

Principles of Micro- and Nanofabrication for Electronic and Photonic Devices

Etching 刻蚀

Part IV: CMP and others

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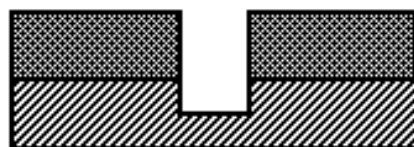
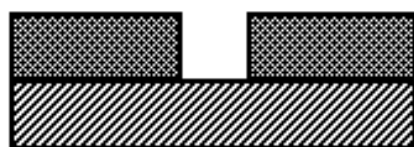
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Etching Methods

- **Wet Etching 湿法刻蚀**
- **Dry Etching 干法刻蚀**
- **CMP and other methods**

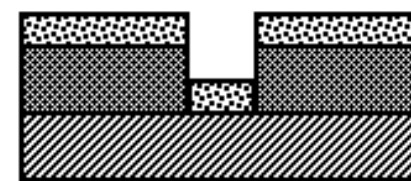
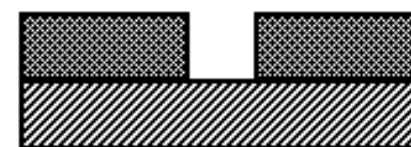
Pattern Formation

Subtractive Process

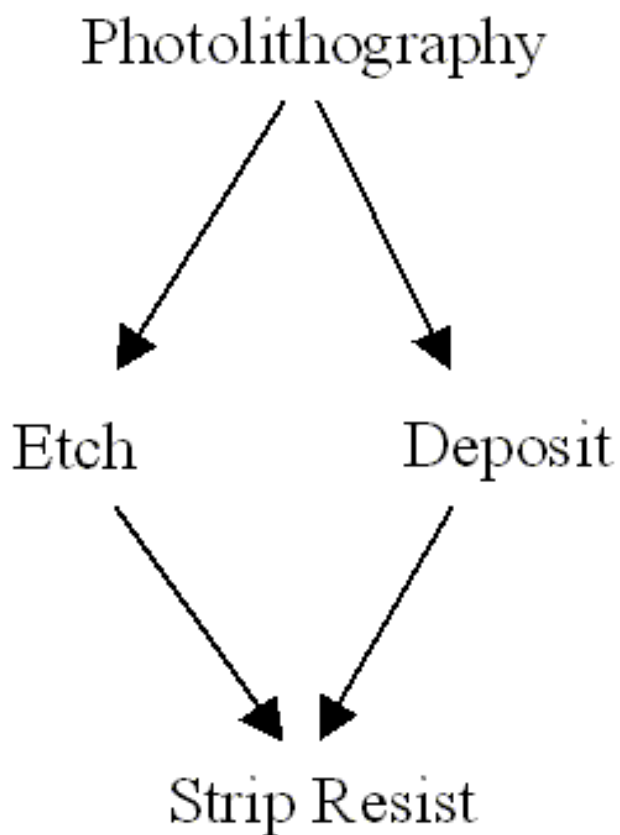


Pattern transfer
