Apparatus for Characterizing Millimeter-Wave propagation through Magnetoelastic Multiferroic Materials

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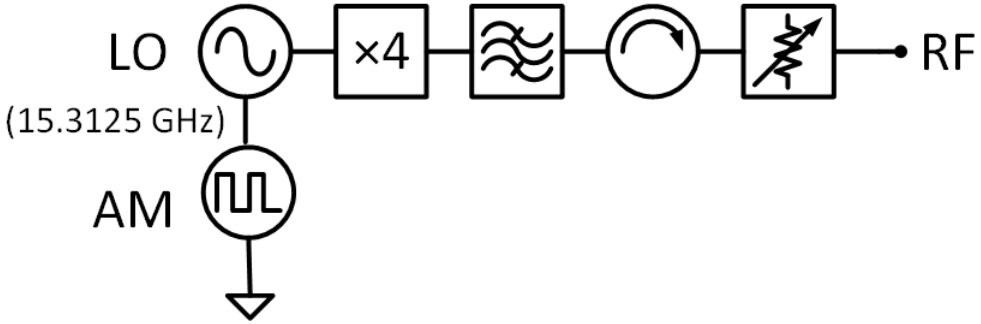
Introduction

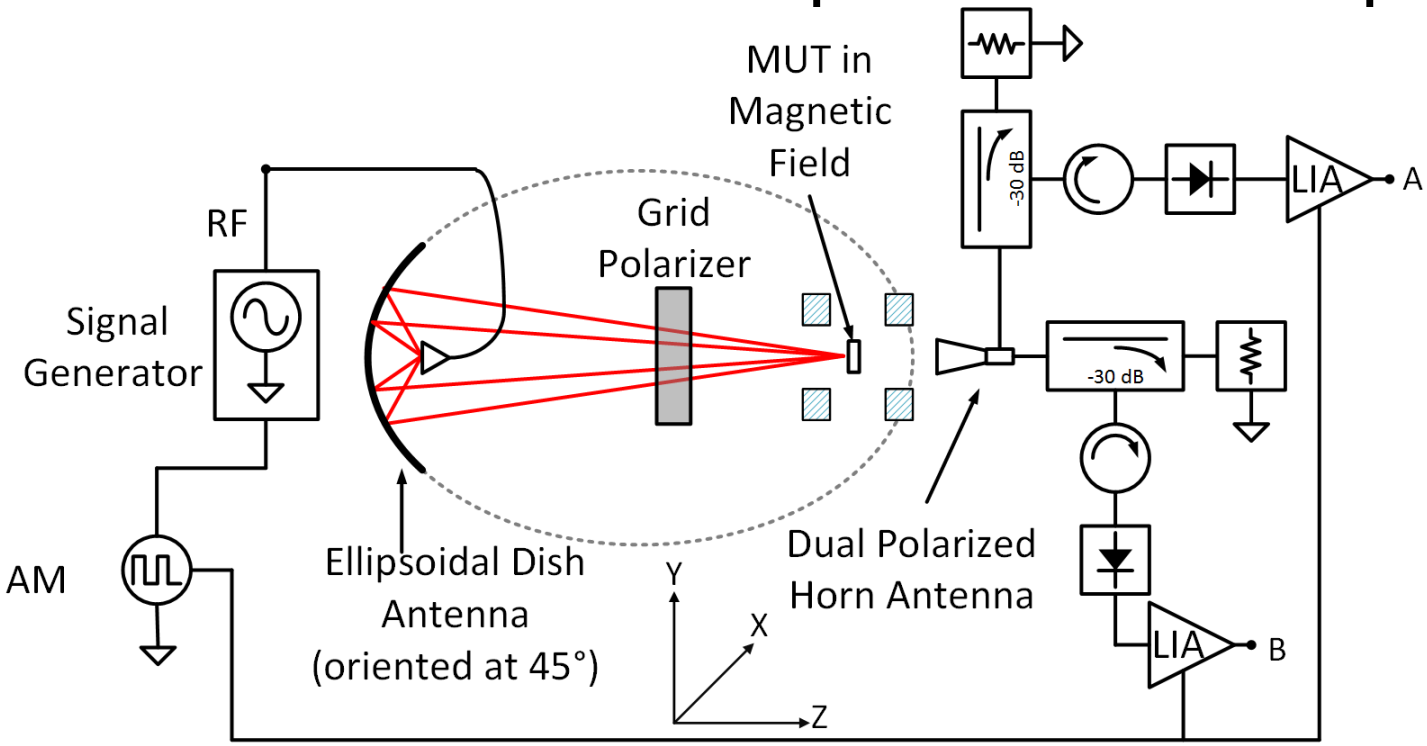
- In Cognitive Radio (CR) communication techniques, polarization can be one of the unique features S. K. Sharma et al.
- Smart antennas (MIMO systems) which are widely used in CR communication techniques requires strict spacing between antenna elements, which makes the system bulky Zhang et al.
- In such cases, polarization can be used in signal processing for devices with size and cost limits Zhang et al.
- However, smart antennas with polarization tunability would be of great advantage in CR techniques.
- This polarization tunability can be achieved using voltage controlled magnetism in magnetoelastic multiferroic materials.

