Designing, Making and Testing Sample Holder for Electron Paramagnetic Resonance

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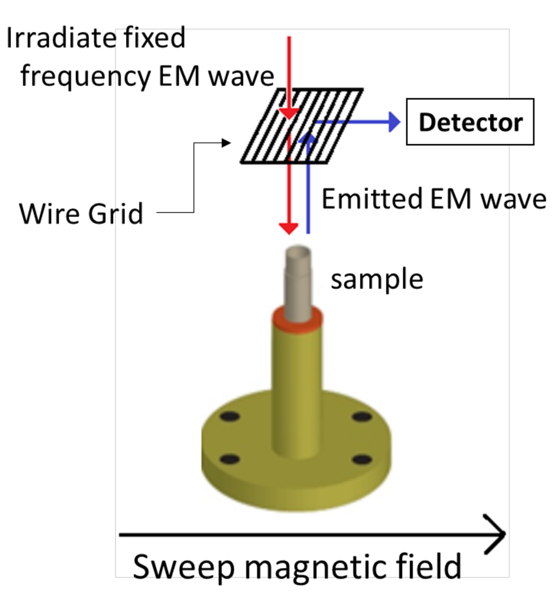
Electron Paramagnetic Resonance

Electron paramagnetic resonance (EPR) is a spectroscopic tool to study material with unpaired electrons and is used in Physics, Material Science, Chemistry and Biology. It allows to observe various properties of materials by observing the behavior and local environment of electrons.

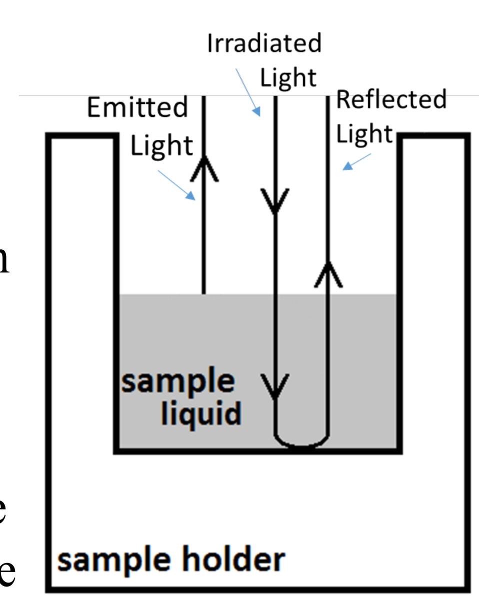


Generally, each light's frequency correspond to a specific external magnetic field in terms of energy. EPR works by shining fixed frequency EM radiation while sweeping external magnetic field into sample material. By detecting reflected EM radiation and showing it as a signal, EPR allows to observe the behavior and local environment of electrons.


