

CHE323/CHE384
 Chemical Processes for Micro- and Nanofabrication
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Lecture 36 Etch, part 3

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Reading:
 Chapter 11, *Fabrication Engineering at the Micro- and Nanoscale*, 4th edition, Campbell

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Etch Tradeoff

	High Selectivity	Low Selectivity
High Anisotropy	?	Sputter Etching
Low Anisotropy	Plasma Etching or Wet Etching	

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Plasma Etching Steps

1. Electron strikes a gas molecule, creating free radical
2. Free radical diffuses to wafer surface
3. Free radical is adsorbed onto surface
4. Reaction at surface
5. Reaction product is volatilized, diffuses into gas

Generally this process is isotropic,
 with potentially high selectivity

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Reactive Ion Etching (RIE)

- A kind of ion-enhanced plasma etching
- Use ion bombardment to significantly increase the rate of one of these steps
 - Surface adsorption
 - Surface reaction
 - Byproduct removal
- Chemical etching occurs only where the ions strike, giving both selectivity and anisotropy

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RIE Possible Mechanisms

- Ions may break bonds on surface, making the surface more reactive
- Etch reaction products may stay on surface until sputtered off by ions
- Etch byproducts (polymers from etched resist, for example) may coat the surface until sputtered off by ions
 - Called sidewall passivation or polymerization

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Sidewall Passivation

Fabrication Engineering at the Micro- and Nanoscale, 4th edition, Campbell, p. 310

Figure 11.11 Schematic diagram of a high pressure anisotropic etch showing the formation of sidewall passivating films.

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Reactive Ion Etching (RIE)

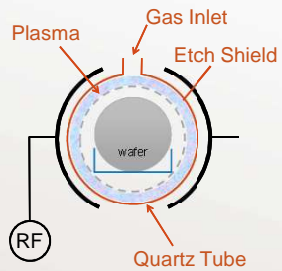
- RIE can produce good selectivity, high anisotropy, and moderate etch rates
- Sometimes
- Every RIE process is custom – unique to the film being etched, the mask material, and the etch stop layer
 - Control is sometimes difficult

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Etch Systems – Barrel Etcher

- Full boat of wafers etched at once
- Reactive neutrals diffuse to wafer
 - Chemical etching only
 - No ion bombardment, no ion damage
 - High throughput
 - Poor uniformity
- Used for non-critical etching and stripping
 - Ex: photoresist ashing

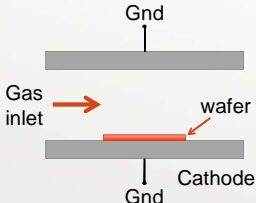


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Etch Systems – Parallel Plate

- Plasma Mode
 - Moderate pressure
 - Both wafer and chamber grounded
 - Low ion flux, little ion damage
 - Good uniformity
 - High selectivity

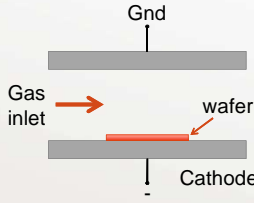


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Etch Systems – Parallel Plate

- RIE Mode
 - Lower pressure (10 – 100 mtorr)
 - Ground chamber, plasma voltage is hundreds of Volts
 - More energetic ions
 - Good anisotropy
 - Moderate/High selectivity

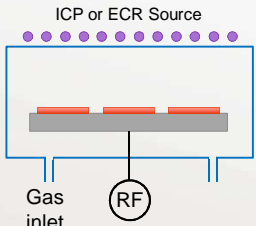


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Etch Systems – High Density Plasma

- ICP – inductively coupled plasma
- ECR – electron cyclotron resonance
- Create high density plasma without affecting wafer bias
 - Run in RIE mode
 - Low pressure (1–10 mtorr), but high etch rates due to high density plasma
 - Less ionic bombardment
 - Very popular



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Lecture 36: What have we learned?

- What problem is reactive ion etching trying to solve?
- How does RIE work?
- What is sidewall passivation?
- What are the characteristics of barrel etchers and why are they used?
- Why are high density plasma systems popular?

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