by etching

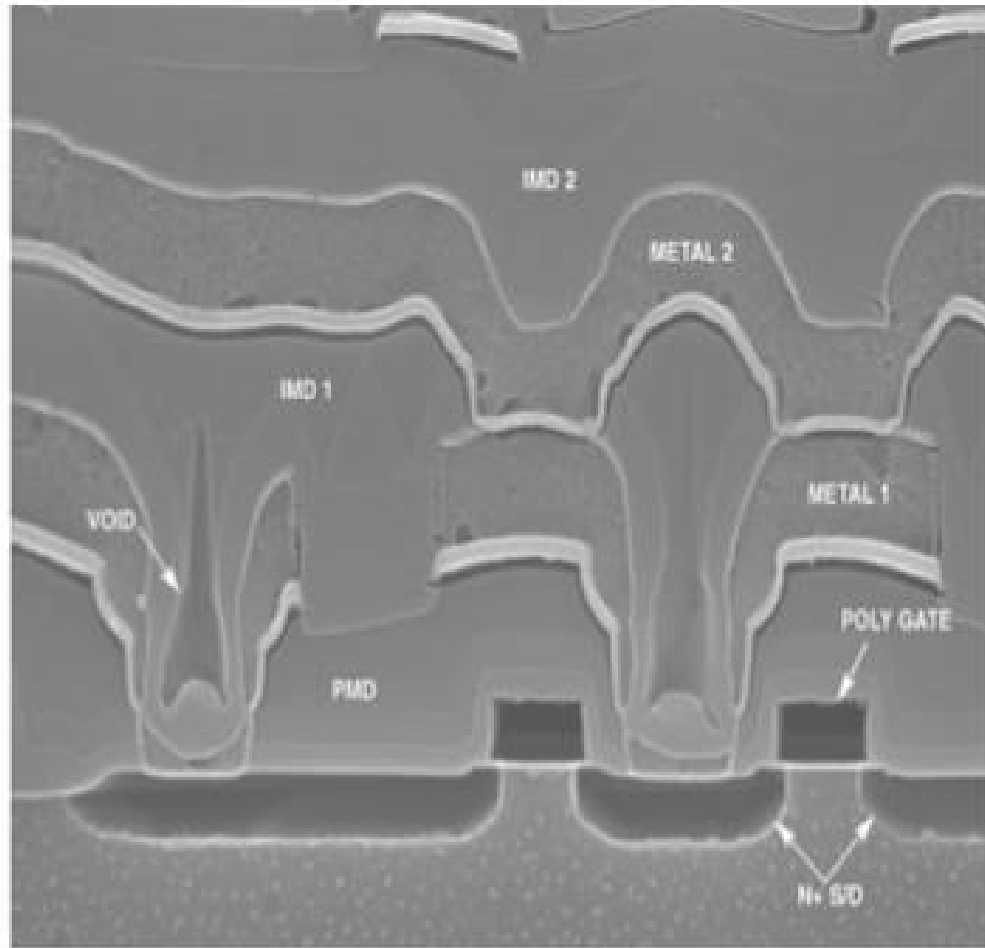
Additive Process



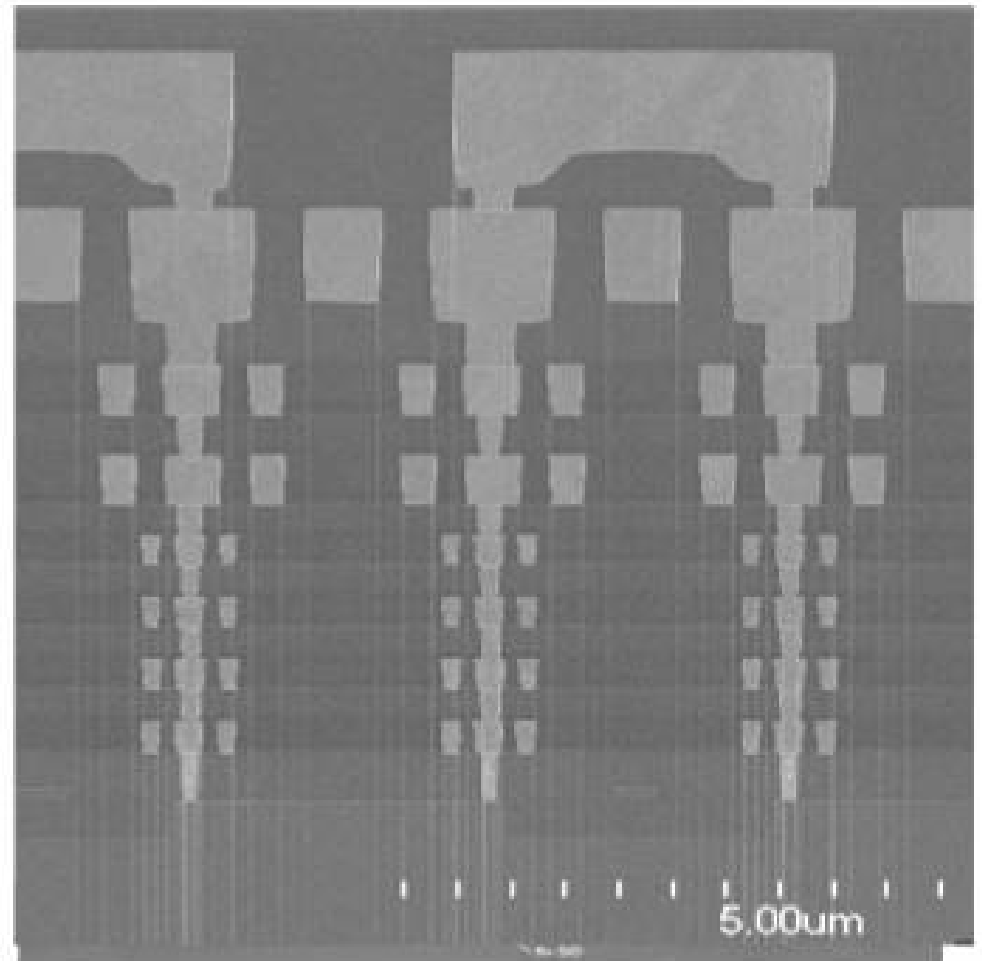
Pattern transfer
by lift off



Planar Layers are Desirable

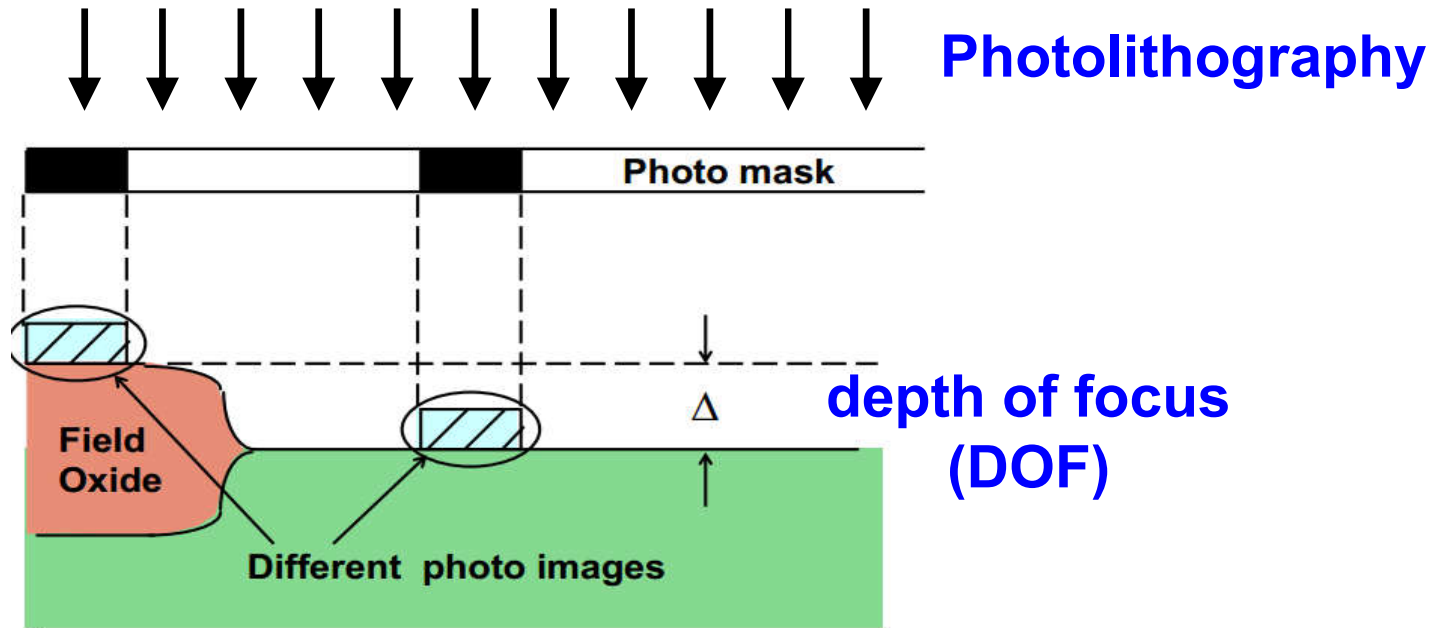


non-planarized IC



planarized IC

Issues with Depth of Focus (DOF)

