ME 517: Micro- and Nanoscale Processes

Lecture 6: Microfabrication - Techniques III

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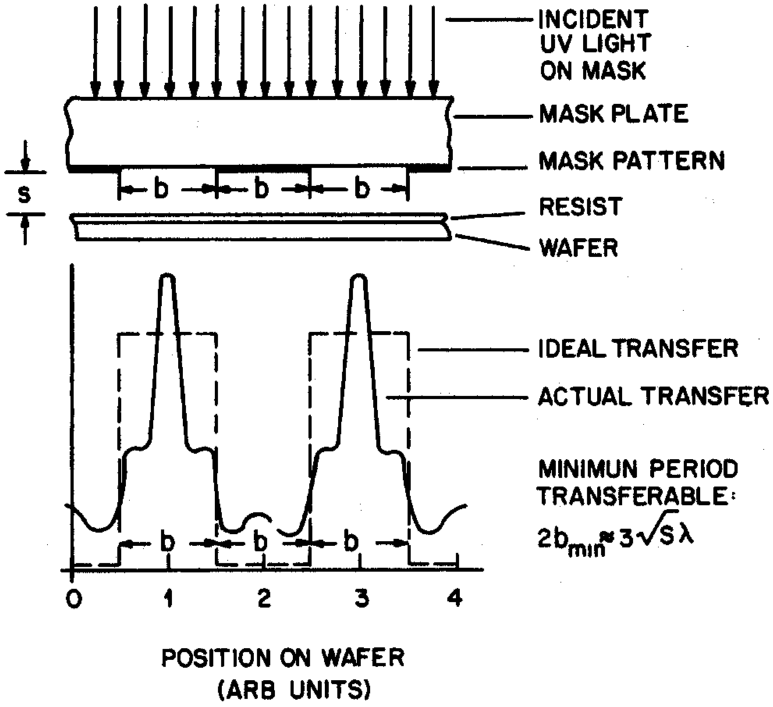
Spring 2014

•Lithography Resolution



C.G. Wilson, in Introduction to Microlithography, Thompson, L.F., Willson, C.G., and Bowden, M.J., ACS, 1994.

$$2b_{\mathrm{min}} = 3\sqrt{\lambda\left(s + \frac{Z}{2}\right)}$$

Contact Printing

$s = 0$
λ =400 nm
Z = 1000 nm (photoresist thickness)
b_{min} ~ 750 nm

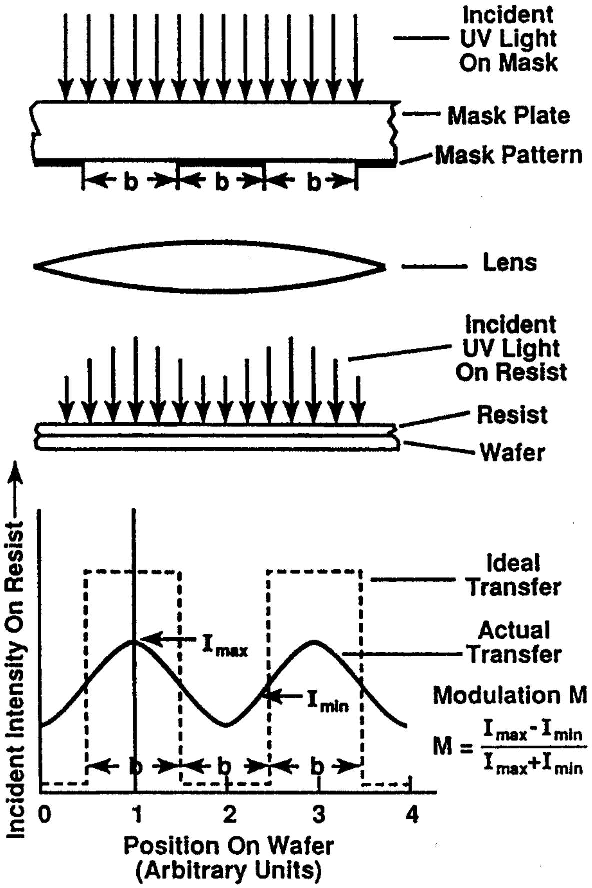
Proximity Printing

$$2b_{\mathrm{min}} = 3\sqrt{\lambda s}$$

b_{min} ~ 2,000 nm

•Lithography Resolution

Projection Printing



Optical resolution

$$R = \frac{0.7\lambda}{NA}$$

Resist profile

$$\frac{dZ}{dX} = \frac{dZ}{dD}\frac{dD}{dX}$$ Where D is dose

Vertical profile as a function of dose

$$\frac{dZ}{dD} = \frac{\gamma_p}{D_p}$$

Intensity profile

$$\frac{dD}{dx} = \frac{2NA}{\lambda\left(1 - 0.7\left(\frac{DOF \cdot NA^2}{\lambda}\right)\right)}$$

Brodie, I and J.J. Muray, The Physics of Microfabrication, Plenum, 1982.

