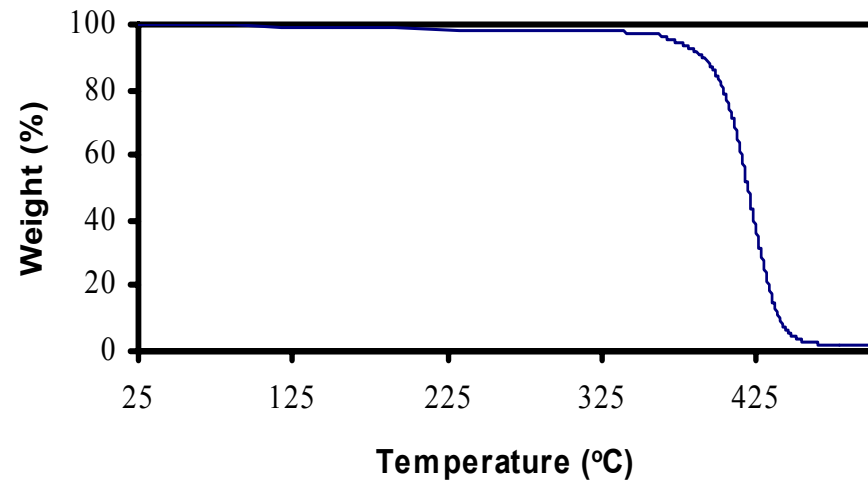
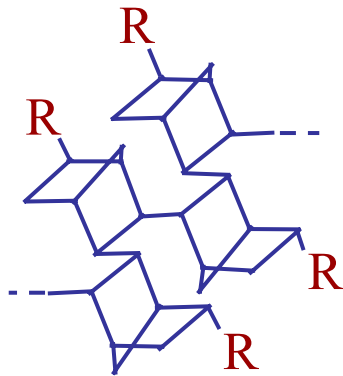
Sacrificial material

- Decomposition in a narrow & useful temperature range
- Clean decomposition - little or no residue
- Adhesion to Si, SiO₂, SiN, metals
- Resistance to subsequent processing/solvents

Encapsulating dielectric material

- Curing or deposition temperature below the onset of decomposition
- Tolerance to the decomposition temperature
- Adequate step coverage
- Low elastic modulus combined with mechanical strength to span cavity
- Permeability to decomposition products

Encapsulating material for PNB



- PECVD Silicon Dioxide/Silicon Nitride
- Polyimide:
- Other materials like FLARE

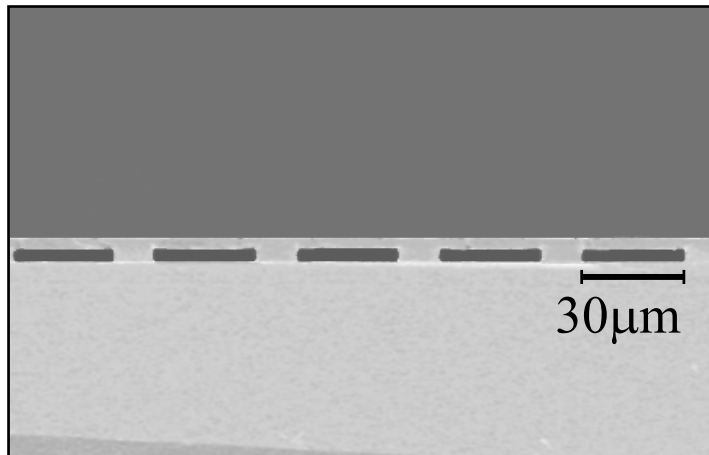
Polymer Encapsulated Microchannels

Shape is dependent on:

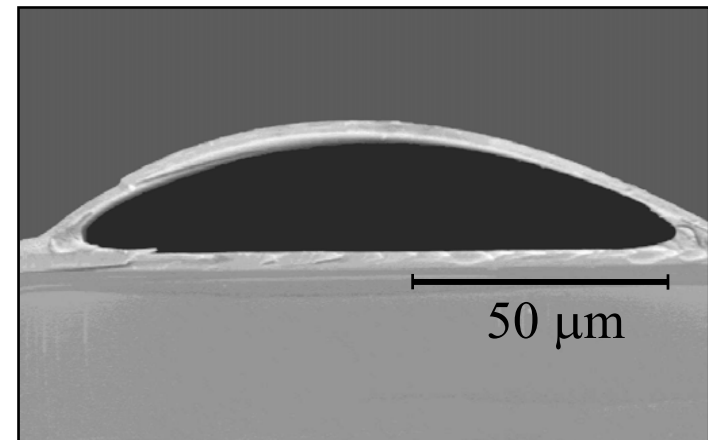
- size of the air-gap
- overcoat material
- decomposition rate