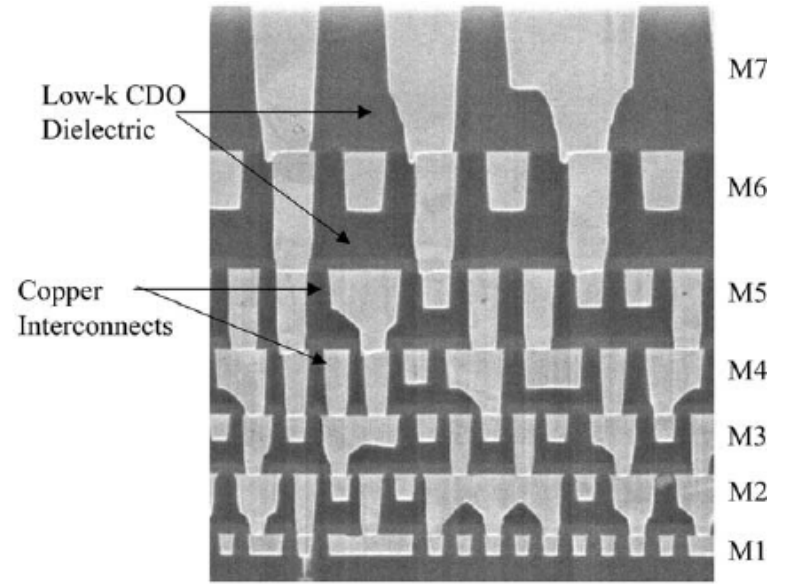
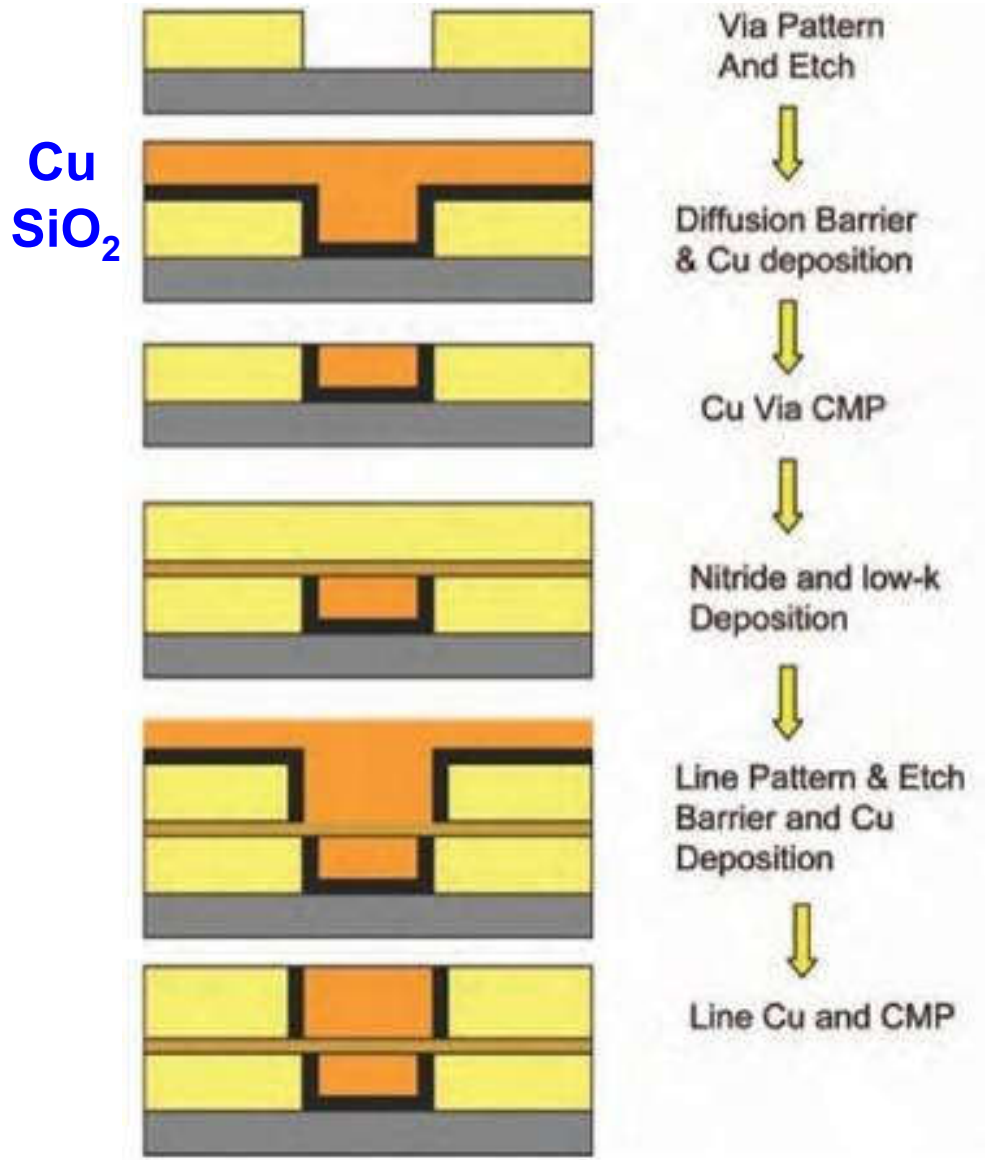