Sherwin's Group's EPR

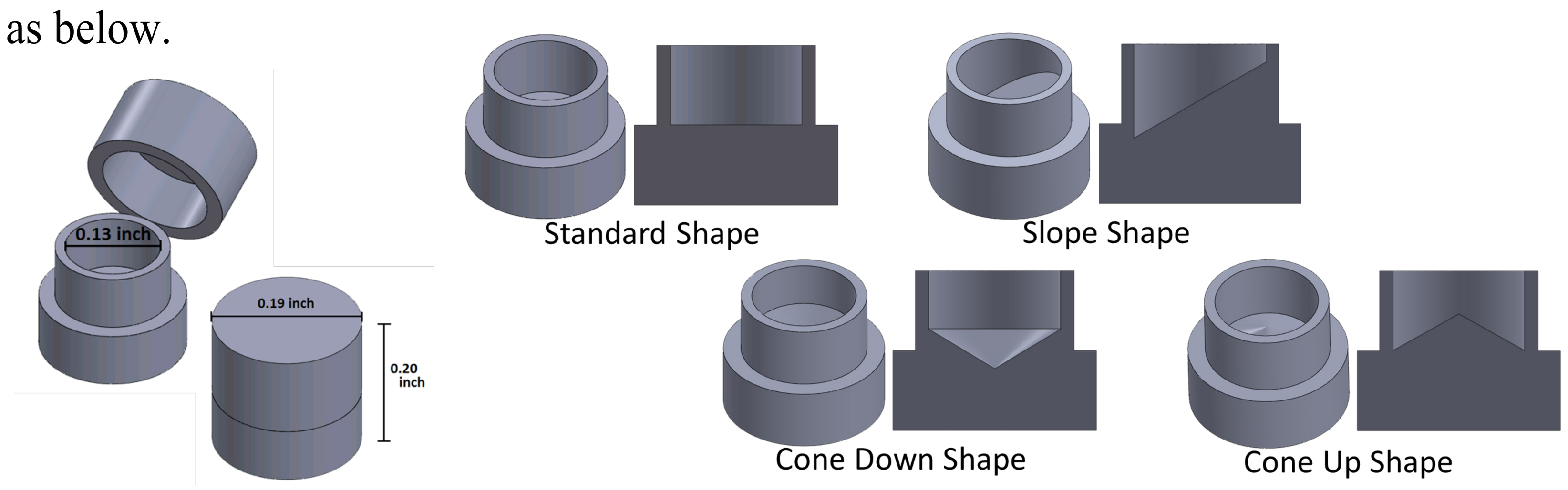
Problems

However, EPR does not always show a reliable signal. Although EPR are expected to detect only emitted light, it also happens to detect the reflected light passing through the sample, and some spurious effects occurs because of this light. The detected radiation acquire some phase as it passes through the sample before being measured by the detector. In addition, large volume samples or samples with a high concentration of spins are susceptible to refractive broadening, which can artificially change the signal. The goal of this summer was designing, making and testing new sample holder geometries to minimize these effects.



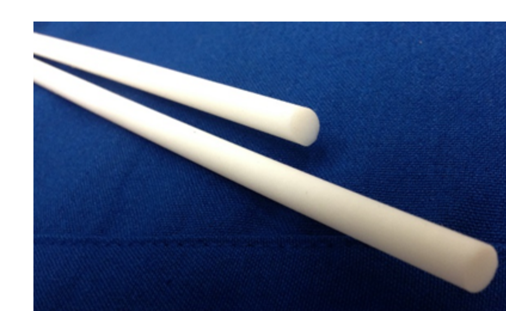
Designing and Making

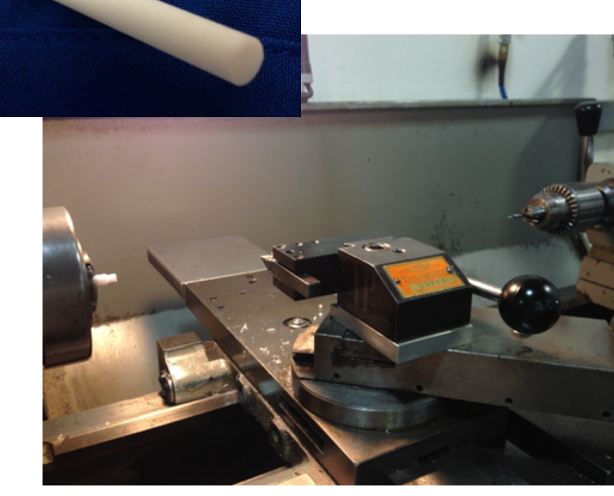
First step was designing new sample holder shapes using 3D designing software, SolidWorks. I designed a standard sample holder shape and three new sample holder shape as below.

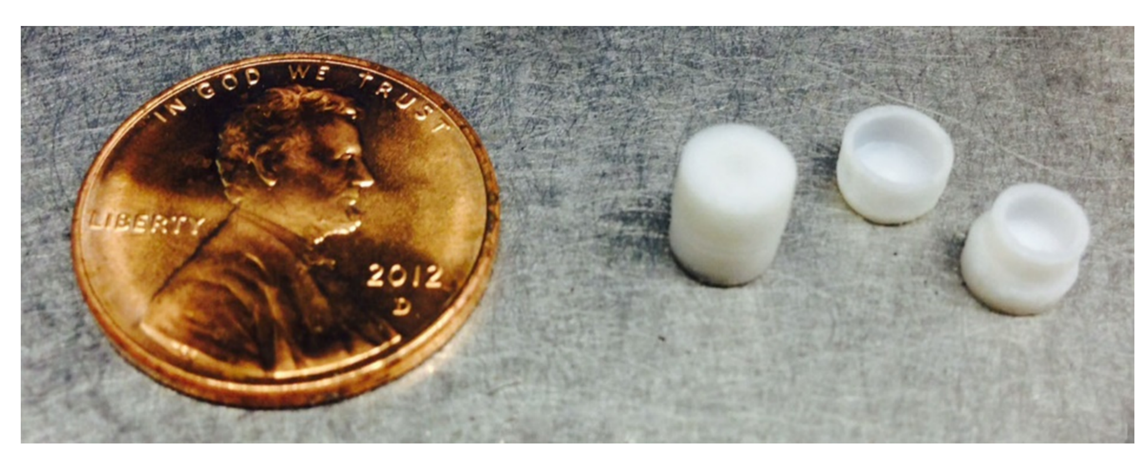


With Standard Shape, spurious effects are caused by perpendicularly reflected light on the flat bottom. In order to avoid those reflection, new sample holders were made to reflect light into different directions and let detector only read emitted light.

