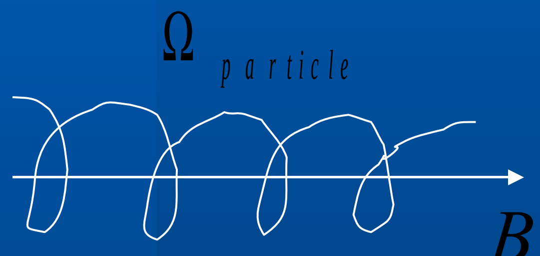
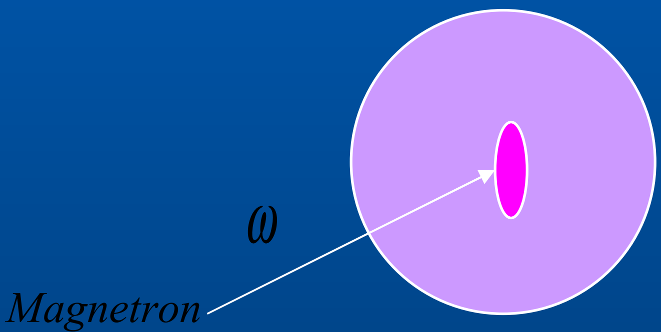
Construction and Operation of an Electron Cyclotron Resonance Sputter Source

W. Cox, B. Zhao, A. Post-Zwicker

Electron Cyclotron Resonance

- Microwave-electron interaction:





$$\Omega_{particle} = \frac{ZeB}{m}$$

$$\omega_{Magnetron} - k_{\|} v_{\|} = m\Omega_{particle}$$

- When microwaves are in phase with particle gyration, the particle experiences an E field and accelerates in the perpendicular direction.

Benefits of ECR Sputtering

•ECR systems deposit semiconductor and metal thin films on materials.

•Optimized deposition of thin films yield smooth surfaces with excellent crystallinity or atom arrangement, and have excellent electrical properties.

•Films can be deposited without substrate heating, thus sensitive substrates could be used.

•The thin film materials need not be conducting.

•Lucrative, rewarding, and novel applications in materials and semiconductor processing.

ECR Sputtering

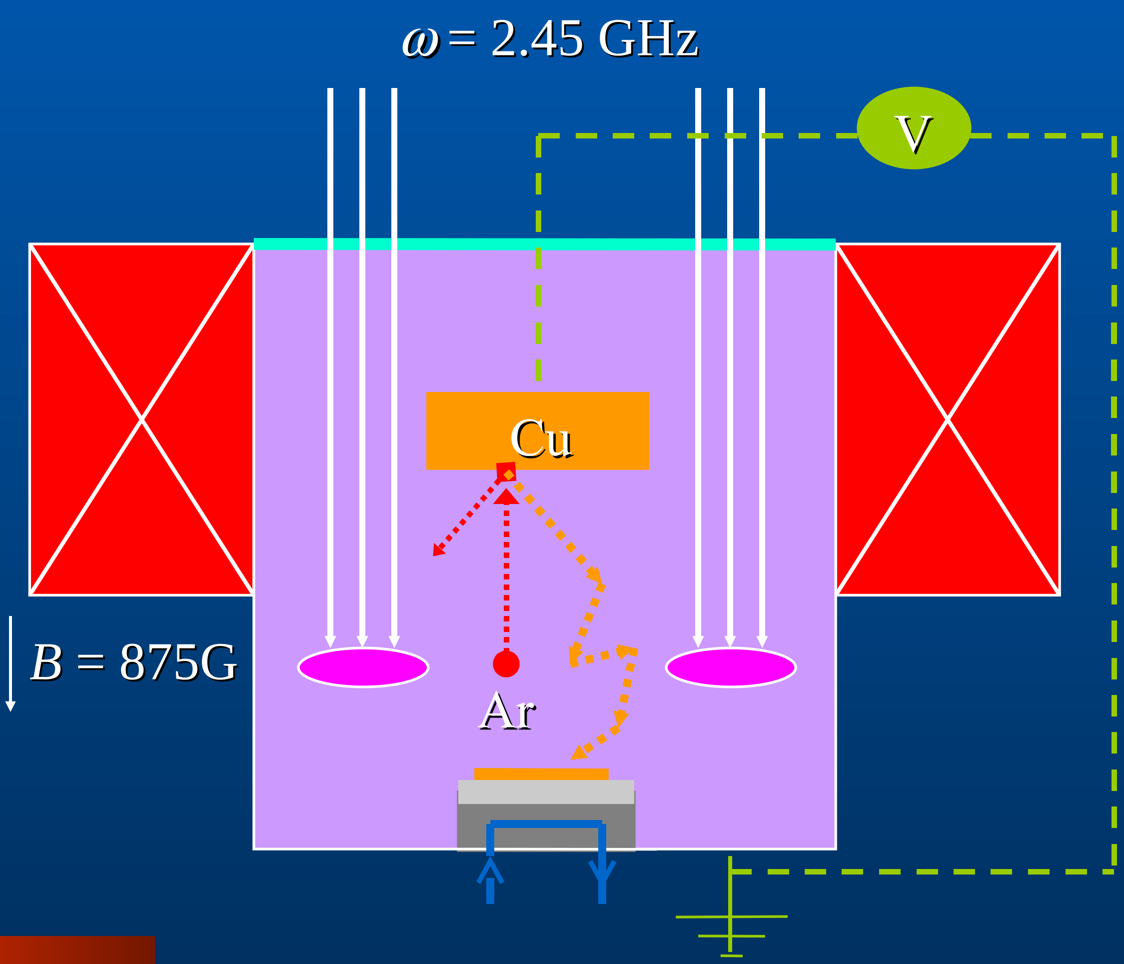
- Microwaves resonate with electrons in B field to heat the plasma.