$$(1) l_m \cong 0.6 \frac{\lambda}{NA} \quad \text{want small } l_m$$

$$(2) DOF = \pm \frac{\lambda}{2(NA)^2} \quad \text{want large } DOF$$

smaller λ , larger NA
----> smaller DOF

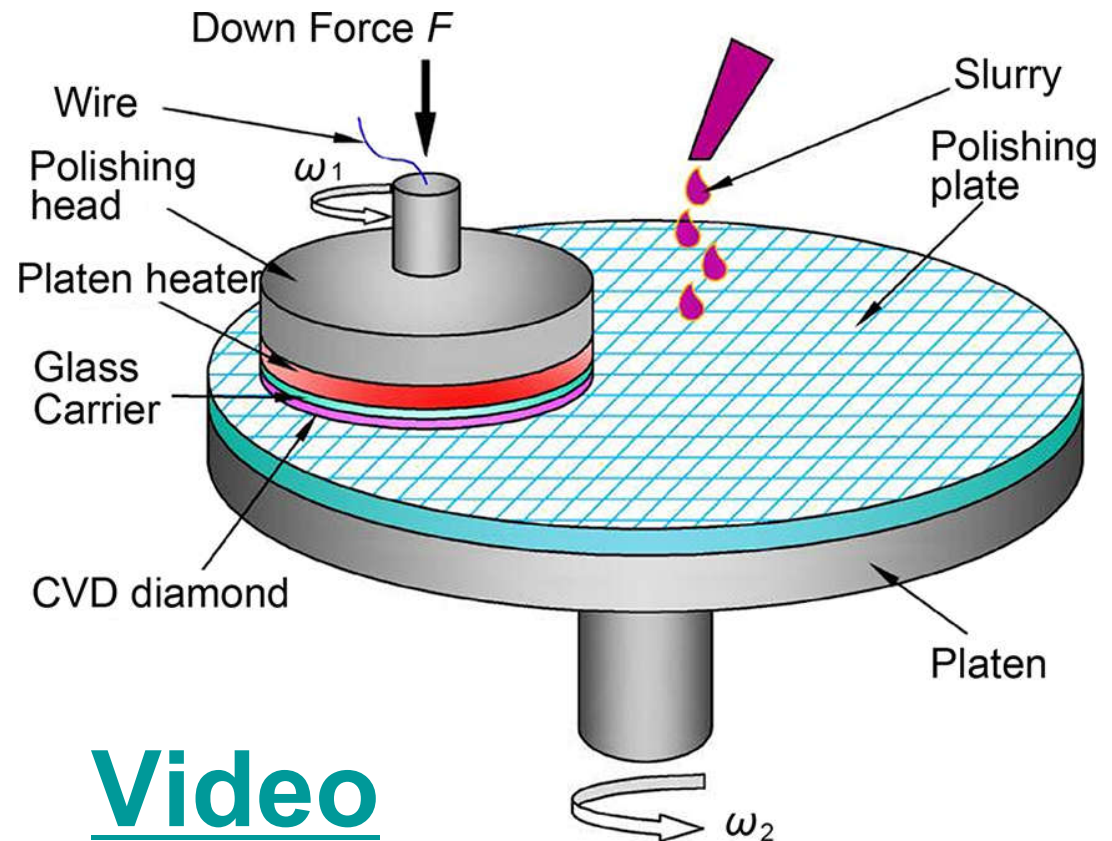
Damascene Process



ancient art work

CMP: Chemical Mechanical Polishing

- Chemical selectivity + Mechanical Planarization
- applied for Cu, W, SiO₂, ...

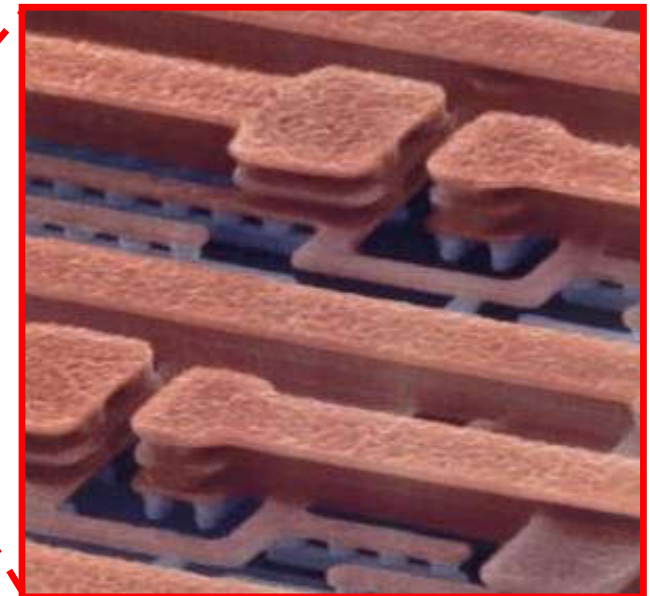
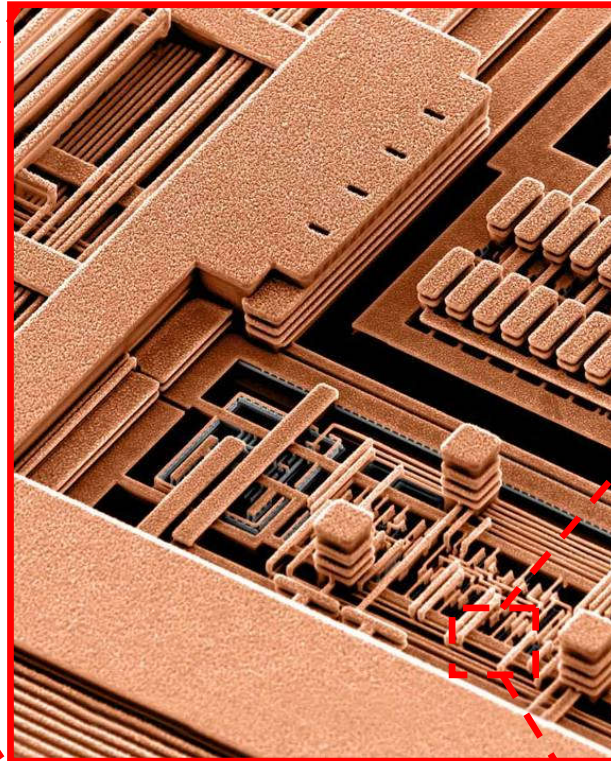


