

# Microchannel fabrication using decomposable polymer

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# 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

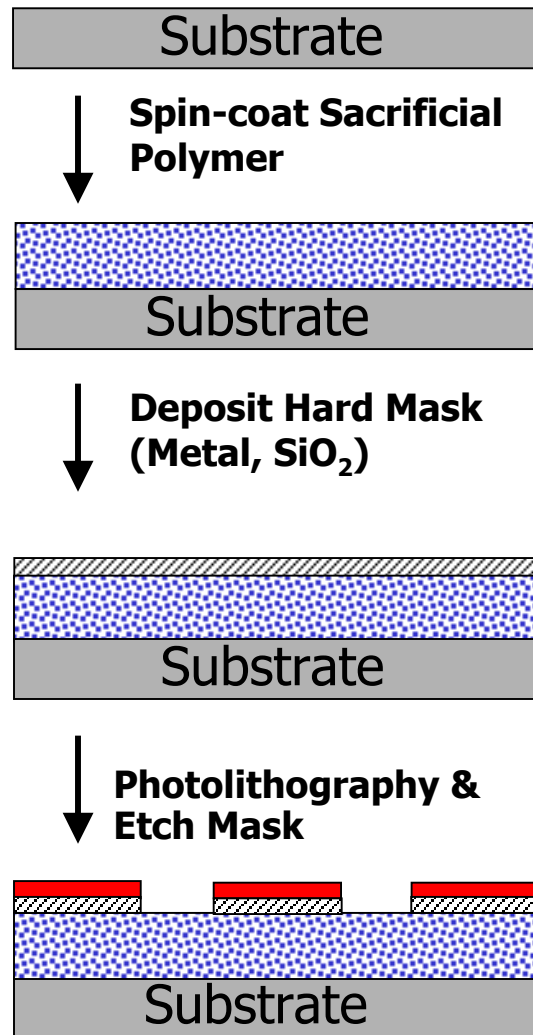
- make complete closed air-gap structures

- control over size/shape

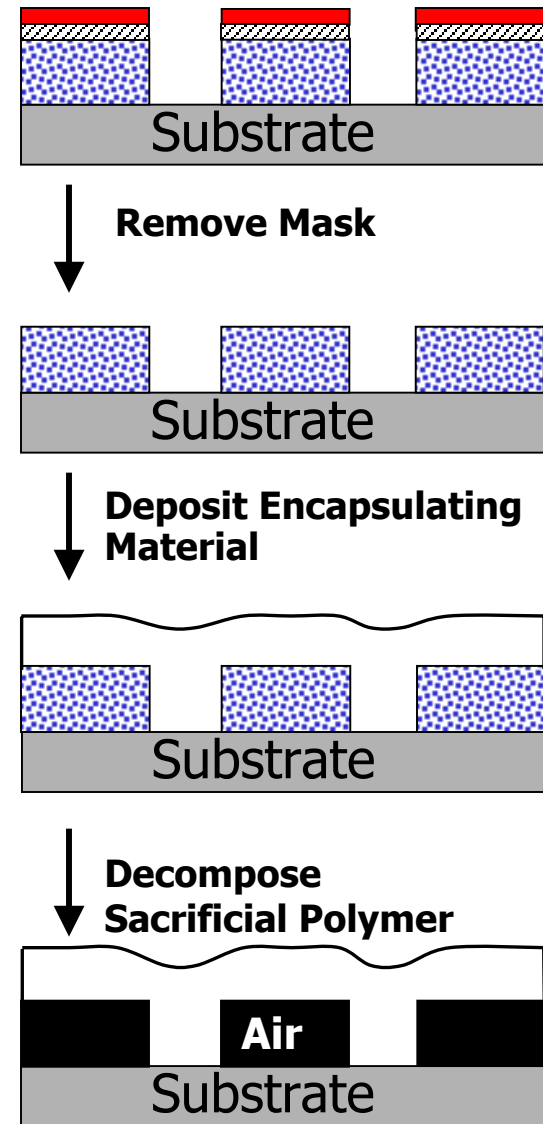
- wide range of compatible encapsulating material

