Static and Dynamic Magnetization Measurements of Synthetic Antiferromagnets

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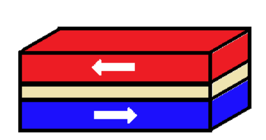
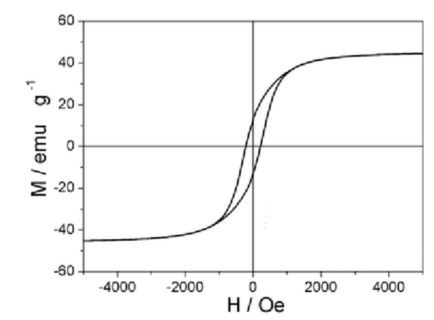
Abstract

This study focused on synthetic antiferromagnetic (SAF) samples that were tested with a Tunnel Diode Oscillator (TDO) and Vector Network Analyzer (VNA) to find points of magnetic switching. The samples, provided by Seagate Technology, consist of two FeCoB layers (80nm) separated by Ru spacer, which varies in thickness of 14 and 16 Å between the two samples studied. Critical curves were constructed for low and high frequencies, demonstrating the magnetic switching of the sample at different angles with an applied magnetic field.



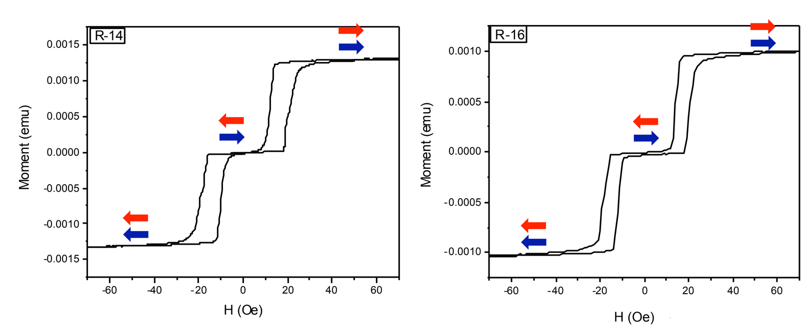
SAF structure



Major hysteresis loop (MHL) of a ferromagnetic material

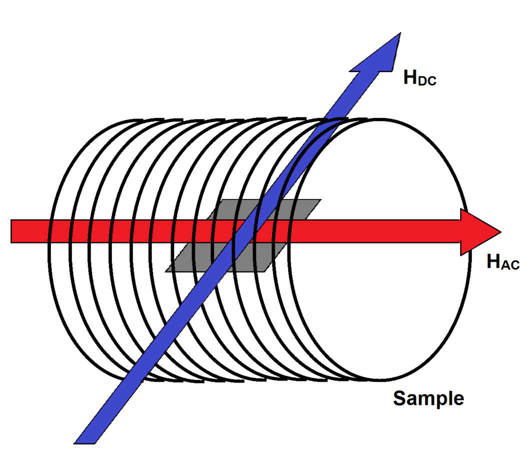
Introduction

SAF structures consist of two ferromagnetic thin films separated by an non-magnetic interlayer. This form of layering may lead to new and better structures for non-volatile memory.



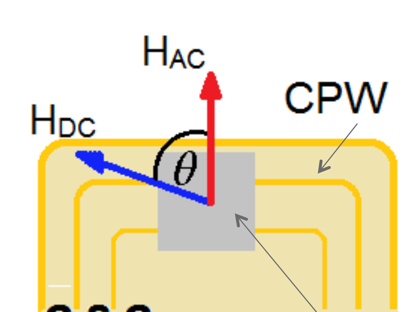
MHL of the two SAF samples studied

The first experimental setup for the TDO is portrayed below. The sample is placed inside a coil with its easy axis parallel to the long axis of the coil. The AC field is applied at a fixed direction along the sample's easy axis while the DC field is rotated in the plane of the AC field.



TDO coil with sample inside. The DC magnetic field is ramped from negative saturation to positive and the susceptibility is obtained as a function of applied field.