[Video](#)

3D IC



Electroplating + CMP
dirtiest process for the most advanced IC

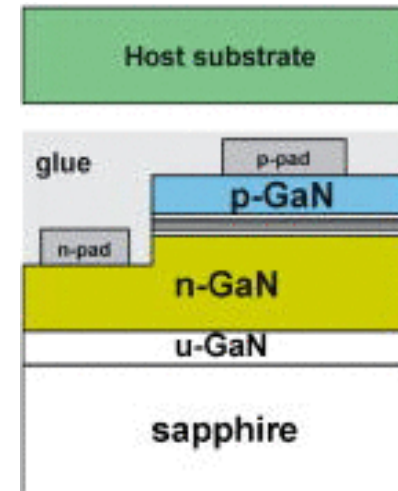


Other Methods for Etching

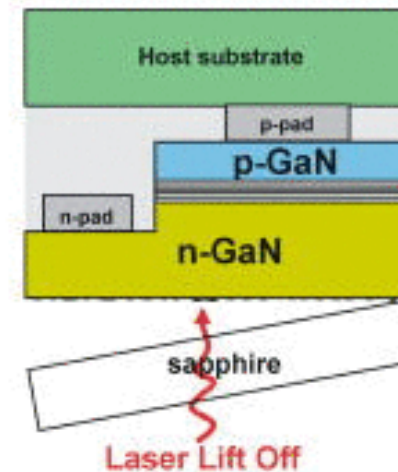
- **Laser Lift-Off**
- **FIB: Focused Ion Beam**
- **Laser Milling**
- ...