- no wet chemicals to remove sacrificial

# *Fabrication via Non-photosensitive Sacrificial Polymer*

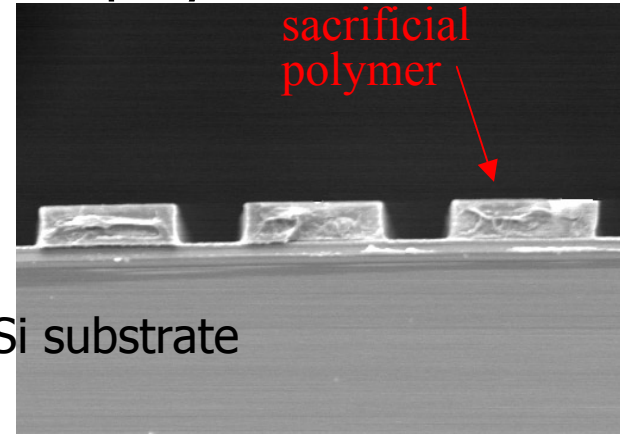


Plasma Etch polymer

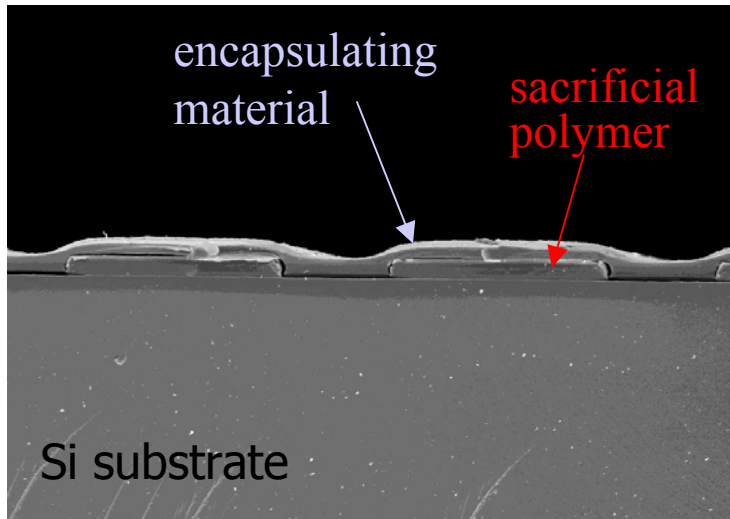


# *Microchannel Fabrication via Sacrificial Polymer*

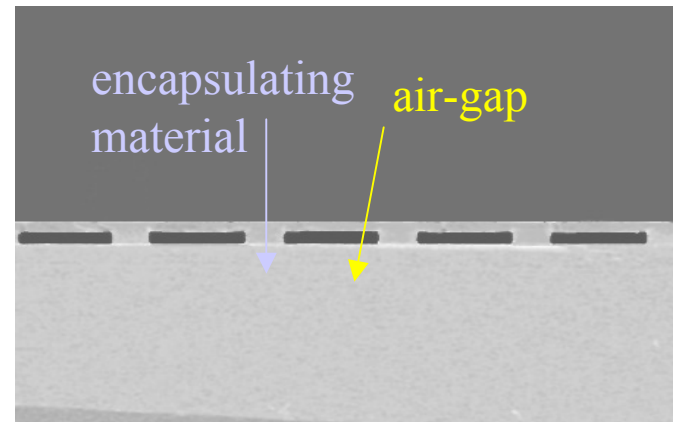
## Patterned polymer film



## Deposition of encapsulating material before decomposition



## Completed air-gaps



Si substrate

# Material Property Requirements

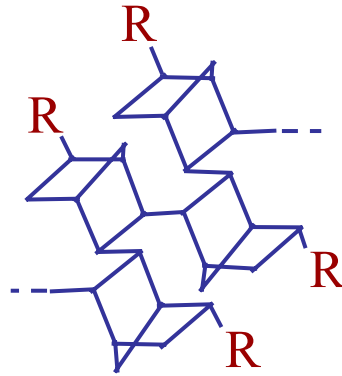
## Sacrificial material

- Decomposition in a narrow & useful temperature range
- Clean decomposition - little or no residue
- Adhesion to Si, SiO<sub>2</sub>, 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