- Bias voltage is applied to accelerate plasma (Ar) ions towards the sputtering material (Cu).

- Argon ions collide with the sputtering material.

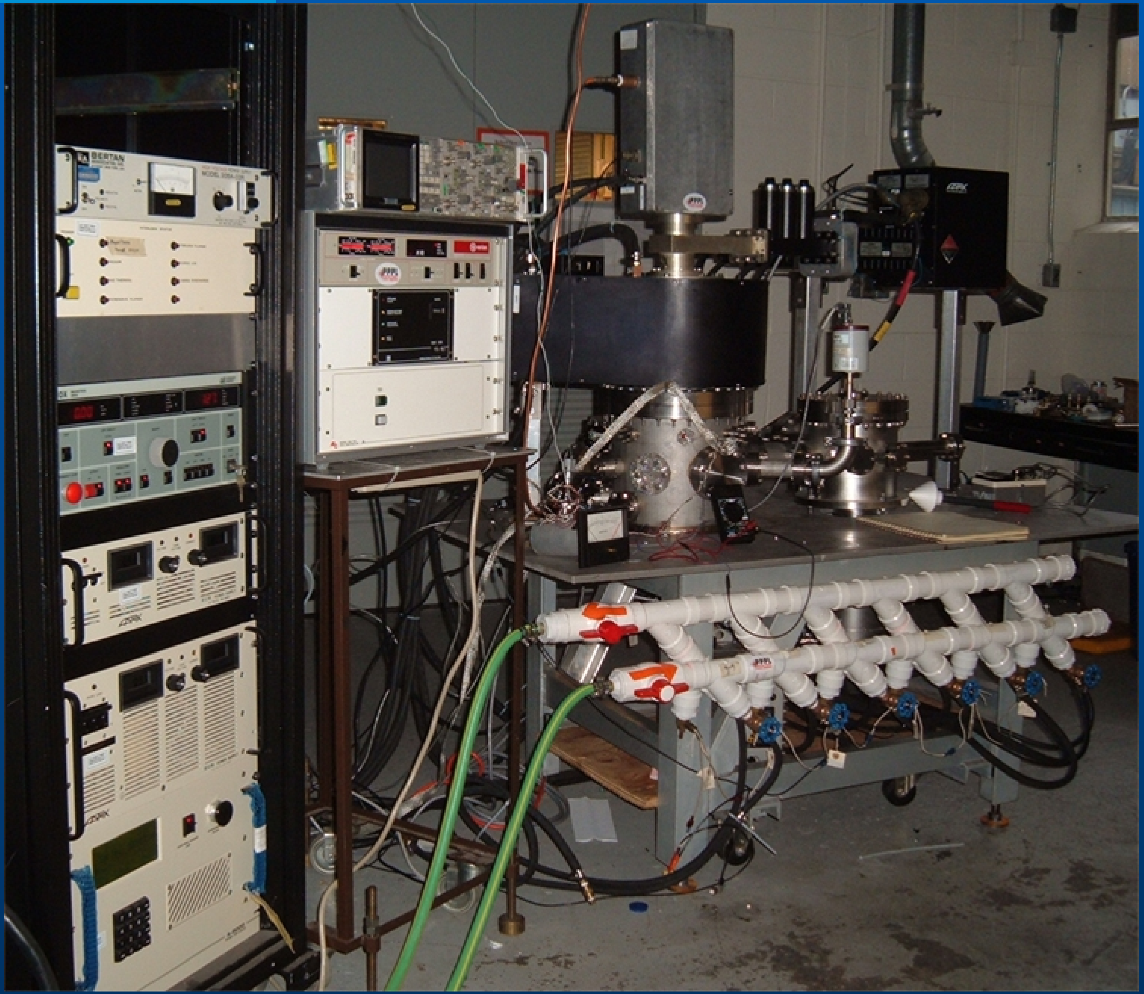
- The sputtering material diffuses into plasma.