GaN Laser Liftoff

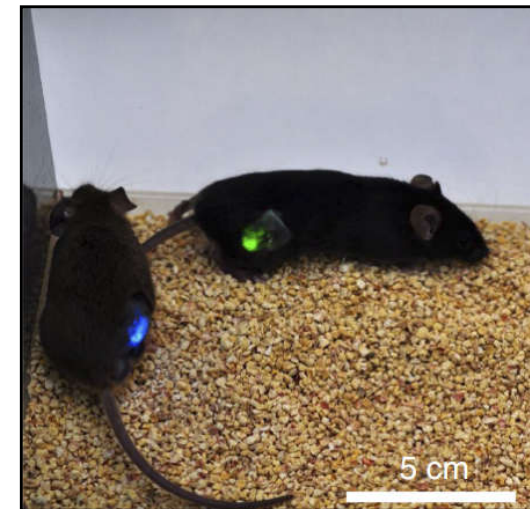
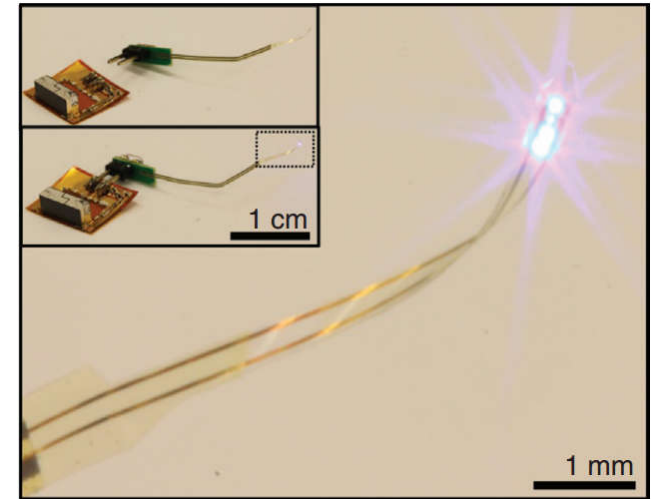
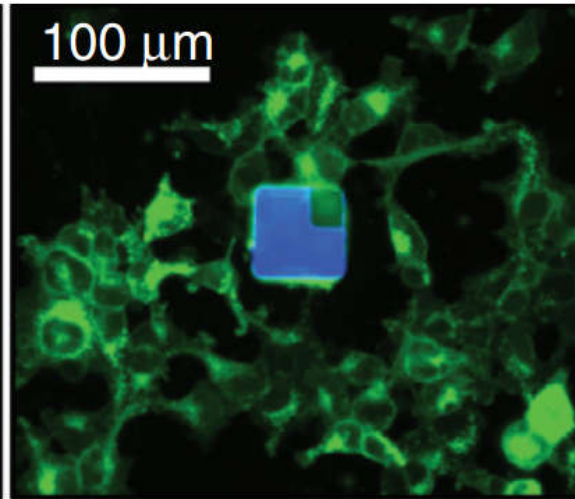
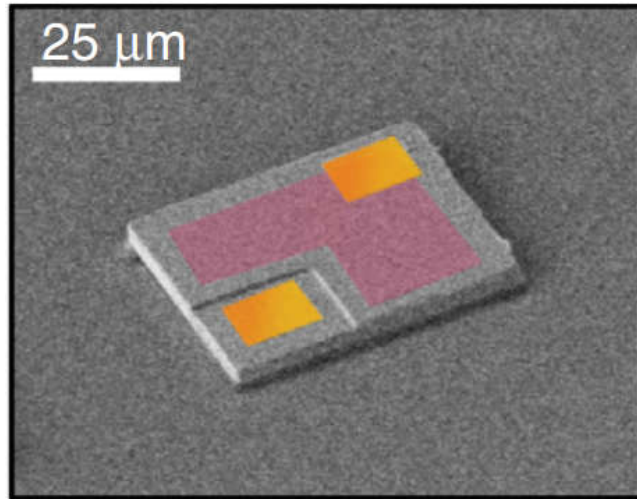
- GaN devices grown on sapphire
 - low cost
 - low thermal conductivity
 - electrically insulating
 - sapphire is very difficult to etch