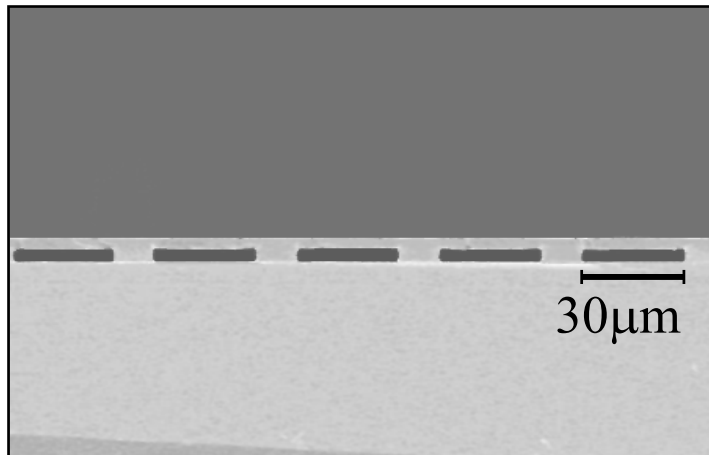
# *Polymer Encapsulated Microchannels*

Shape is dependent on:

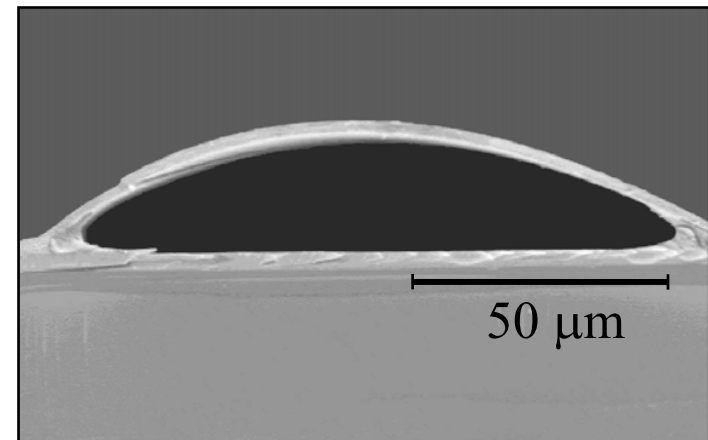
- size of the air-gap
- overcoat material
- decomposition rate

Size of structures:

- 0.25 - 1000  $\mu\text{m}$  in width
- 1-30  $\mu\text{m}$  in height
- overcoat thickness 1-28  $\mu\text{m}$

