Developing Sample Holders for Ultrafast Electron Spin Resonance

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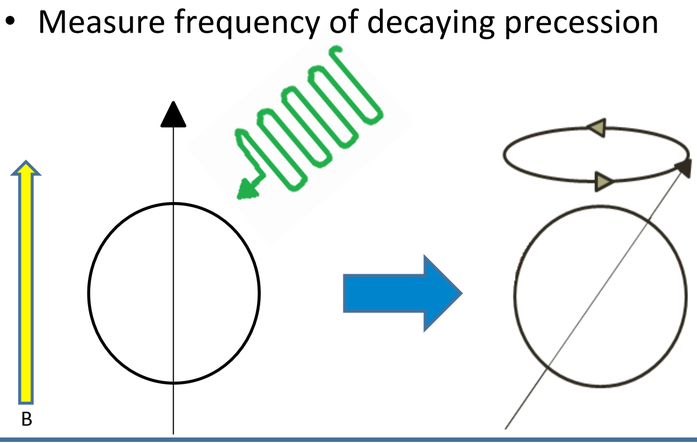
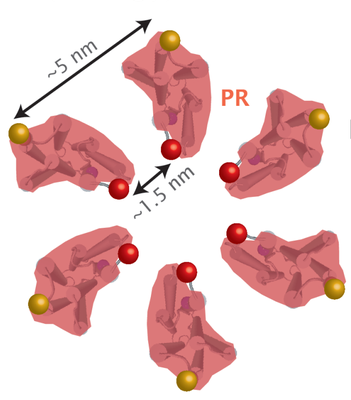
Electron Spin Resonance

- Excite electrons with power source
- Excitation causes precession of electron spins
- Measure frequency of decaying precession



Why Study ESR?

- **Goal**: Investigate local environment of solids and liquids
- Application: Studying structures of protein complexes (biology)

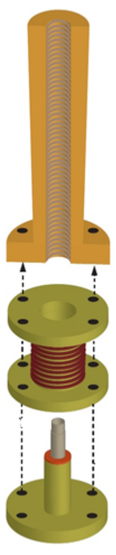


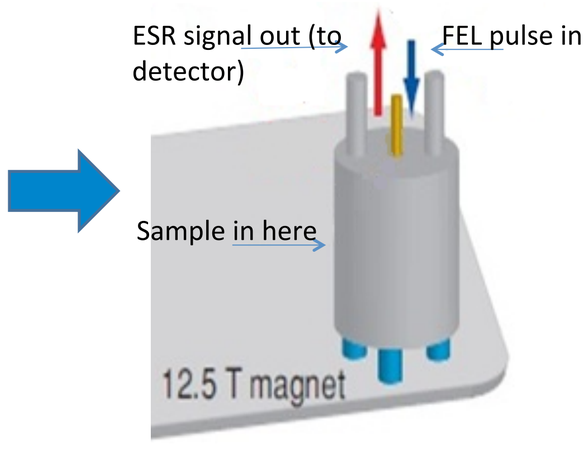
What Makes ESR at UCSB Unique?

- Powered by Free Electron Laser (FEL)
  - Power 10^4x greater than typical ESR Experiment
  - Frequencies above 100 GHz
- Strong Magnet
  - 12.5 Tesla = 200,000x magnetic field of earth

Advantage: High power allows measurements of very rapid spins

Testing Samples

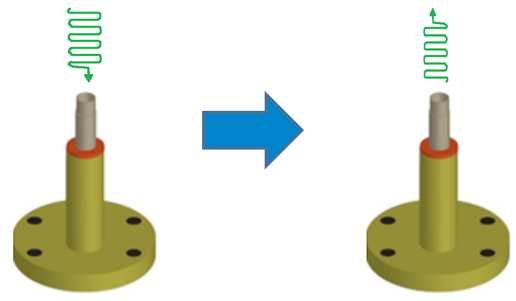




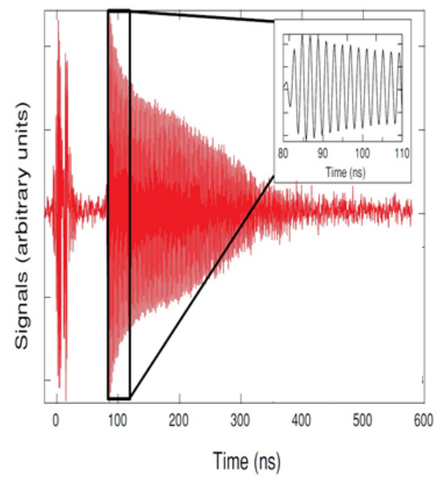
- Sample placed in sample holder
- Holder placed at the end of waveguide
- Waveguide inserted in magnet
- FEL pulse sent down waveguide
- ESR signal (response of electrons to FEL pulse) measured by detector

Problem: Sample Holders reflect some FEL pulse back to detector

- Interferes with ESR signal
- Must turn detector on 80 ns after pulse shot
- Must reduce "dead-time"



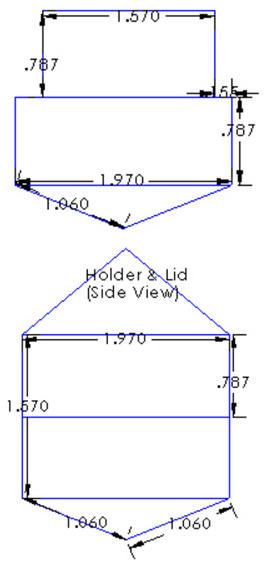
Free Induction Decay (ESR Signal)