61.25 GHz Signal generator



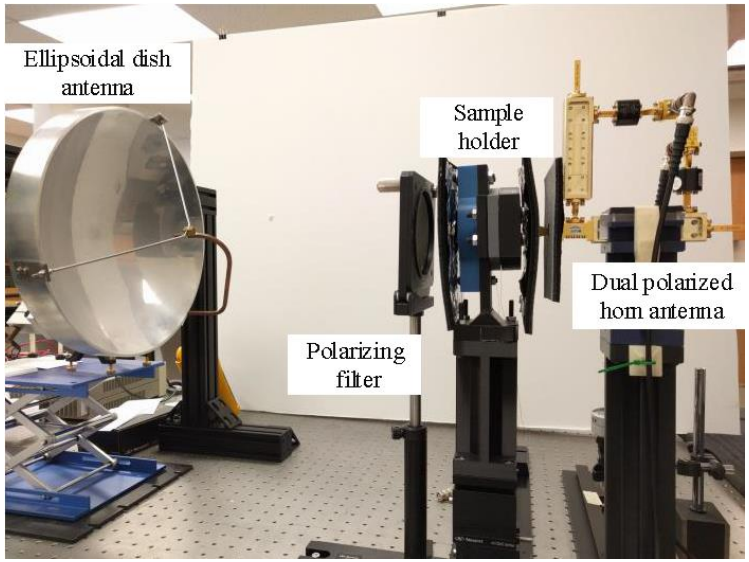
- The 61.25 GHz signal generator was built from commercially off the shelf (COTS) components
- Input power level was maintained at 5dBm and input microwaves were amplitude modulated with a chopping frequency of 13.7 kHz.
- The signal was fed to a ellipsoidal dish antenna made out of aluminum with a customized rectangular feed.

Schematic of the experimental set-up

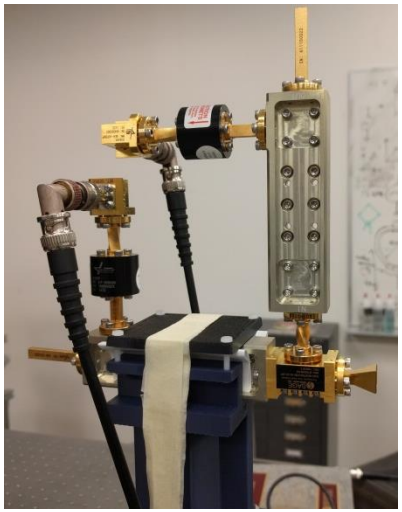


- The ellipsoidal dish antenna generates a Gaussian beam at approximately 480 mm from the antenna, where Material Under Test (MUT) is held in a sample holder.

