Ultra Clean Magnetically Enhanced Reactive Ion Etching (UCMERIE)

ECE 6450

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Reactive Ion Etching (RIE)

- Should probably be called Ion Assisted Etching

Advantages of RIE

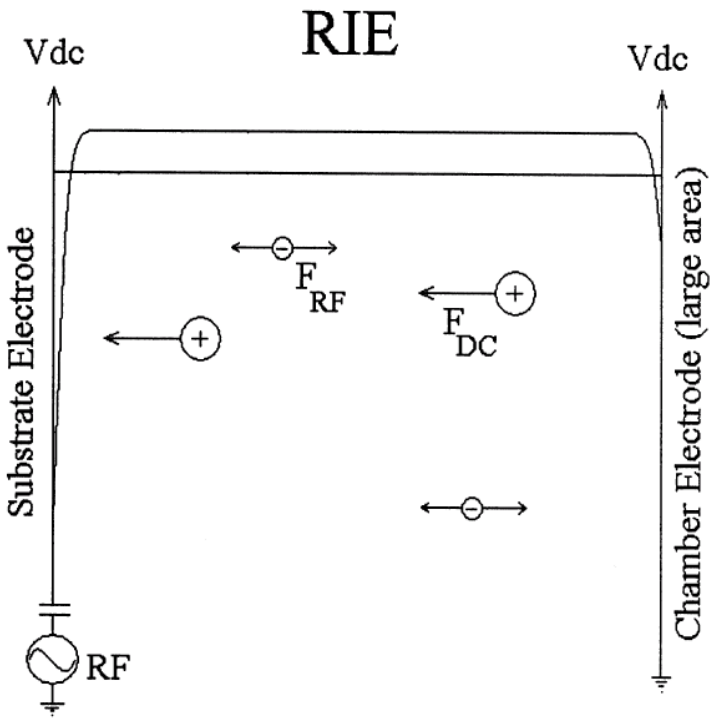
- Anisotrophy
- Selectivity

Disadvantages of RIE

- Substrate damage due to high ion energies
- Poor etch rates in deep structures

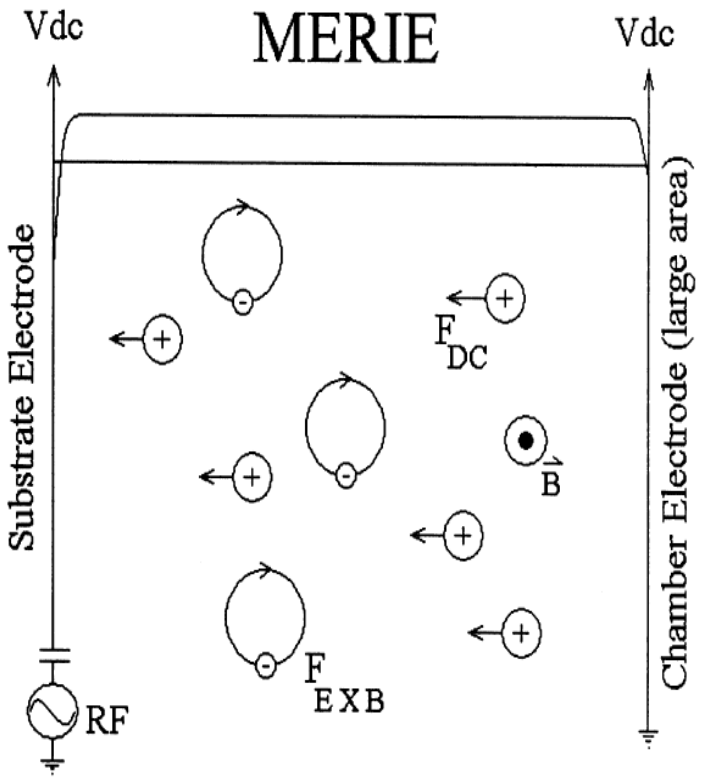
Reactive Ion Etching

- Electrons accelerated by Alternating RF electric field
- Electrons oscillate back and forth gaining energy
- Electrons strike heavier atoms creating ions
- Electrons strike electrodes and establish a DC bias
- Ions accelerated by DC field (hundreds of volts)