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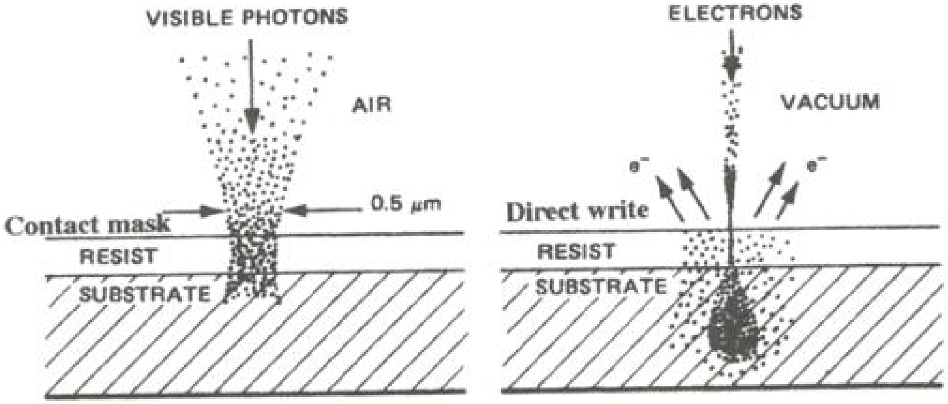
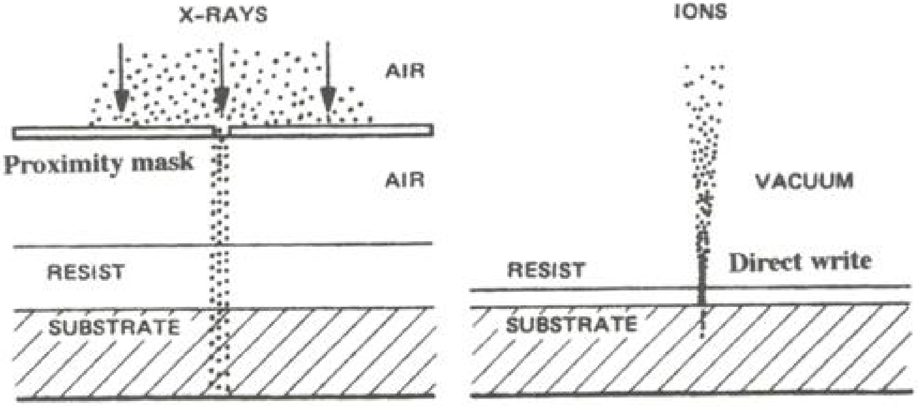
•Other Forms of lithography