- The beam after passing through the MUT was received using a dual polarized horn antenna.
- The horizontal and vertical ports on the dual polarized antenna were connected to power detectors via directional couplers.
- Channel A and channel B on the lock-in amplifier gives the power detected from horizontal and vertical ports.
- The lock-in amplifier was set to a reference frequency of 13.7 kHz



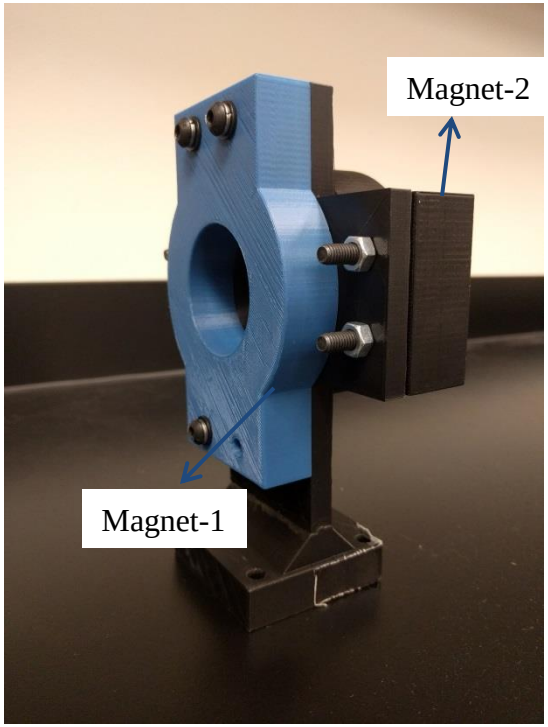
a) Experimental set-up

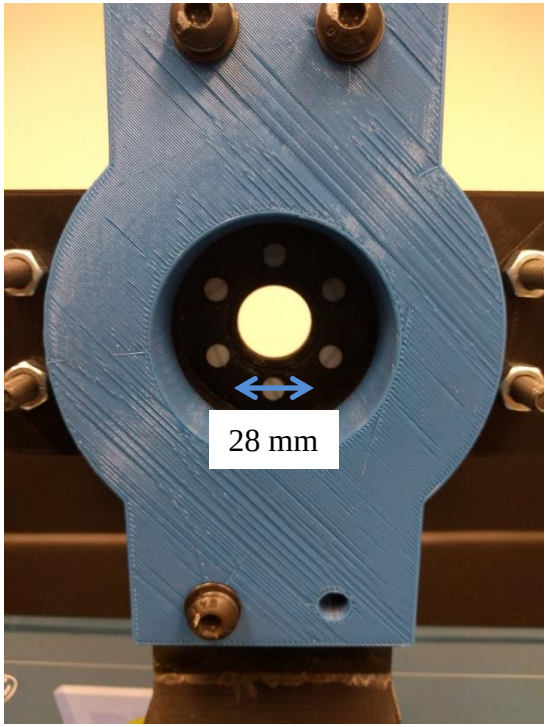


b) Dual polarized horn antenna

Sample holder

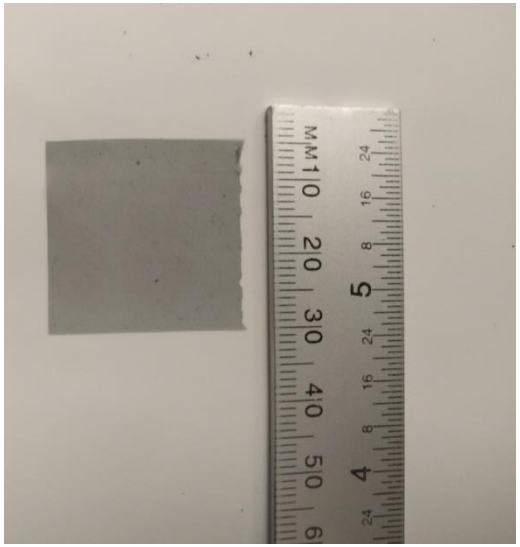
- Customized holder with two magnets embedded in them creating a static magnetic field of 30 mT at the center.