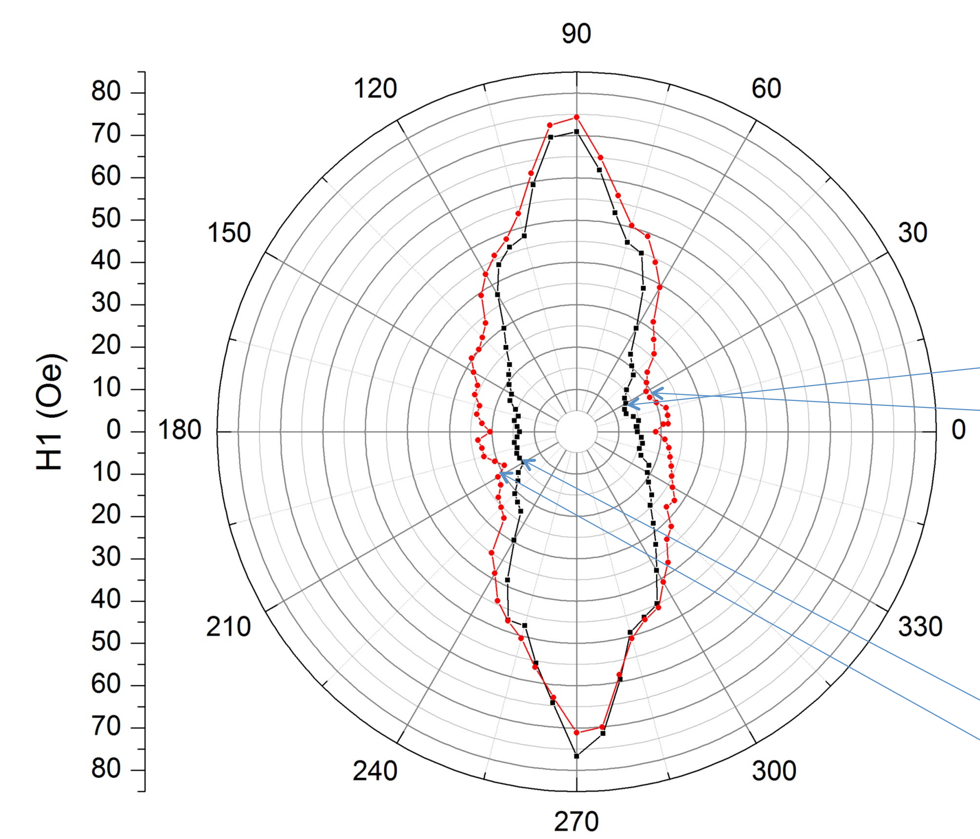
In the second experiment we used a coplanar waveguide (CPW) to find ferromagnetic resonance (FMR). The AC magnetic field in the microwave frequency was held constant and applied along the sample's hard axis. The DC magnetic field was swept from positive saturation to negative and rotated in small increments in the plane of the AC field to see the angular variation of FMR.



Coplanar Waveguide with sample

Experimental Results

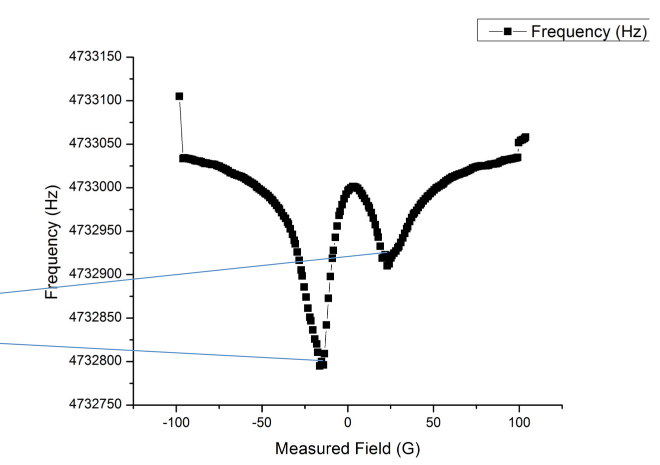
TDO Critical Curve R-16



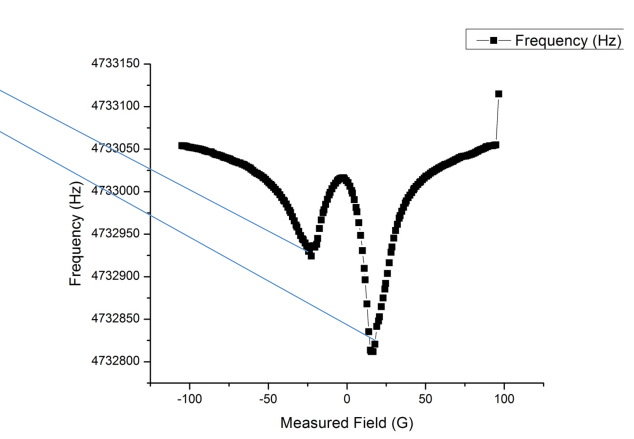
Critical Curve shows and explains points where magnetization reversal occurs