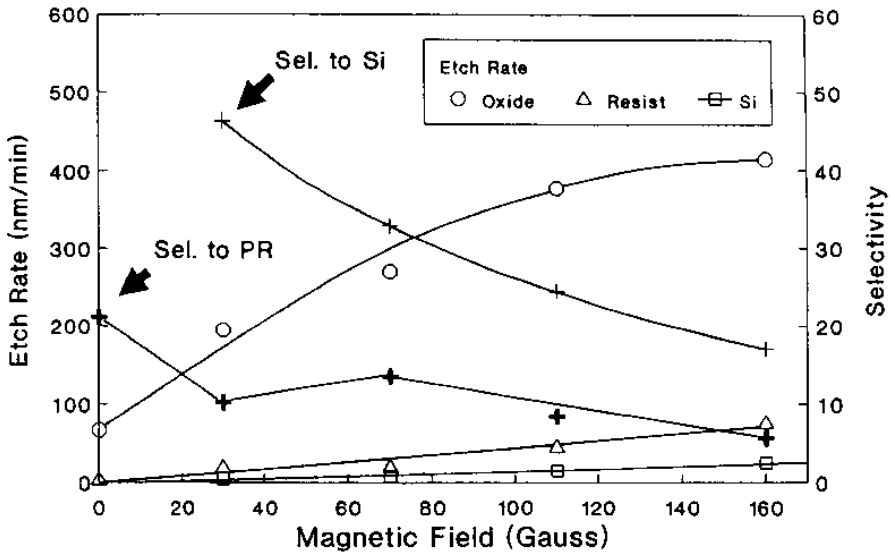


Magnetically Enhanced RIE

- Magnetic field is applied parallel to the substrate
- The electrons now move in a loop
- More electrons in the plasma increases the number of ions
- Smaller DC Bias (tens of volts)
- More slower moving ions, less substrate damage