Size of structures:

- 0.25 - 1000 μm in width
- 1-30 μm in height
- overcoat thickness 1-28 μm

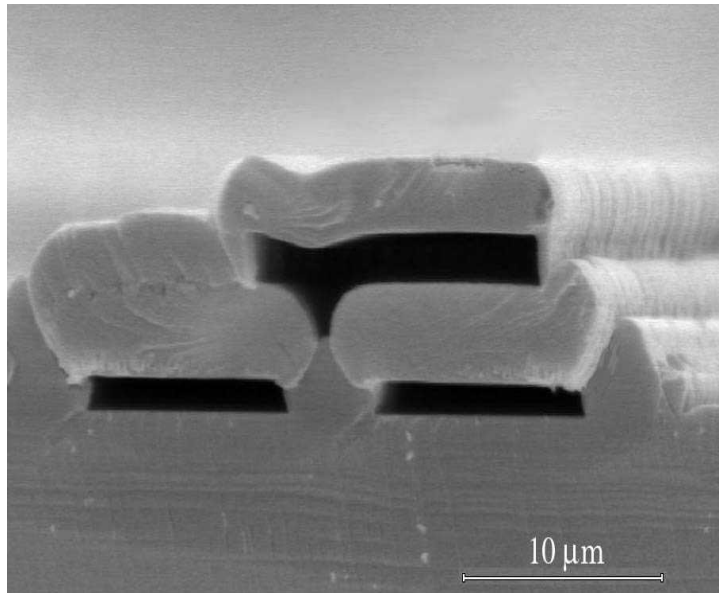


30mm air-gaps overcoated with Ultradel™ 7501

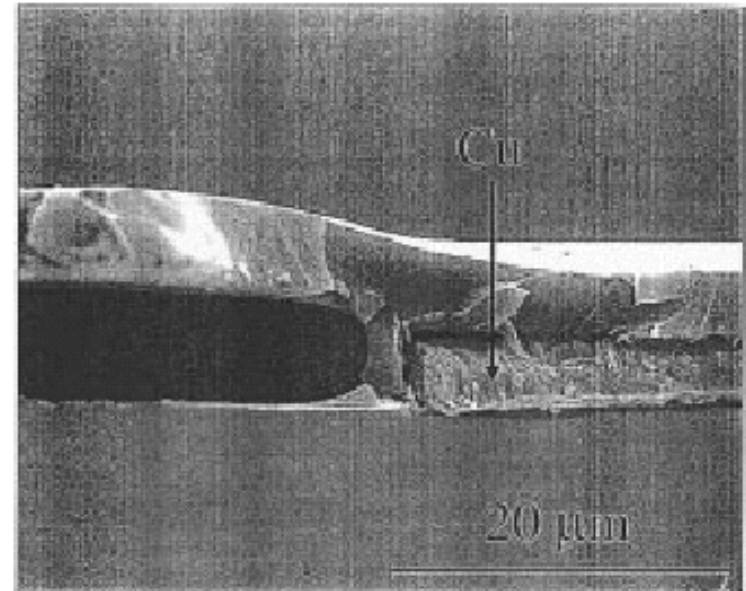


140 μm air-gap fabricated with PNB
overcoated with PI 2734

Encapsulated Microchannels



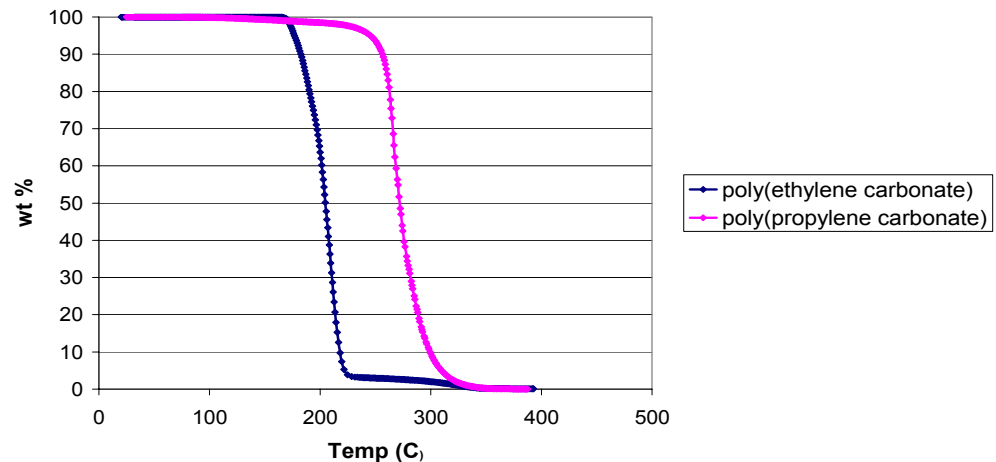
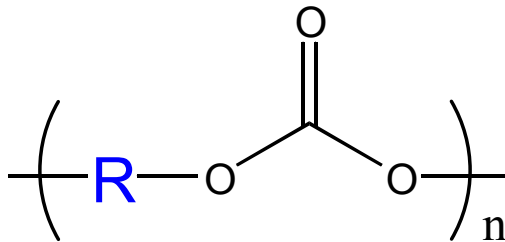
Multilevel channels encapsulated in SiO₂



Copper lines insulated by Ultradel 7501 from the air channel

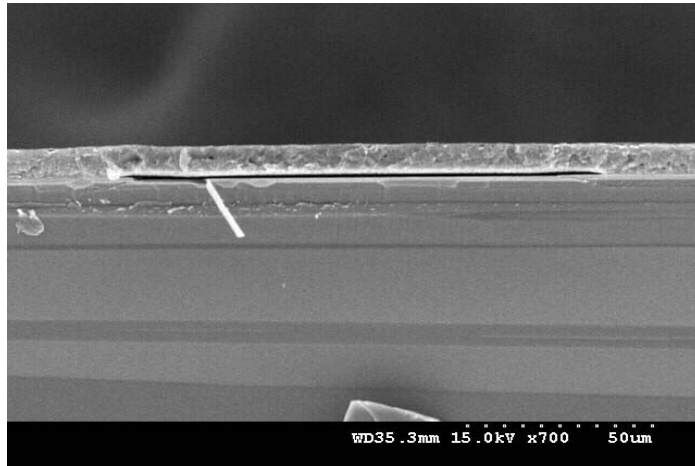