(a) PHOTOLITHOGRAPHY
Routinely linewidths of 2-3 µm

(b) ELECTRON-BEAM LITHOGRAPHY
Linewidths of 0.1 µm

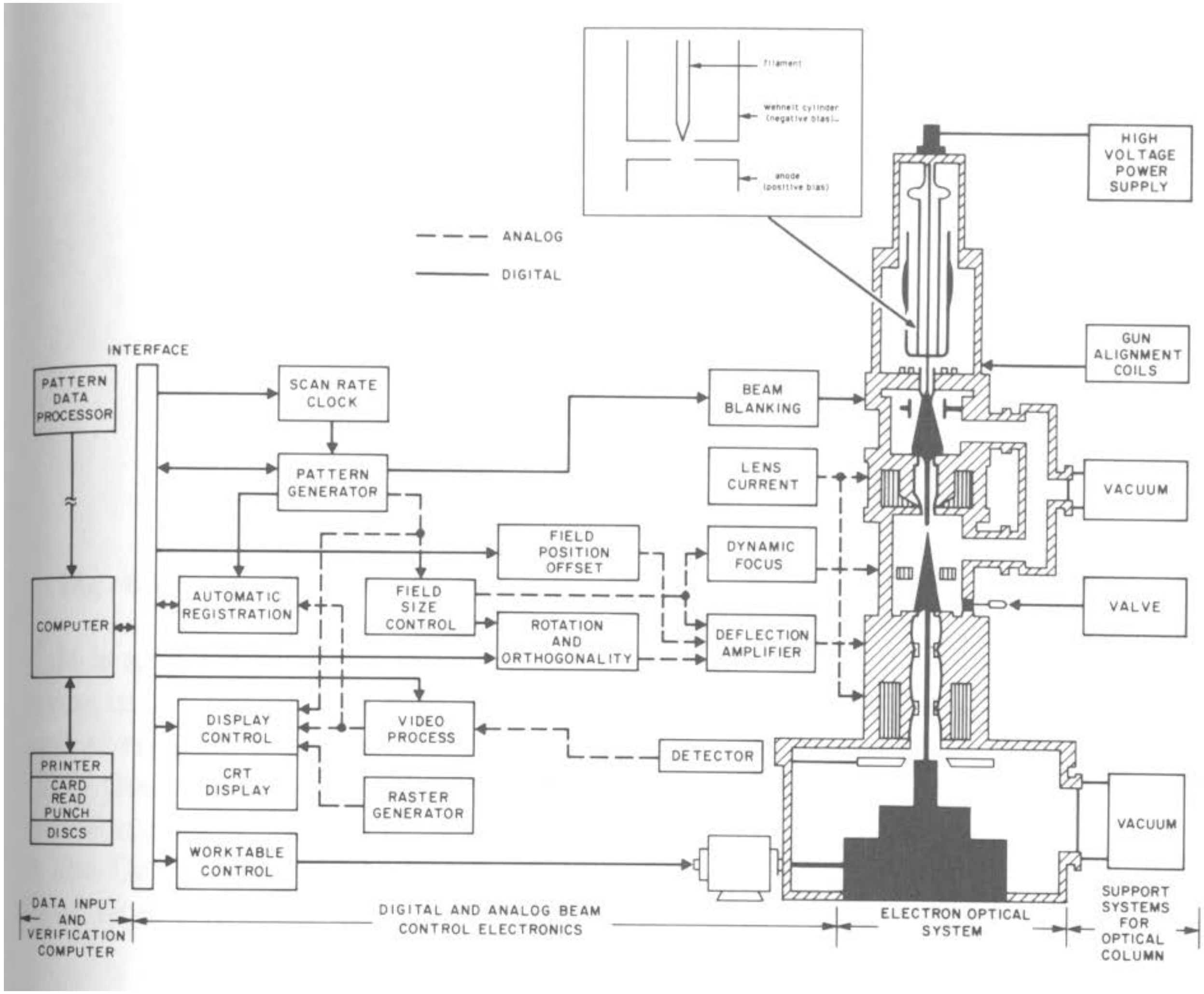


(c) X-RAY LITHOGRAPHY
Linewidths of 0.2 µm

(d) ION-BEAM LITHOGRAPHY
Linewidths of 0.1 µm

Brodie, I and J.J. Muray, The Physics of Microfabrication, Plenum, 1982.

•Electron Beam Lithography



Fabrication Part 2: Outline of Additive and Subtractive Techniques

Dry Etching Techniques

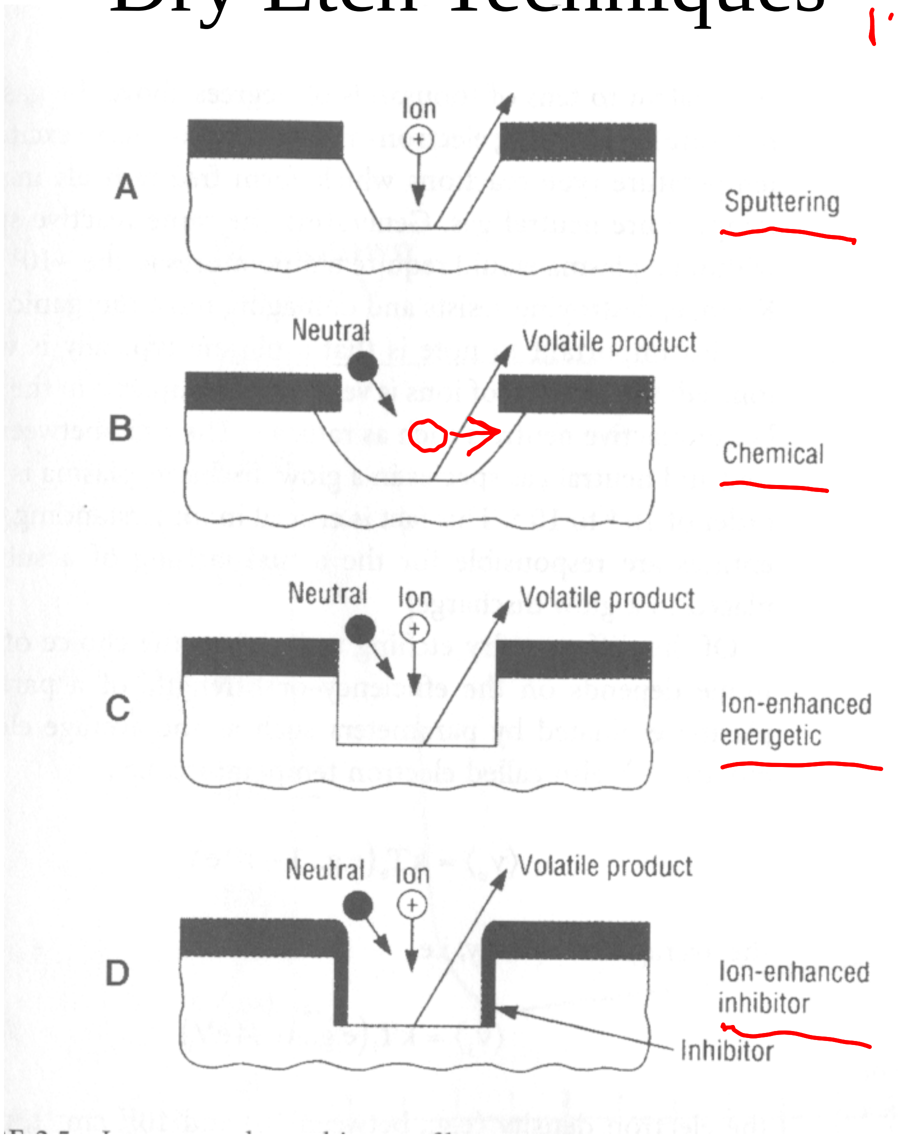
- DC and RF Plasmas
- Sputtering
- Characteristics
- Chemical Etching Techniques
- Physical-Chemical Etching Techniques
- Reaction Systems