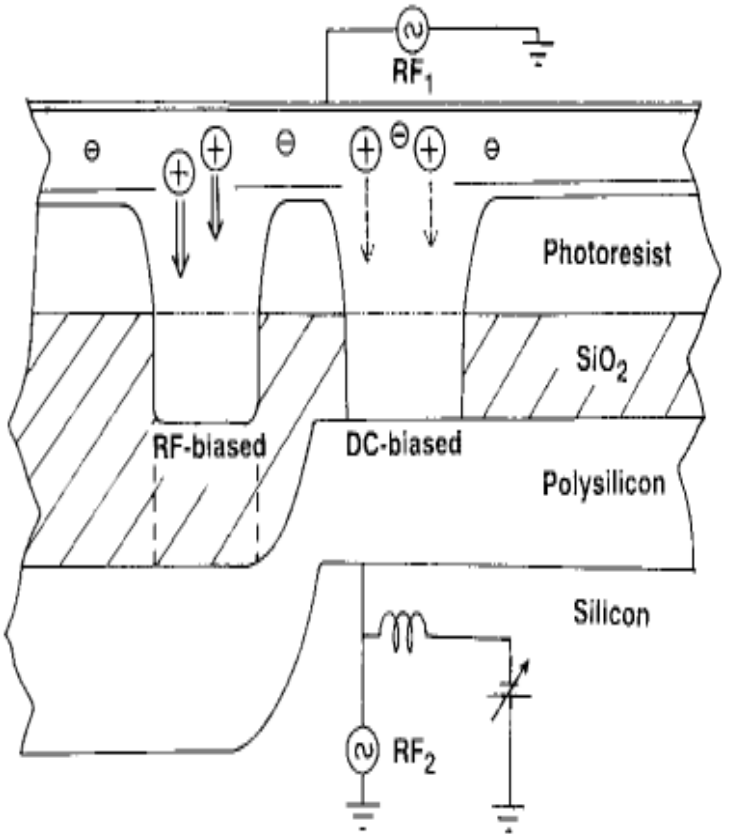
Problems with MERIE



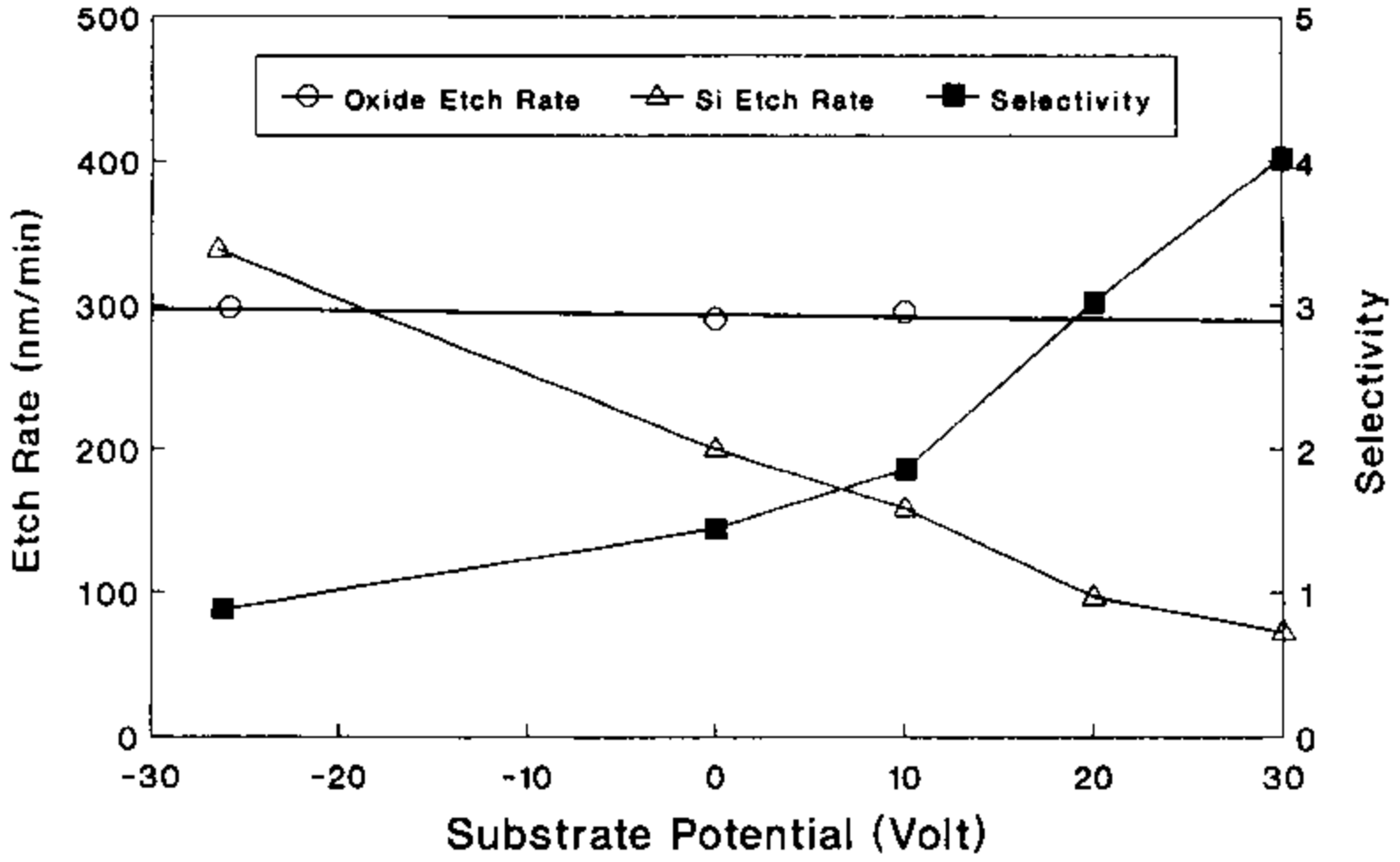
- Etch rates increase and selectivity decreases with increasing Magnetic field strength
- No independent control of ion energy and ion flux (high plasma density = high ion energy)