Encapsulating Materials for PC

With Polycarbonate sacrificial material:



- Silicon Dioxide (PECVD inorganic material)
- thermoset photosensitive epoxy
- thermoplastic photosensitive polynorbornene
- Dow Cyclotene Bisbenzoycyclobutene 3022-57

Air-gaps fabricated using Polycarbonate sacrificial material

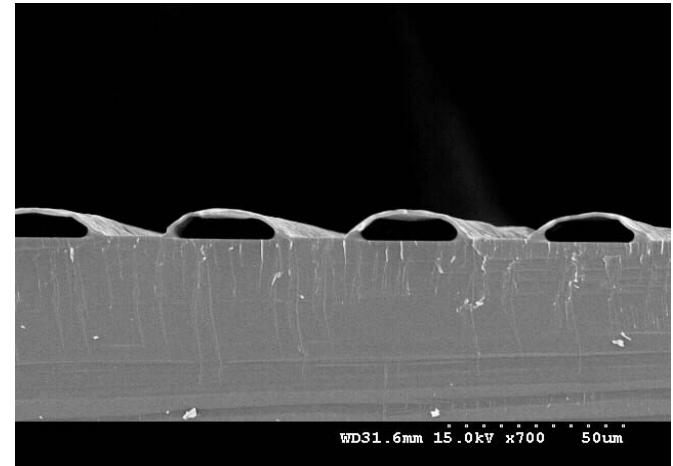


Encapsulating material: LMB 7081

Sacrificial material: poly(ethyl carbonate)

Encapsulant thickness: 7.6 μm

Air-gap height: 1.5 μm



Sacrificial material:
Poly(ethyl carbonate)