Analysis of Data

30deg

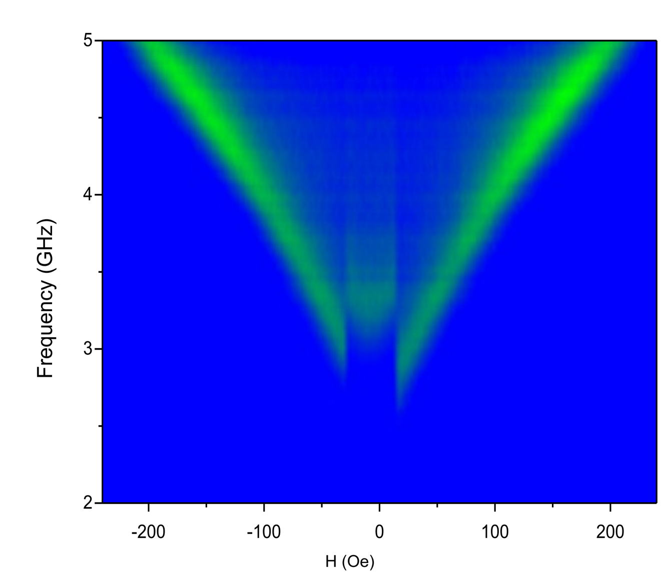


210deg



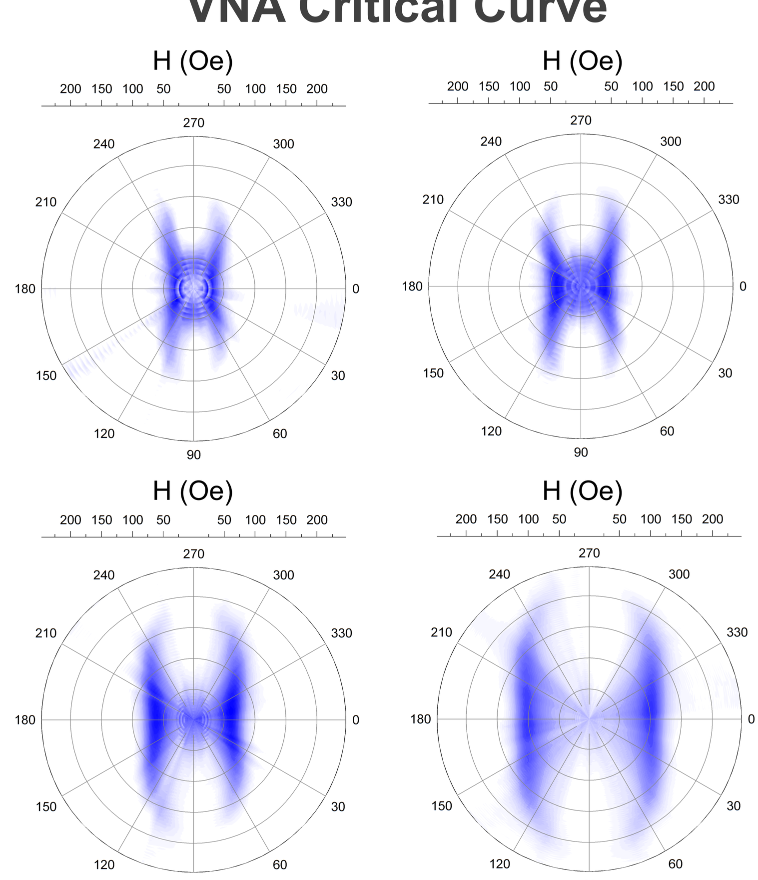
Once the data was obtained from the TDO we then defined the minimums as magnetic switching points which were then labeled as H1 and H2. These were then used to plot the polar graph

Ferromagnetic Resonance R-14



Broadband absorption spectrum for R-14. The highlighted green curve represents where FMR occurs.

VNA Critical Curve



The FMR curves were plotted in a polar contour chart to show angular dependence of the FMR absorption. The points of strongest absorption are represented in the darker shading.

Conclusion

In this study, we used two different methods to characterize magnetic switching in a SAF structure. It is shown that in the static experiment, the switching diagram can be constructed using the switching peak in the frequency vs. field plots. In the dynamic experiment, a critical curve for different constant-wave frequencies is constructed from the microwave absorption spectra of different angles.

References

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Acknowledgments

This material is based upon work supported by the National Science Foundation under the NSF EPSCoR Cooperative Agreement No. EPS-1003897 with additional support from the Louisiana Board of Regents."