Improving Selectivity

- Conducting poly is positively DC biased
- Non-conducting oxide is RF biased
- DC bias controls ion flux to poly
- RF2 controls ion flux to oxide

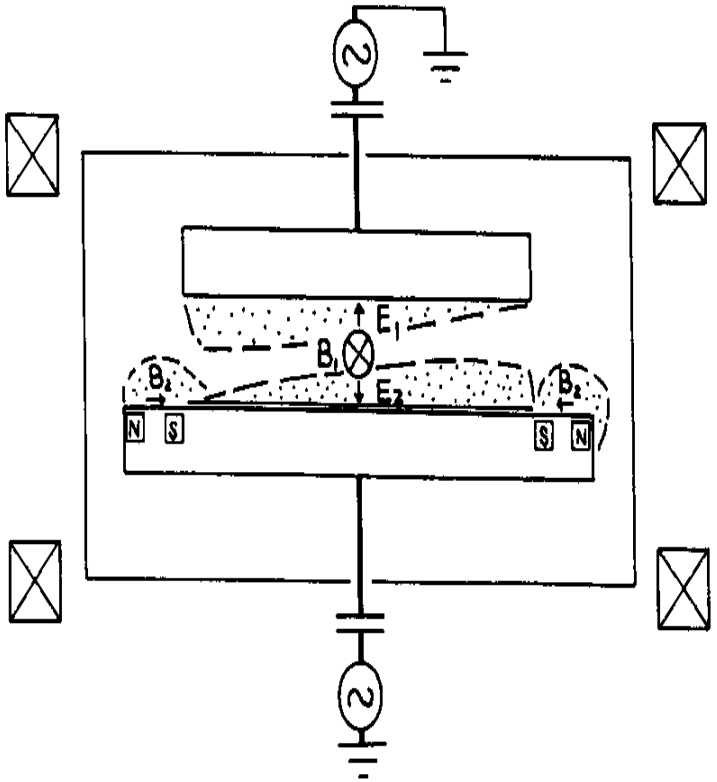


Improving Selectivity



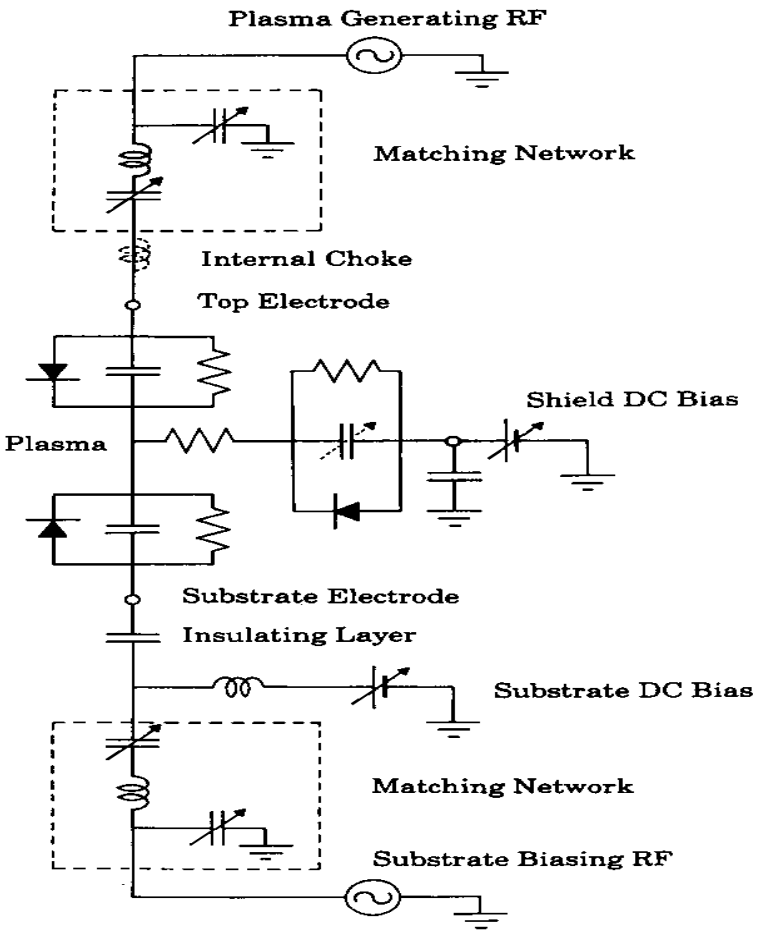
Improving Plasma Distribution

- Non-uniform plasma causes non uniform ion flux
- E X B causes a plasma drift across the wafer