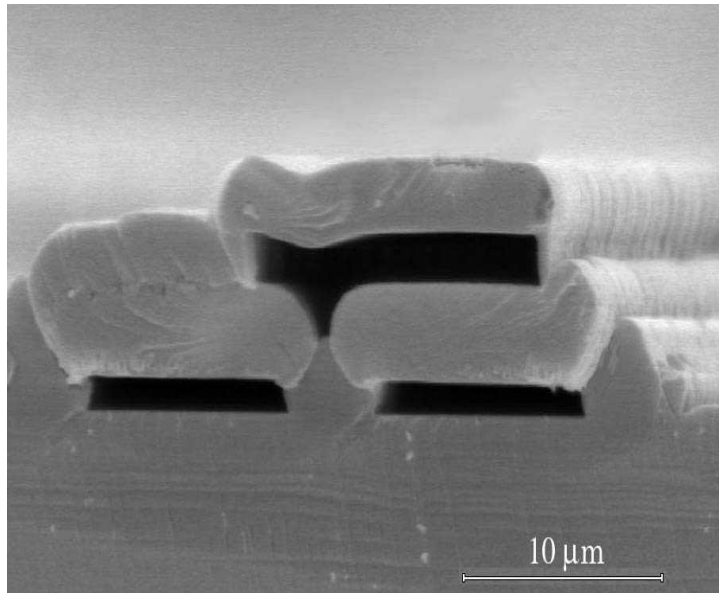


30mm air-gaps overcoated with Ultradel™ 7501

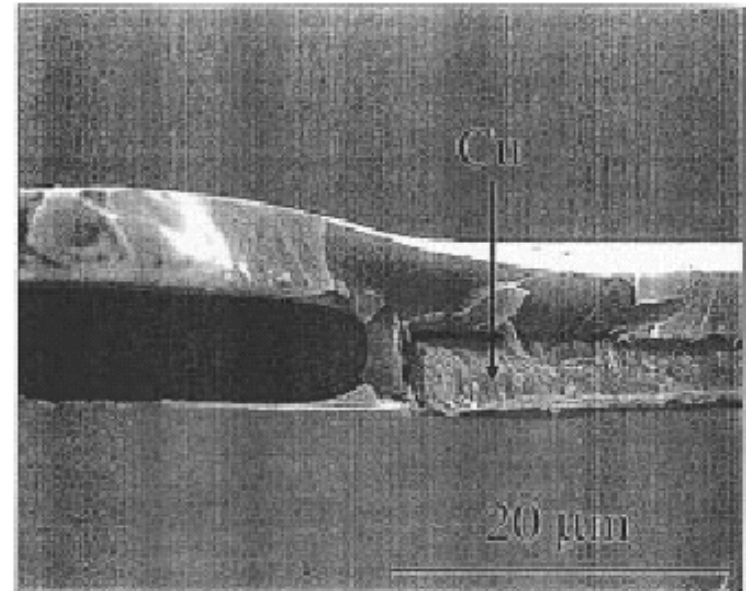


140 $\mu\text{m}$  air-gap fabricated with PNB  
overcoated with PI 2734

# *Encapsulated Microchannels*



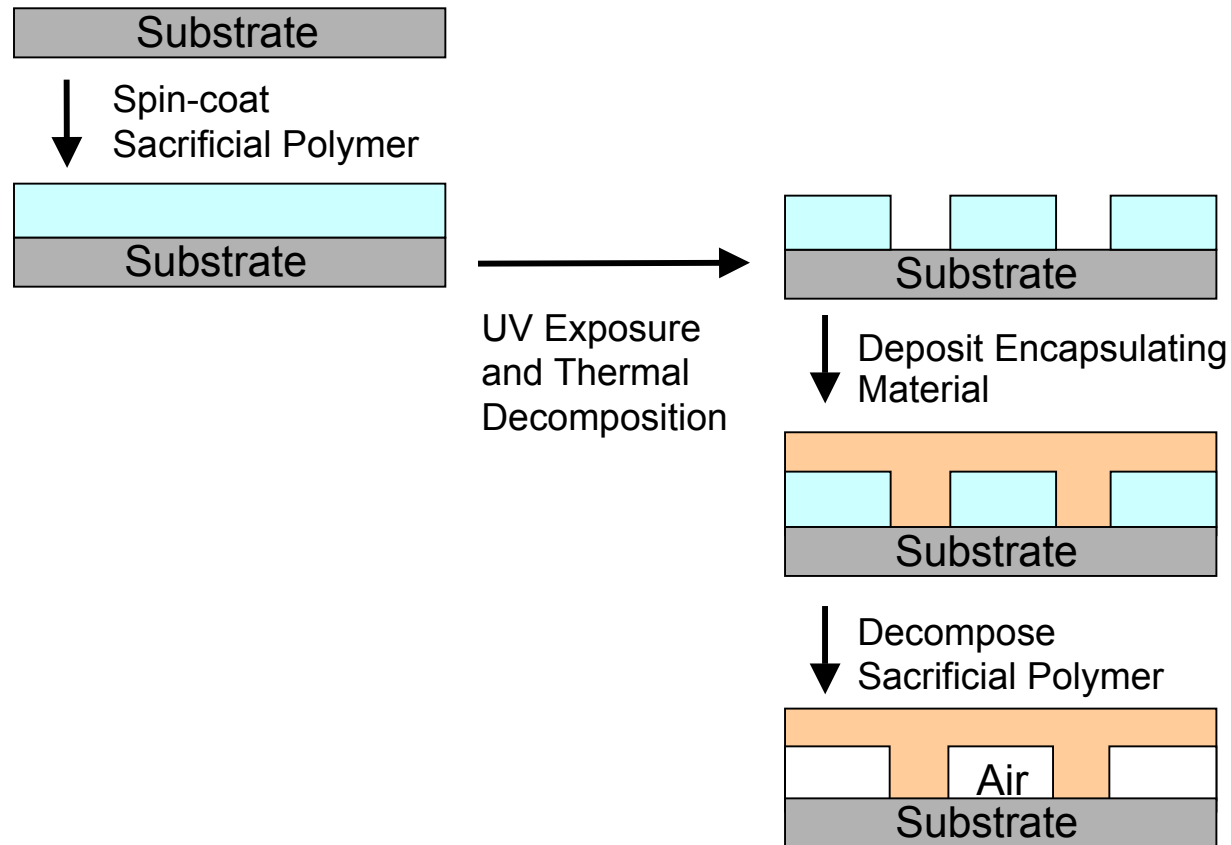
**Multilevel channels encapsulated in SiO<sub>2</sub>**