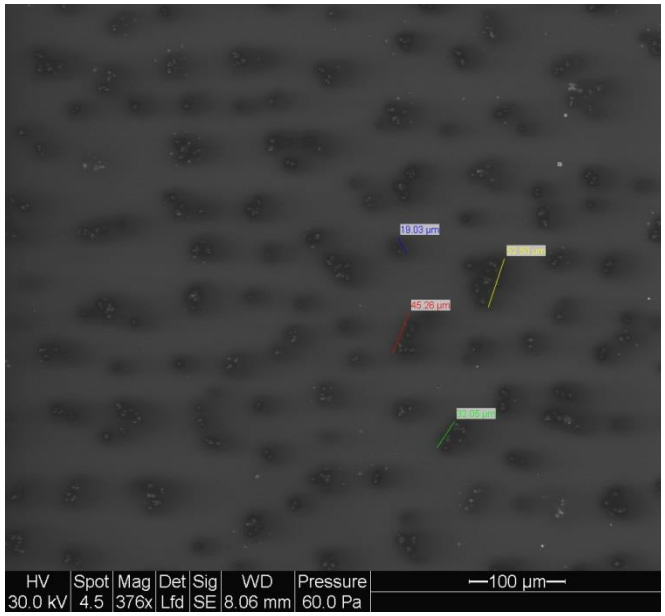




Material under test (MUT)

- Silicone rubber with nickel micro-particles
- Grown on the EMP line at NPIC, University of Akron