- Static magnets embedded in the substrate electrode provides a supplementary source of dense plasma



Contamination Control

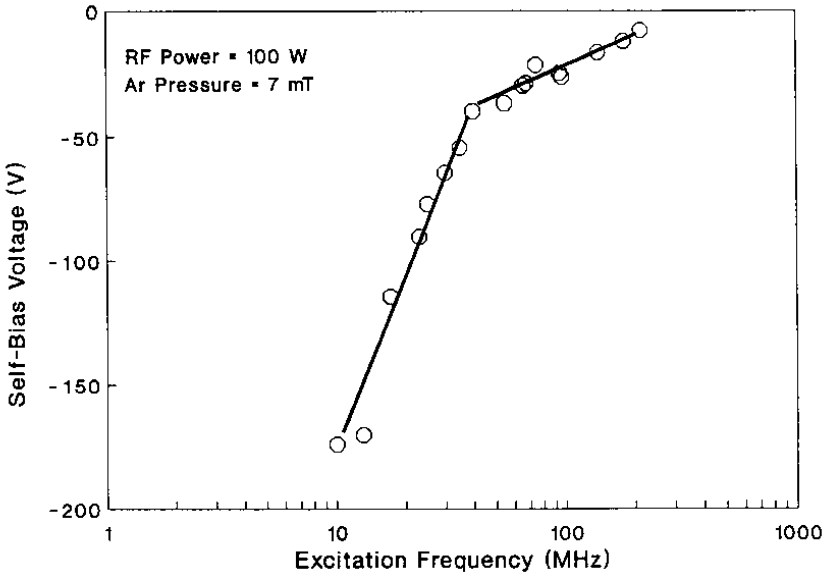
- Plasma potential & chamber material contamination are influenced by the shield DC potential
- Varying the DC potential reduces the capacitance across the sheath between the plasma and shield
- Reduces sputtering of chamber walls