Making More Efficient Sample Holders

Hypothesis: Create a "double cone" holder (cone-shaped lid and bottom)

- Try new materials: Teflon v. Rexolite
- Make 2D sketches in CAD Program (SolidWorks)
- Create holders from plastic rods in machine shop

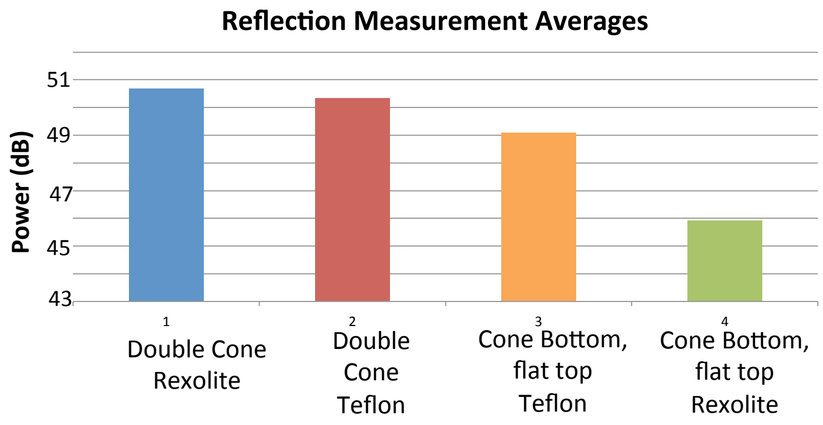


2D CAD sketches

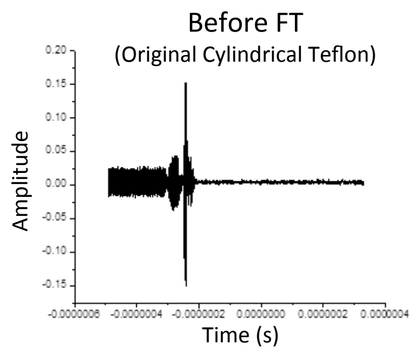
The original holders in Teflon and Rexolite (top), and the double cone holders (bottom)

Initial Test of the Sample Holders

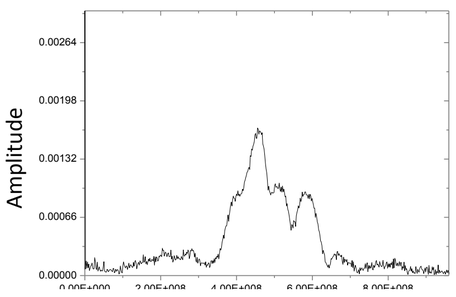
- Load into magnet, test with low power source
- Attenuate signal – higher power = greater reflections
- Units on logarithmic scale



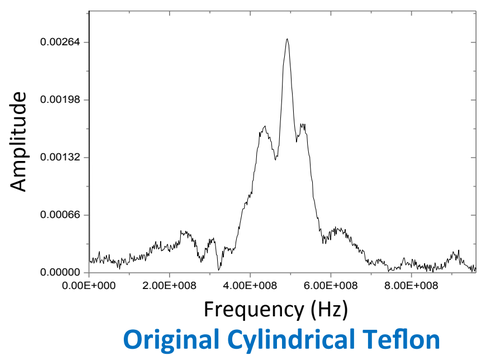
Testing the Sample Holders with the FEL



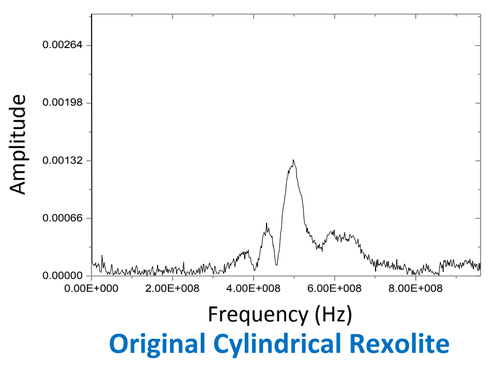
- Load into magnet, test with FEL pulse
- Fourier transform (FT) data to analyze which holder reflects the most FEL pulse (FEL frequency is ~500 MHz)
- Peaks for reflections from the Rexolite holders are considerably smaller than peaks from the Teflon holders



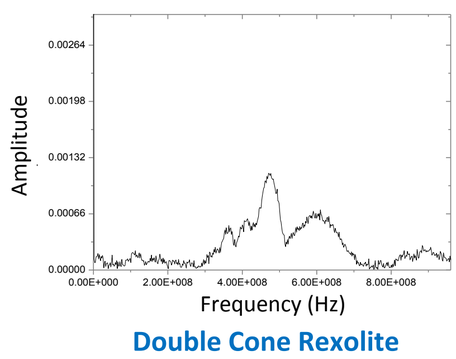
Double Cone Teflon



Original Cylindrical Teflon



Original Cylindrical Rexolite



Double Cone Rexolite

Conclusion

Current Findings: Data from the FEL suggests that Rexolite is a less reflective material than Teflon.

Future Tests:

- Further analysis of the area under the peak region for both double cone holders may give us a more precise idea of how reflective this design is.
- Testing the Rexolite holder with a sample can give us more insight as to whether it is indeed better than the original Teflon holder.

Acknowledgements

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