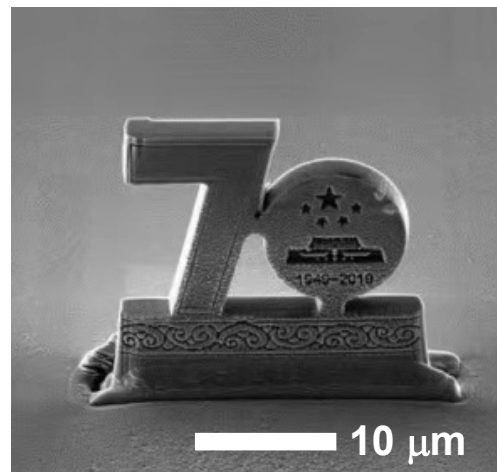
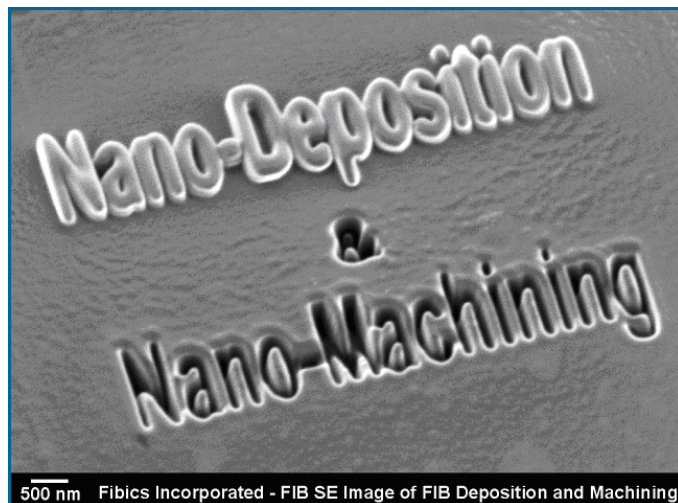
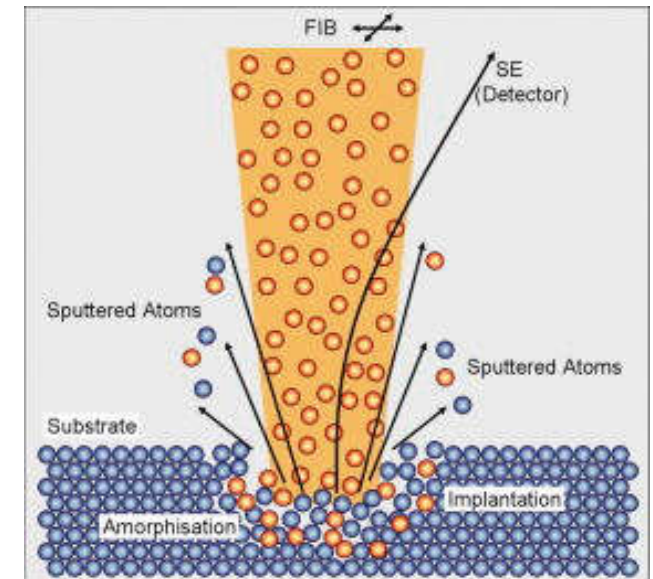
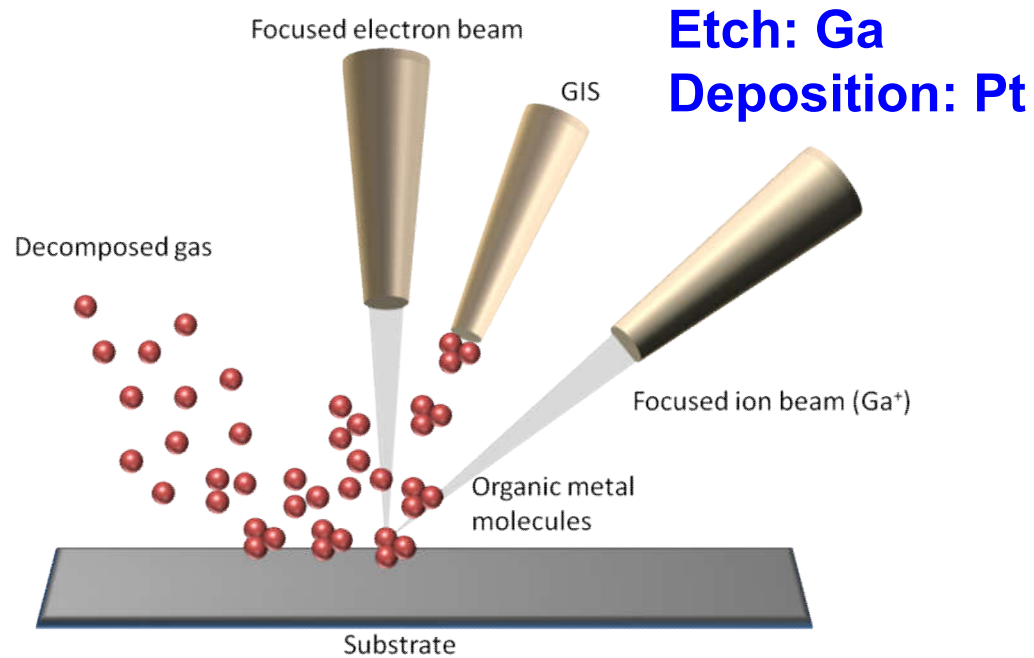
- Release by laser liftoff
 - KrF excimer UV laser (248 nm)
 - $\text{GaN} = \text{Ga} + \text{N}_2$ (gas)
 - bonding onto new substrates



Flexible GaN blue LEDs



FIB: Focused Ion Beam



- nanostructures
- SEM/TEM sample preparation
- doping

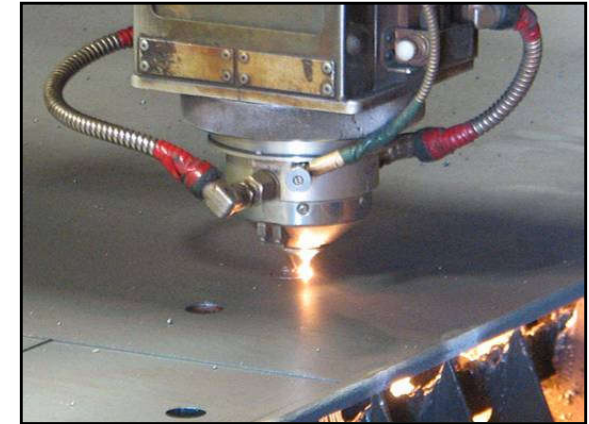
Laser Milling

■ Types

- CO₂ laser 10 μm
- Near-IR laser 1064 nm
- UV laser 365 nm
- Excimer laser 248 nm, 193 nm
- ns, ps, fs laser ...

■ Applications

- die cut, PCB cut, ...



shorter wavelength
shorter pulse



better resolution