**Copper lines insulated by Ultradel 7501 from the air channel**

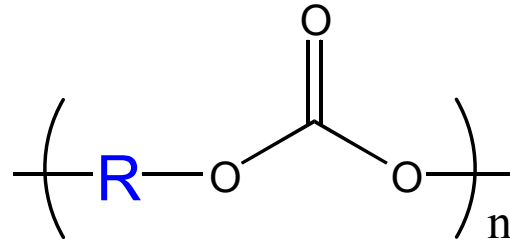


# Photo-definable Microchannels



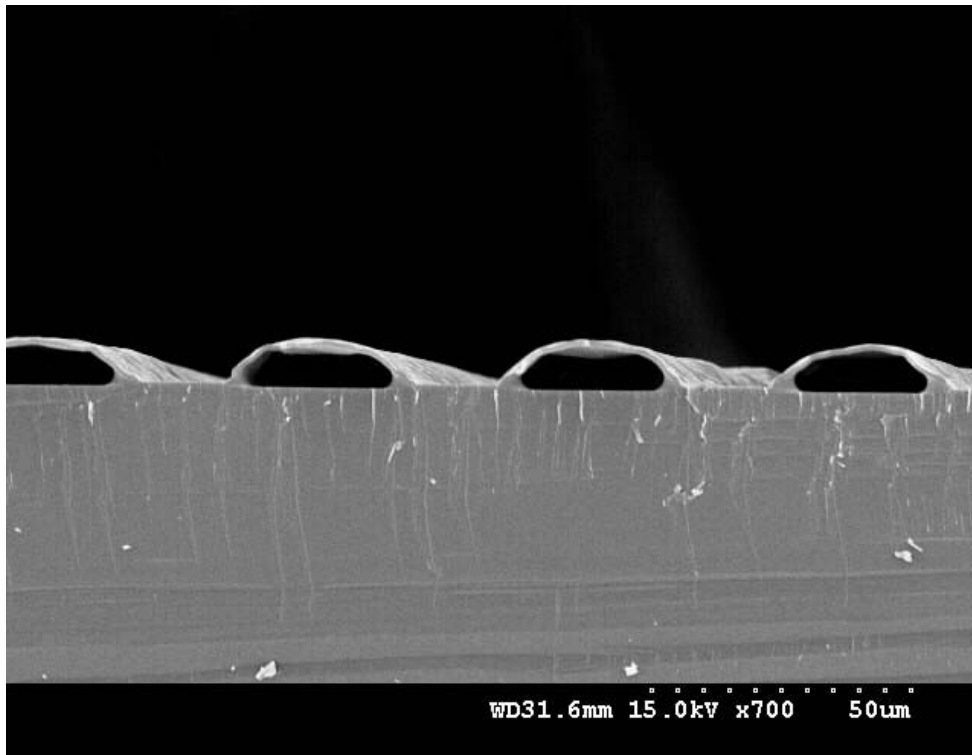
# *Encapsulating Materials for PC*

With Polycarbonate sacrificial material:



- Silicon Dioxide (PECVD inorganic material)
- thermoset photosensitive epoxy
- thermoplastic photosensitive polynorbornene
- BF Goodrich Unity™
- Dow Cyclotene Bisbenzocyclobutene 3022-57

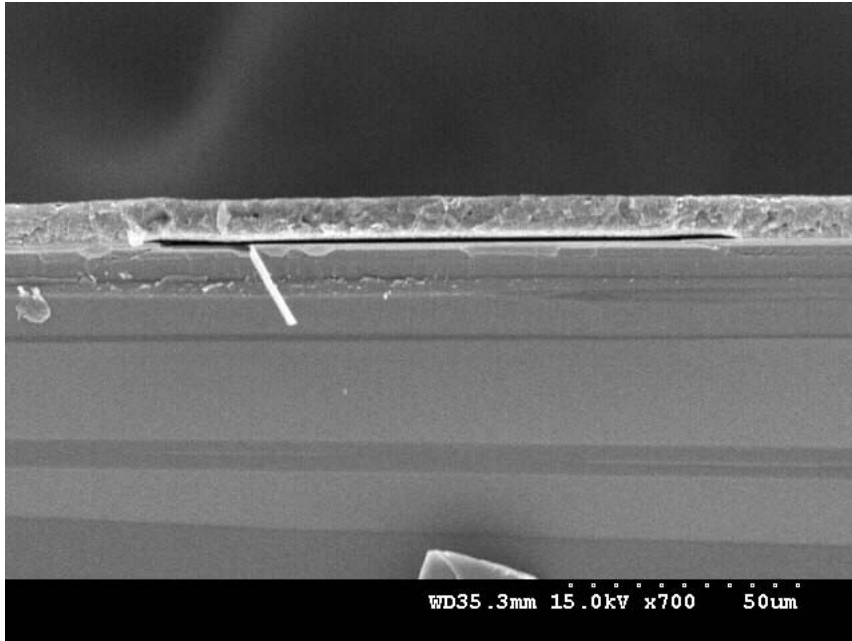
# *Air-gaps fabricated using Polycarbonate sacrificial material*



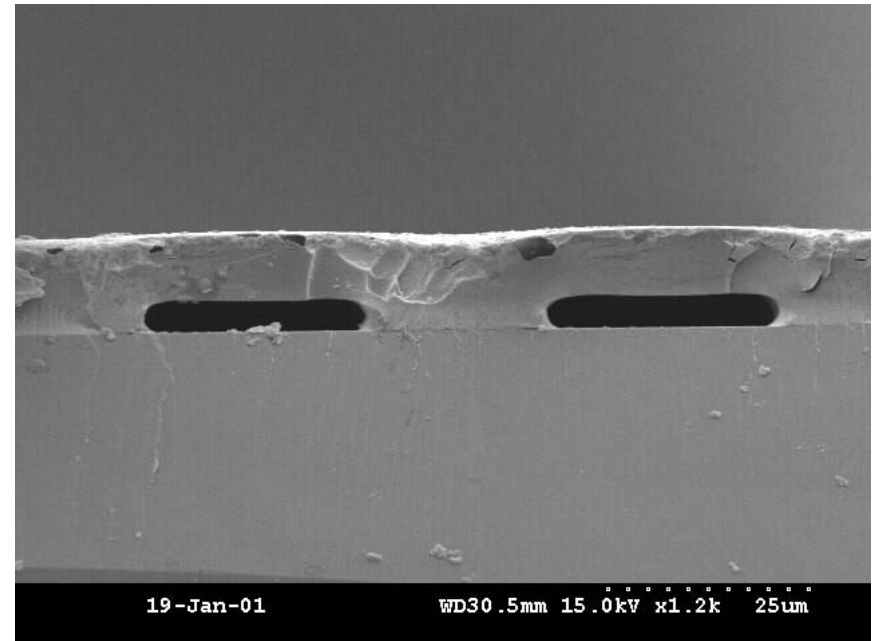
Sacrificial material:  
Poly(ethyl carbonate)