Encapsulating material: 2 μm
silicon dioxide

Photo-definable Microchannels

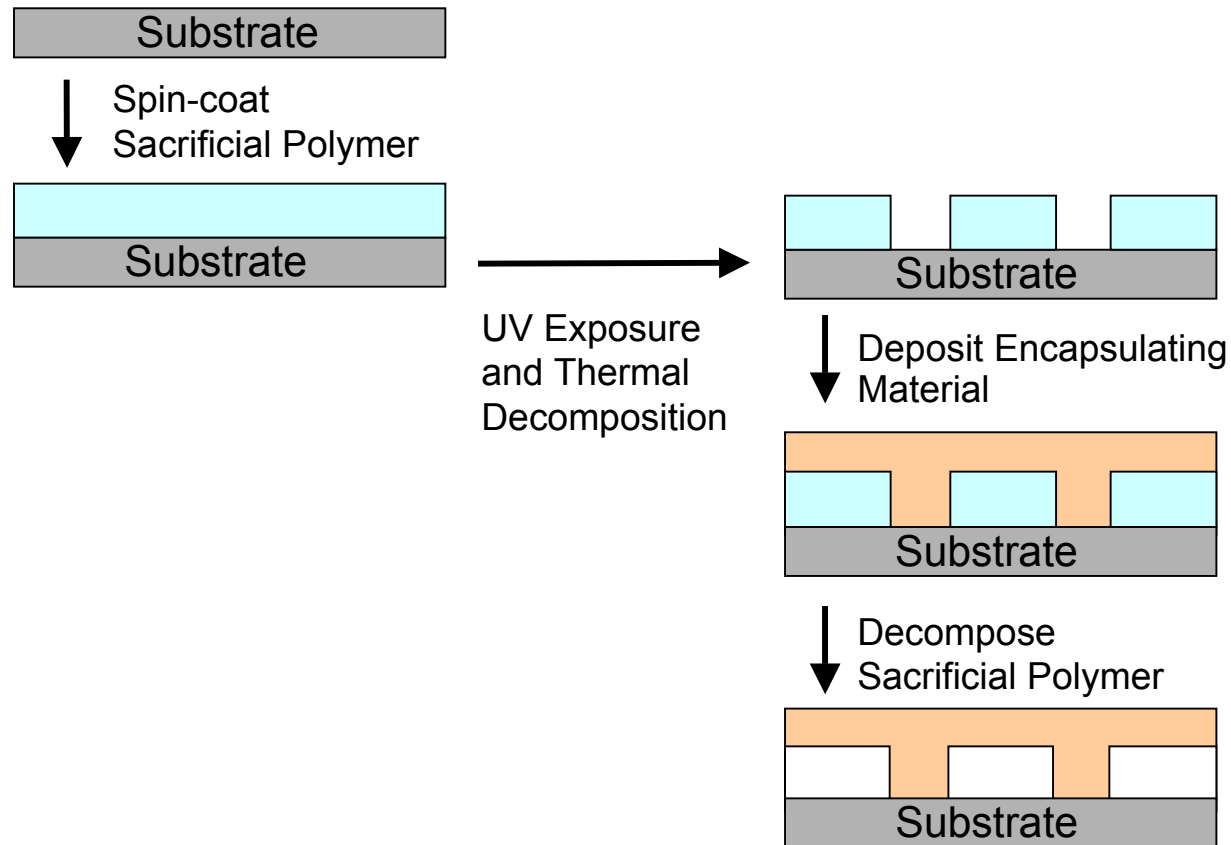
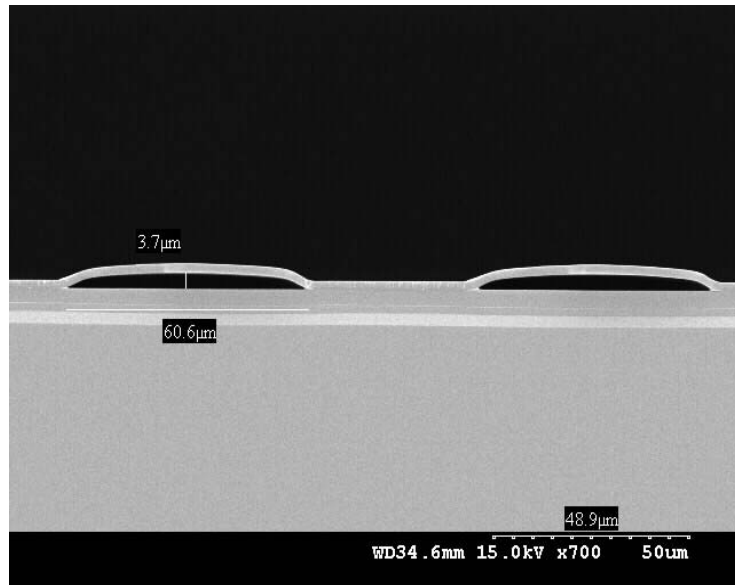
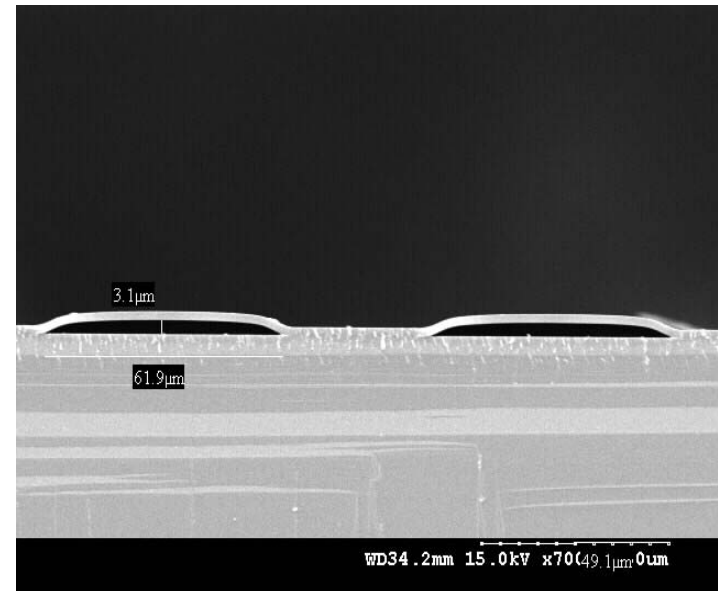