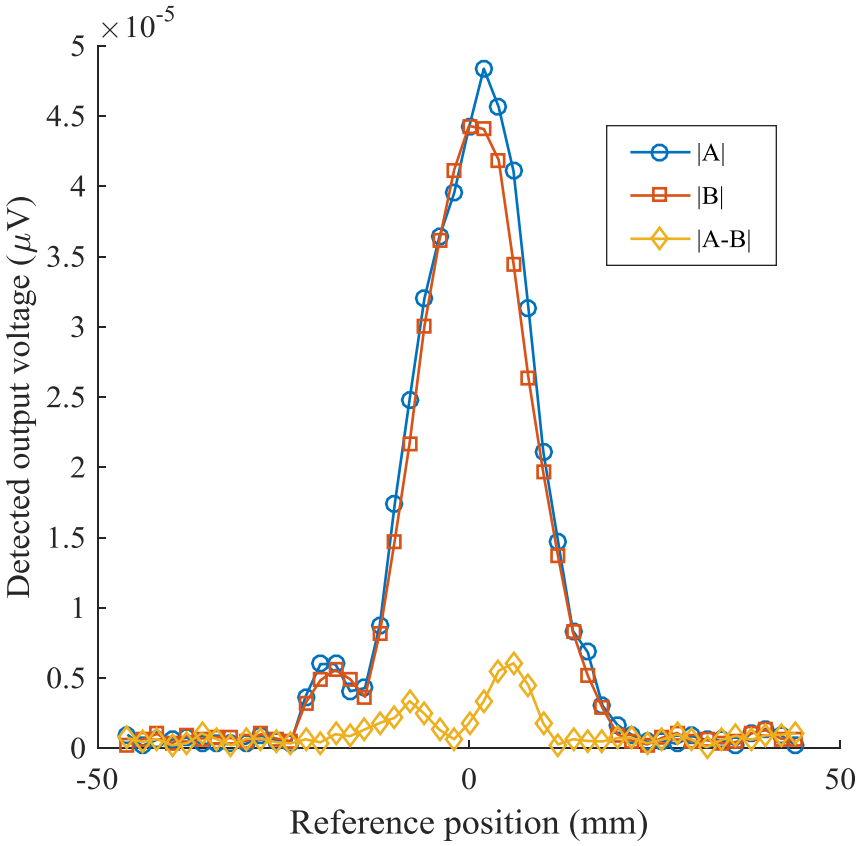


- Average nickel micro particle size 40 µm

Experiments

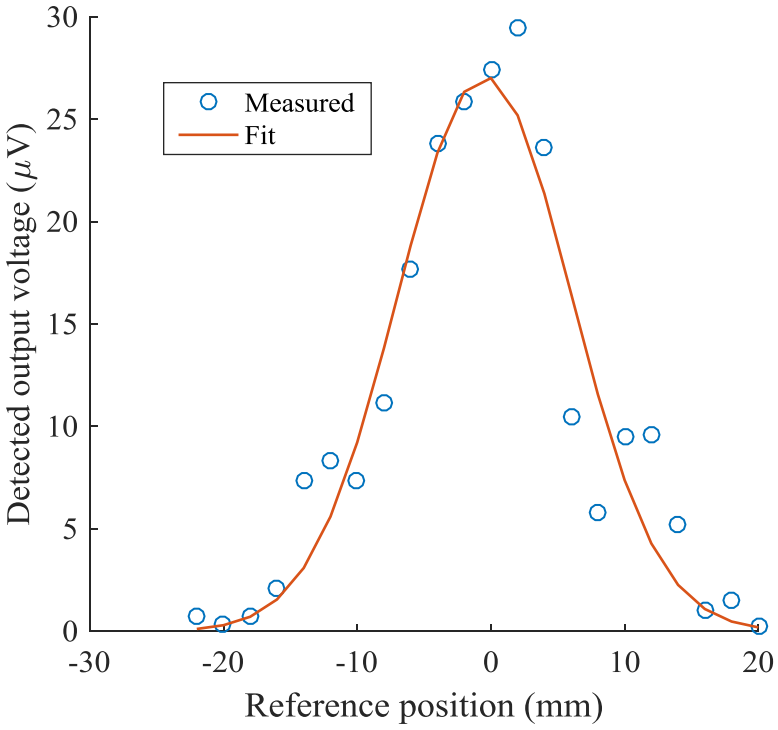
First experiment

- No sample holder placed.
- Beam was detected with dual polarized horn antenna placed very close to the sample holder.
- Ideally both the peaks should be the same.
- Since, a waveguide twist was used with vertical port, there is a difference in this value

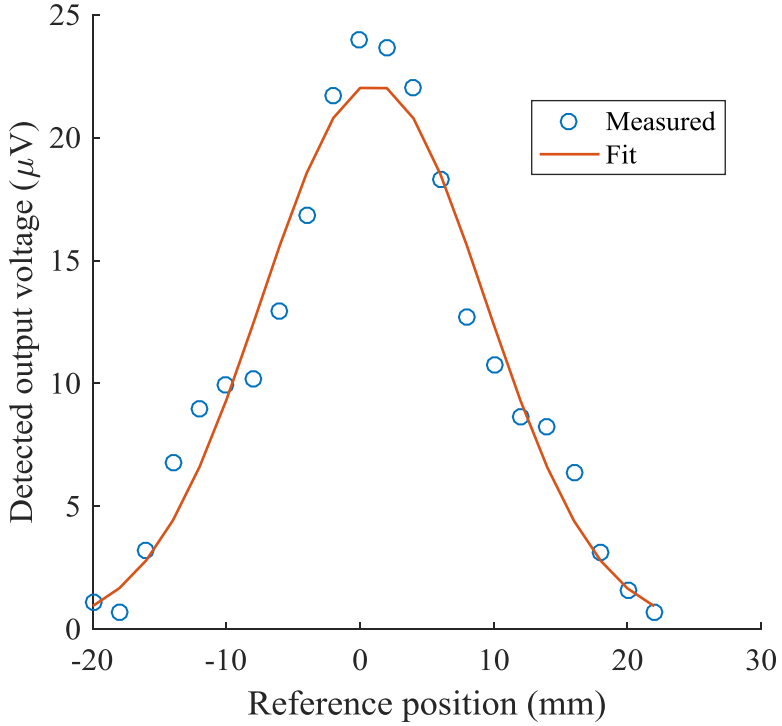


Second experiment

- Sample holder placed with no MUT.