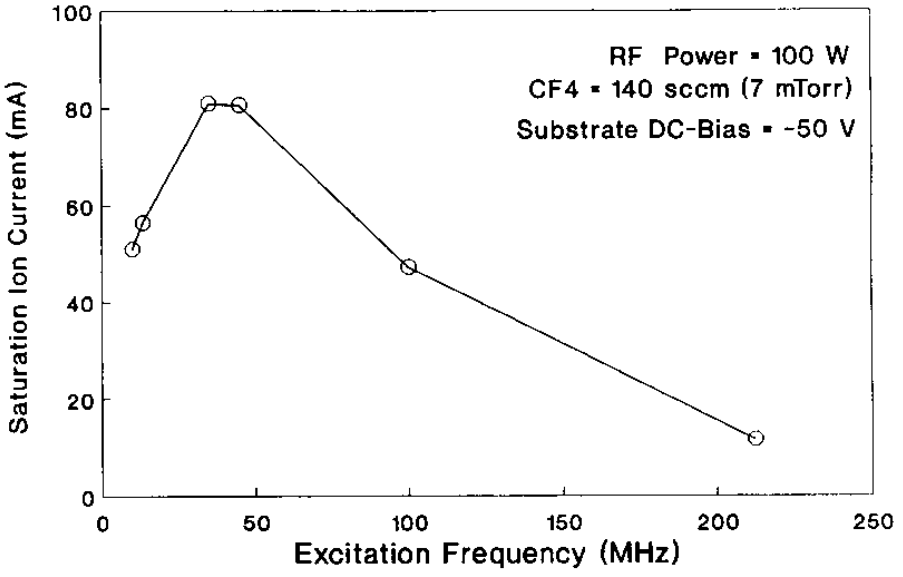


Independent Control of Ion Energy & Plasma Density

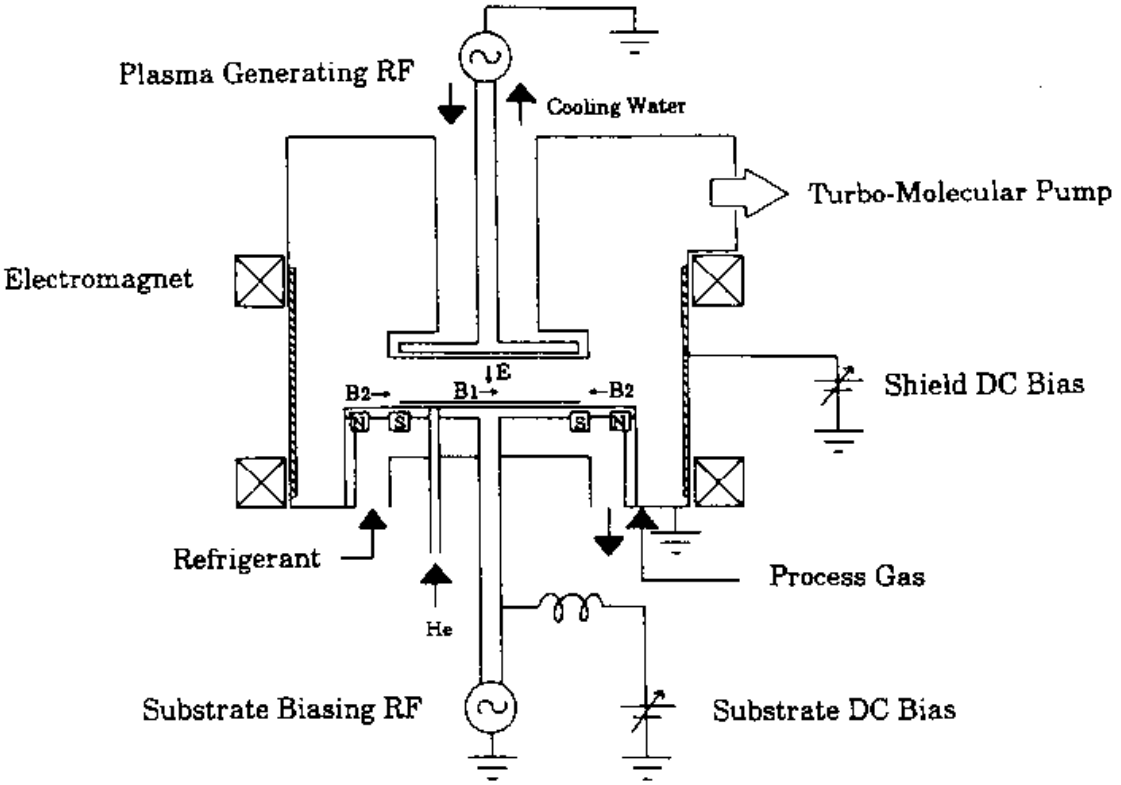
- Plasma generation is controlled by upper electrode (usually > 100 MHz)
- Ion acceleration is controlled by lower electrode (usually < 35 MHz)
- Substrate RF power should be substantially smaller than plasma generating RF power
- Allows finer grained control between two modes: Sputter (physical) and RIE (chemical)

Excitation Frequency





An Improved MERIE - UCMERIE



Conclusions

Minor modifications to standard MERIE systems that is anisotropic and selective. Modifications improved traditional weaknesses of RIE systems

- Decrease in substrate damage
- Uniform plasma distribution (better process control)
- Less contamination due to sputtering
- Independent control over plasma density and ion energy

References

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