Physical Deposition Techniques

- Thermal Deposition and Behavior
- Sputtering
- Chemical Vapor Deposition
- Behavior of CVD
- Electrochemical
- Organic films
- Doping

Dry Etch Techniques

relative etch speeds



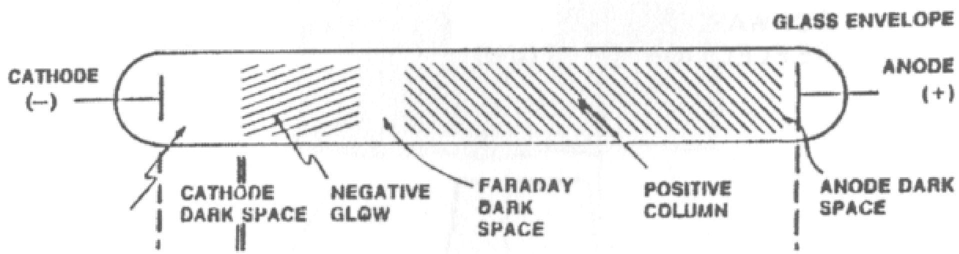
physical

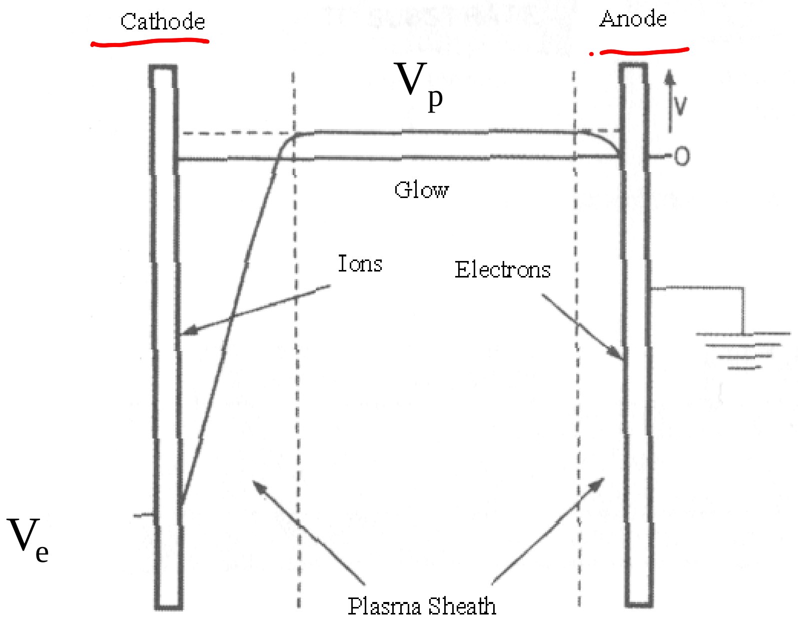
under cutting

RIE

DRIE

DC Plasmas





Plasma

- Electrons transfer enough energy to argon to generate a positive ion and secondary electron. The ionization potential of Ar ~ 15.7 eV.
- Plasma is generated by the avalanching ionization 10-20 gas molecules per secondary electrons.

V_e ~ 1.5 KV Field ~ 100 V/cm