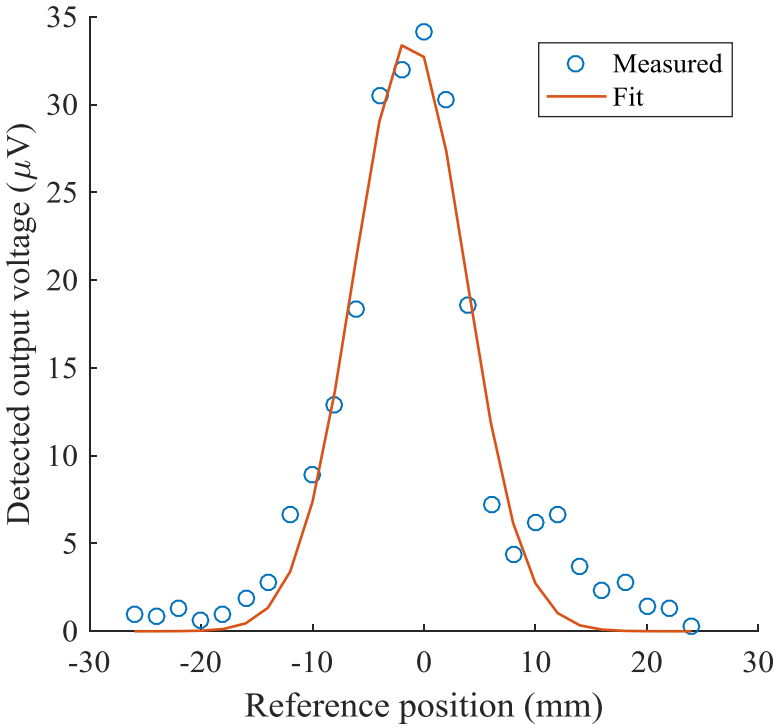
a) Output data from channel A



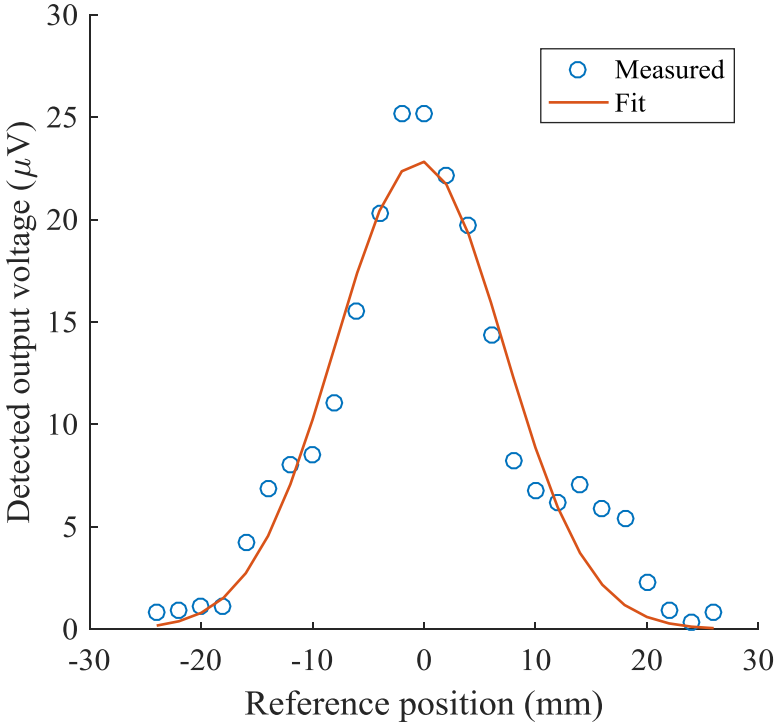
b) Output data from channel B

Third experiment

- Sample holder placed with MUT.