Once the desingnig was completed, sample holder were made from teflon rod using a Lathe following the design at UCSB Physics machine shop.
With the created sample holder, I took measurements with EPR and compared data.


Teflon Rod


Lathe

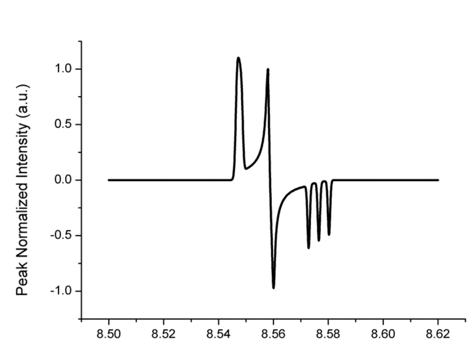


Sample Holder

Data

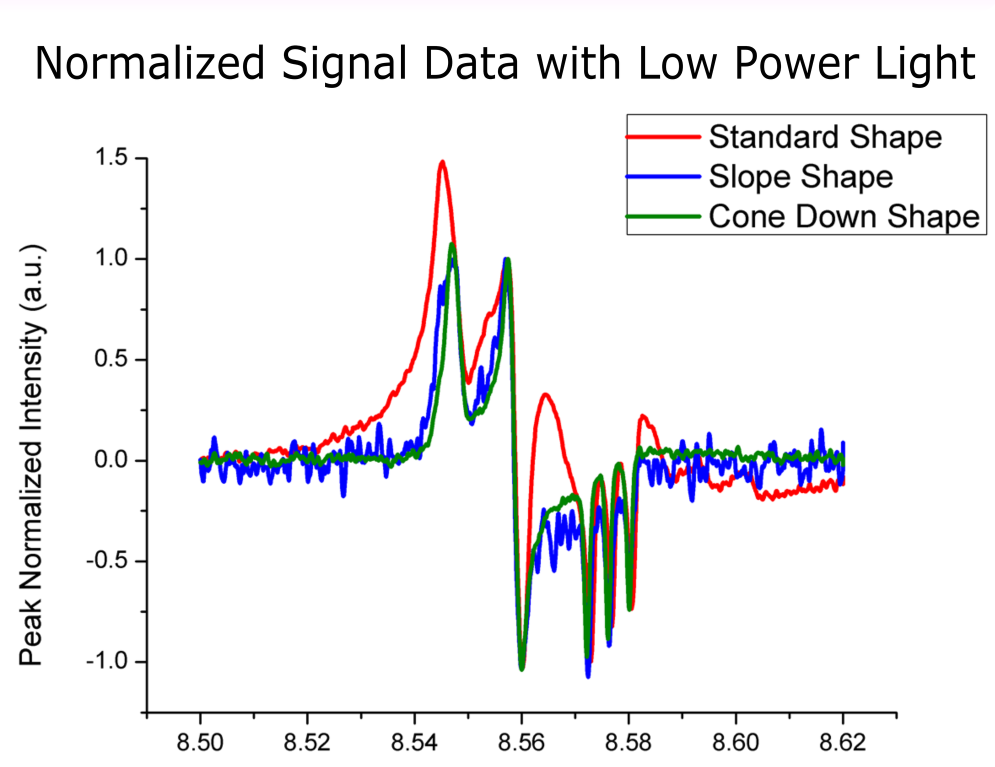
When looking at signal data, the performance was judged based on two criteria. One is high amplitude with low noise, and the other one is no distortion from theoretical lineshape. Note that the data misses Cone Up Shape because I was unable to complete the measument with Cone Up Shape due to hardware problems.