Encapsulating material:  
2  $\mu\text{m}$  silicon dioxide

# *Air-gaps fabricated using Polycarbonate sacrificial material*



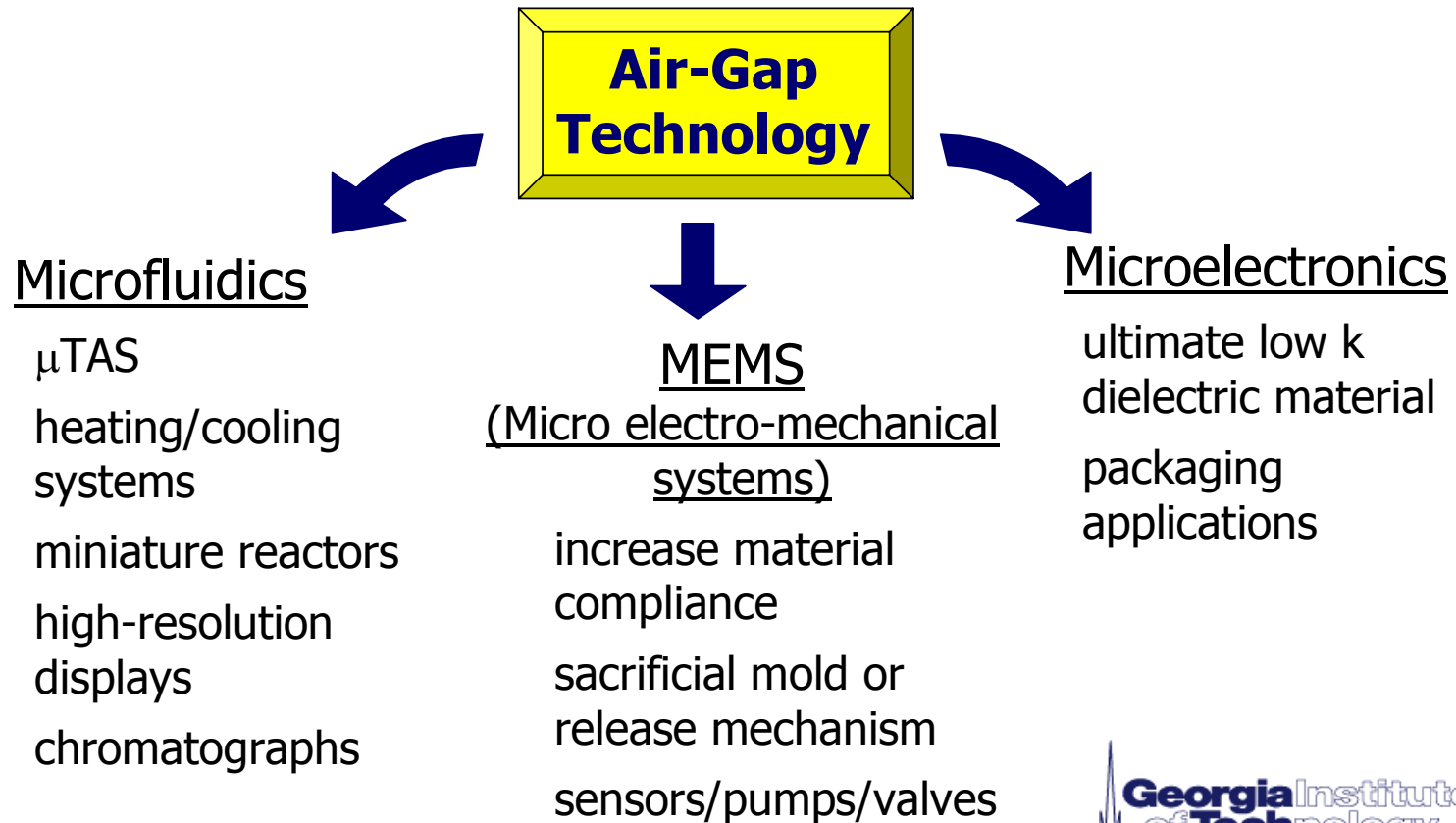
Encapsulating material: LMB 7081 epoxy  
Sacrificial material: poly(ethyl carbonate)  
Encapsulant thickness: 7.6  $\mu\text{m}$   
Air-gap height: 1.5  $\mu\text{m}$