Photo-definable Microchannels

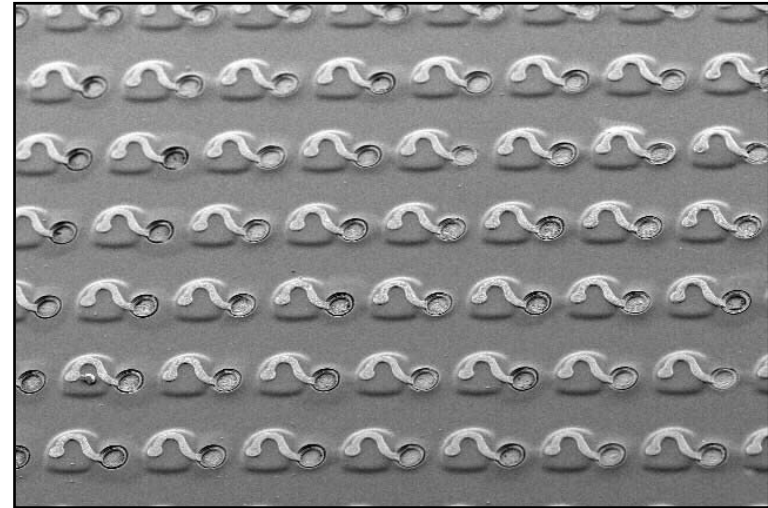
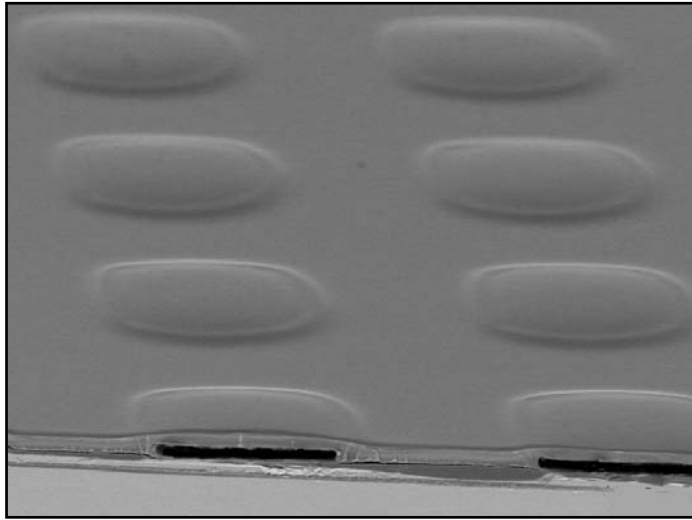


Air-gaps fabricated using Bioact developer

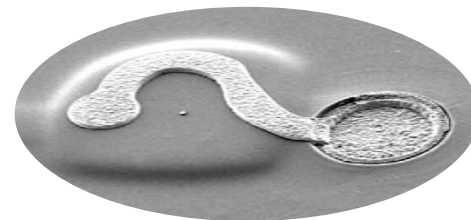


Air-gaps fabricated using Xylene developer

Application of airgap microchannel



- **Air gap dimensions:**
 - 170 μm wide, 10 μm tall
 - 15 μm overcoat polyimide
- **Via:** 55 μm
- **Interconnect Cu:** 10 μm thick



Application of airgap microchannel