Low Power Signal



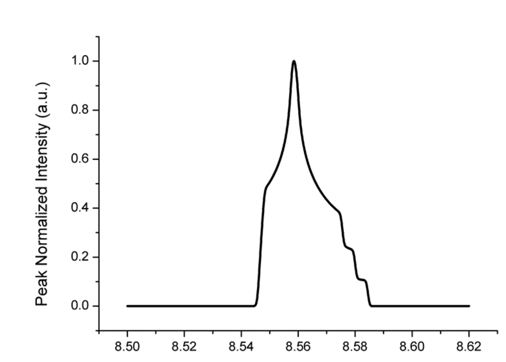
Theoretical Signal of 40mM 4-amino TEMPO with Low Power

Second Peak Intensity (*10^{-4})	
Standard Shape	0.72
Slope Shape	0.63
Cone Down Shape	2.60



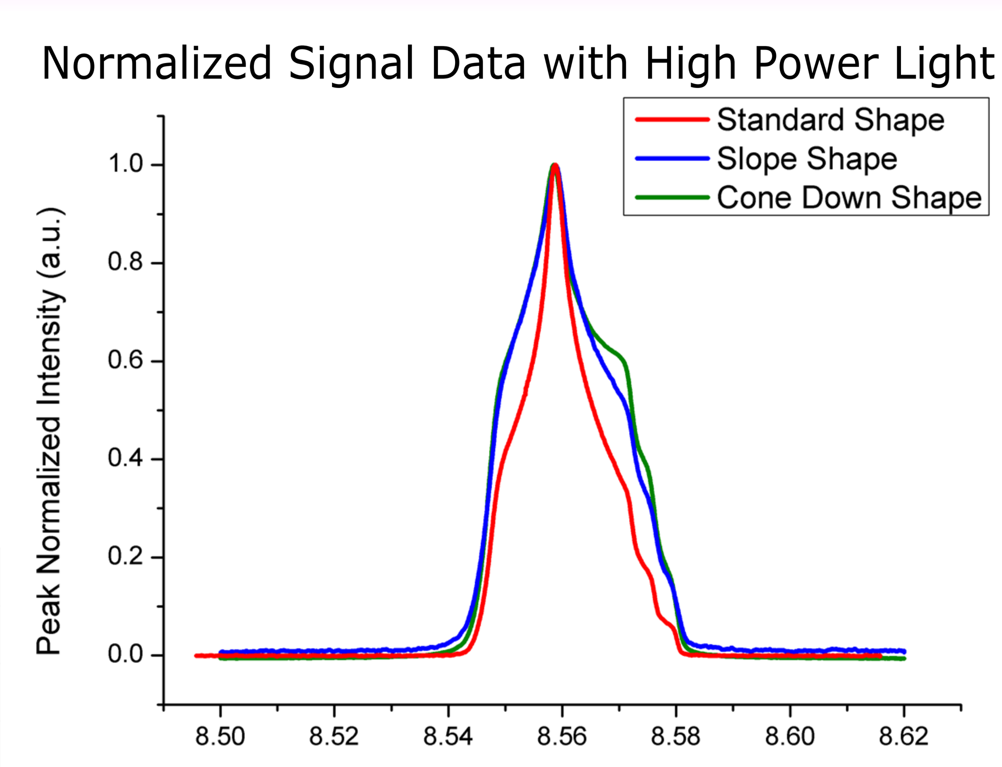
With low power light, Cone Down Shape gave the best lineshape out of the three sample holder. Additionally, Cone Down Shape gave the highest amplitude. Therefore, I concluded that Cone Down Shape gave the best signal with high power light.

High Power Signal



Theoretical Signal of 40mM 4-amino TEMPO with High Power

Peak Intensity (*10^{-4})	
Standard Shape	13.25
Slope Shape	12.05
Cone Down Shape	34.51



With high power light, Cone Down Shape also gave the highest amplitude. However, Cone Down Shape caused an unexpected bump around 8.57 T, which is not good lineshape. On the contrary, Slope Shape gave no distortion with litttle noise. Therefore, I concluded that Slope Shape gave the best lineshape although Cone Down Shape gave the largest signal.

Conclusion

Measurement with Low Power Light
→High Amplitude: Cone Down Shape
→Best Line shape: Cone Down Shape
Measurement with High Power Light
→High Amplitude: Cone Down Shape
→Best Line shape: Slope Shape

Future Works

1. Complete the measurement of Cone Up Shape
2. Further Analysis on the measument result
3. Use 3D printer for precise control of shape

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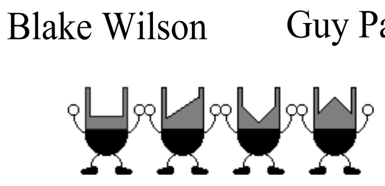

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