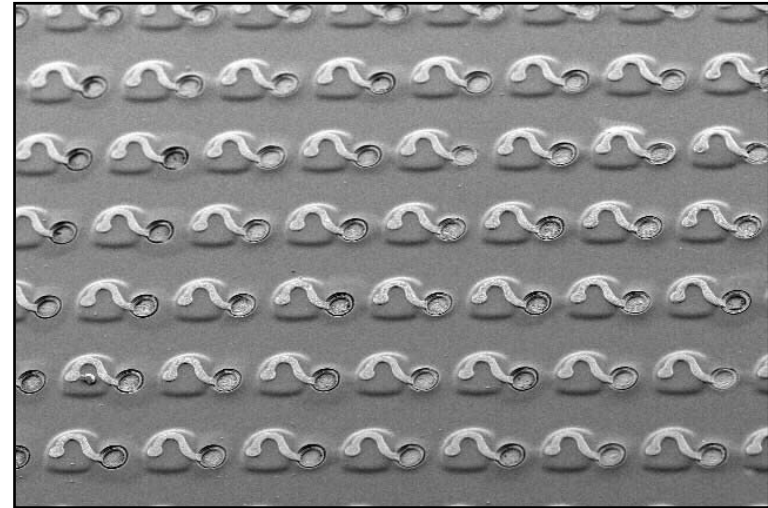
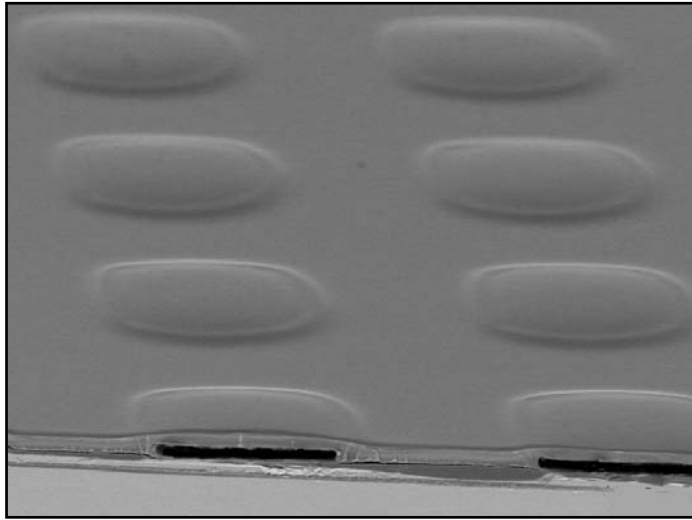
Encapsulating material: Avatrel™  
Sacrificial material: poly(ethyl carbonate)  
Encapsulant thickness: 7.6  $\mu\text{m}$   
Air-gap height: 1.5  $\mu\text{m}$

# Applications

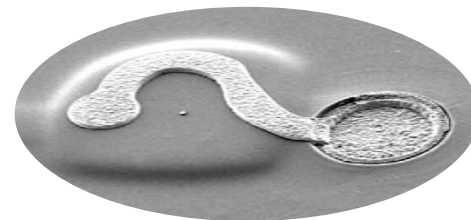
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# Application of airgap microchannel



- **Air gap dimensions:**
  - 170  $\mu\text{m}$  wide, 10  $\mu\text{m}$  tall
  - 15  $\mu\text{m}$  overcoat polyimide
- **Via:** 55  $\mu\text{m}$
- **Interconnect Cu:** 10  $\mu\text{m}$  thick



# Application of airgap microchannel