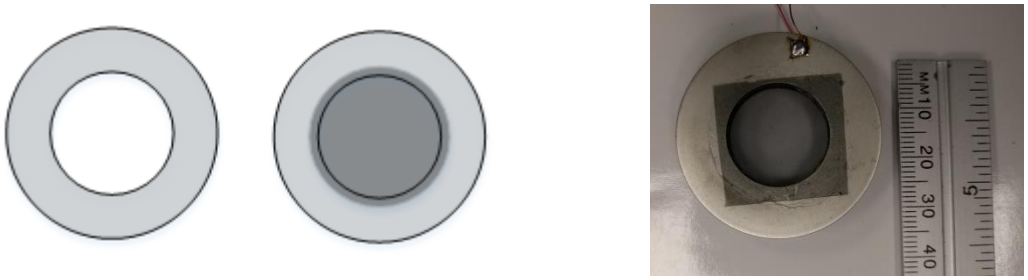
a) Output data from channel A



b) Output data from channel B

Fourth experiment

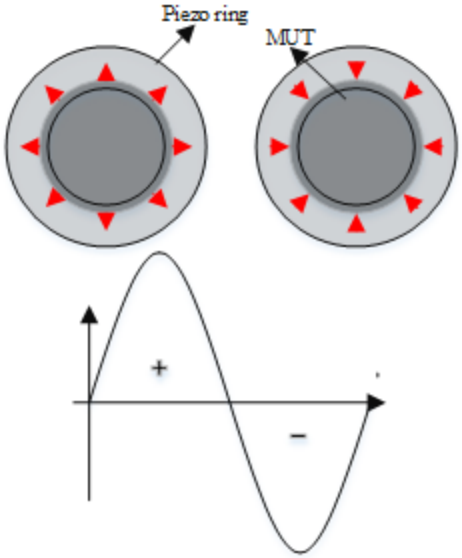
- MUT was attached to a piezoring



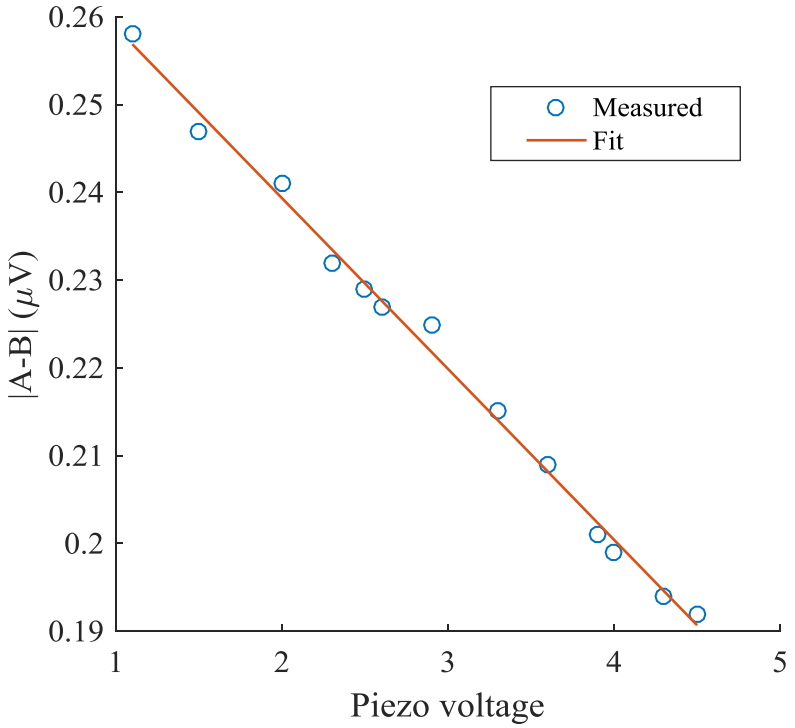
a) b)

a) Schematic of the sample attached to piezo ring b) Photograph of sample attached to piezo ring

- The piezoring was actuated at its radial resonant frequency of 106 kHz.
- Lock-in detection was synchronized with a piezoelectric resonator.
- The piezo actuation was provided using a SVR 500-3 piezo driver.



- The input signal from the signal generator in this experiment is a continuous wave.
- The piezo actuation voltage is varied and any change in |A-B| on the lock-in amplifier corresponds to change in polarization (Faraday rotation)



Conclusion

- Apparatus for characterizing mm-waves through magnetoelastic multiferroic materials was designed and implemented.
- Experimental results indicate that there is a change in polarization on the imparted mm-waves and polarization can be tuned in these materials.
- Efforts are currently underway to accurately determine the change in the poalrization angle (Faraday rotation).
- Once fully characterized, this material can be used as a supporting technology in designing smart antennas for CR techniques.


THANK
YOU !