- The sputtering material deposits onto a substrate.

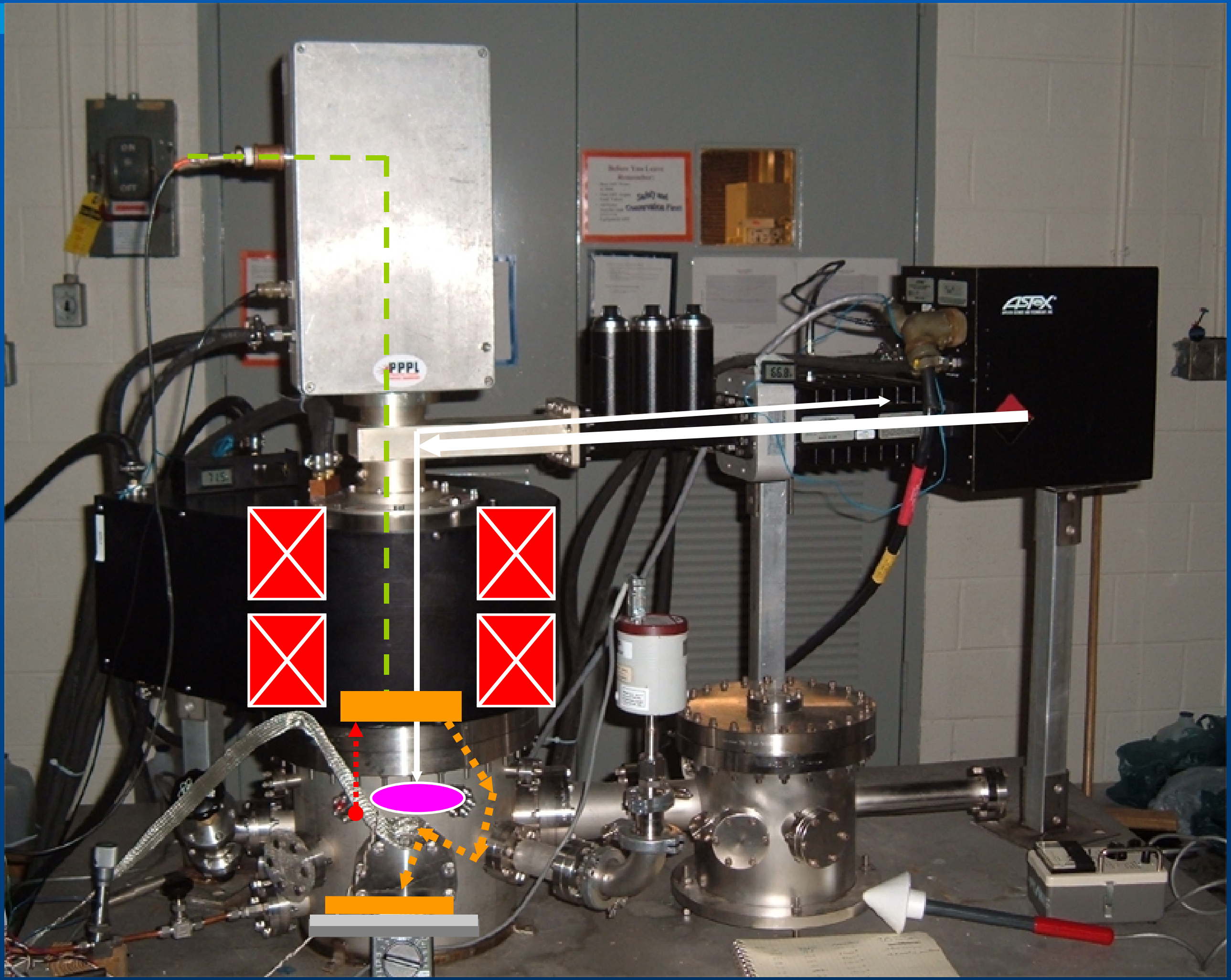


Experimental System Constructed

- Constructed in summer of 2003.
- Stacked magnetic coil confinement scheme (~1kG).
- 5kW capable microwave source.
- Manual triple-stub microwave impedance tuner.
- Silica quartz window.



Experimental System Constructed



Operational Challenges

- **Adequate cooling:**

Old manifold (15 minutes of operation):

New manifold (infinite operation):

- **Microwave impedance tuning:**

Manual triple stub tuner:
<30% Reflected power (10 minutes).

Automated tuner (installation pending):
<1% Reflected power (1 minute).

- **Electrical impedance maximization.**

Operational Challenges (continued)

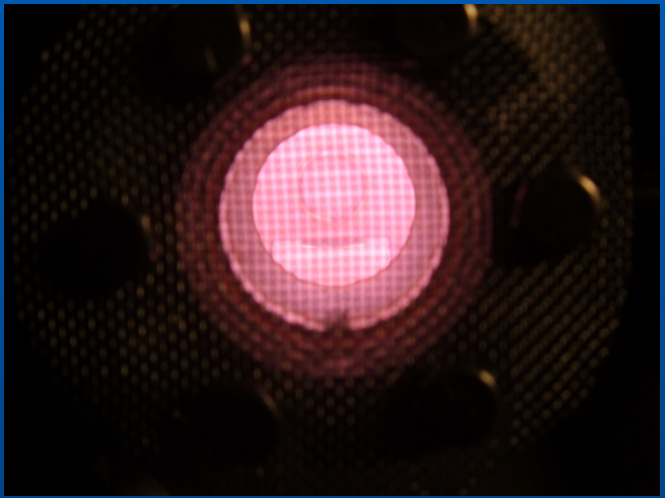
- **ECR plasma created.**

- **Achieving optimum plasma parameters:**

  - The ideal plasma location is in the lower vacuum vessel. Plasmas near the silica quartz window can damage window seals.

  - The ideal pressure is ~1-3mTorr. Pressure regulation is currently achieved using a manual needle valve. It is necessary to install mass-flow controller for precision.

  - Purity of the plasma was confirmed spectroscopically by comparing plasma spectra to NIST reference spectra of Argon.



Experimental Challenges

- **Optimization of sputtering:**
  - Low sputtering current detected.
  - Non-uniform bias voltage dependence observed.
  - Unknown pressure dependence on sputter yield.
  - Unknown temperature and density profiles.
  - Unknown ion energy distribution and concentrations.

Future Work

- **Operational enhancement:**
  - Installation of automatic impedance tuner.
  - Installation of mass-flow controller.
- **Experimental work:**
  - Characterization of deposition (profiles, rates).
  - Characterization of plasma parameters.
  - Optimization of substrate (geometry, temperature, voltage biasing).
- **Eventual use of ECR Sputter System as a user facility for research and education.**

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