Apr 14th, 1:00 PM - 3:00 PM

Transport and magnetic properties of amorphous Fe-Dy-Oxide thin films

Sara Bey
University of Tennessee at Chattanooga

Transport and Magnetic Properties of Amorphous Fe-Dy-Oxide Thin Films

Sara Bey UT-Chattanooga

Olivia Denton, Dr. Tatiana Allen, Krishna Koirala, William Roes, Dr. Gerd Duscher, Dr. Ramki Kalyanaraman

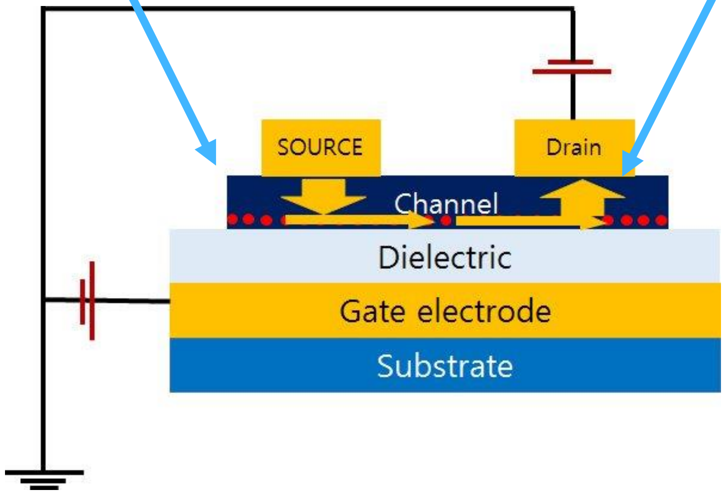
Applications of Multi-Functional Oxides

High mobility, low carrier concentration

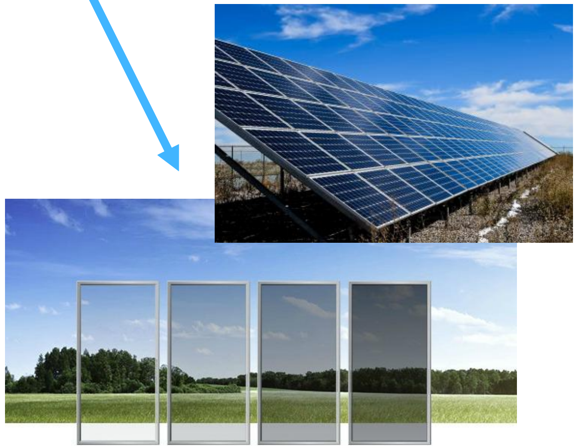
Transparency

Conductivity

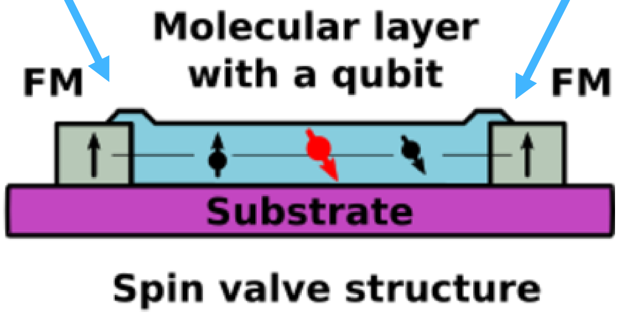
Magnetism



Channel Layer in Thin Film Transistor
Choi, Jon Young. Korean Physical Society 2017.



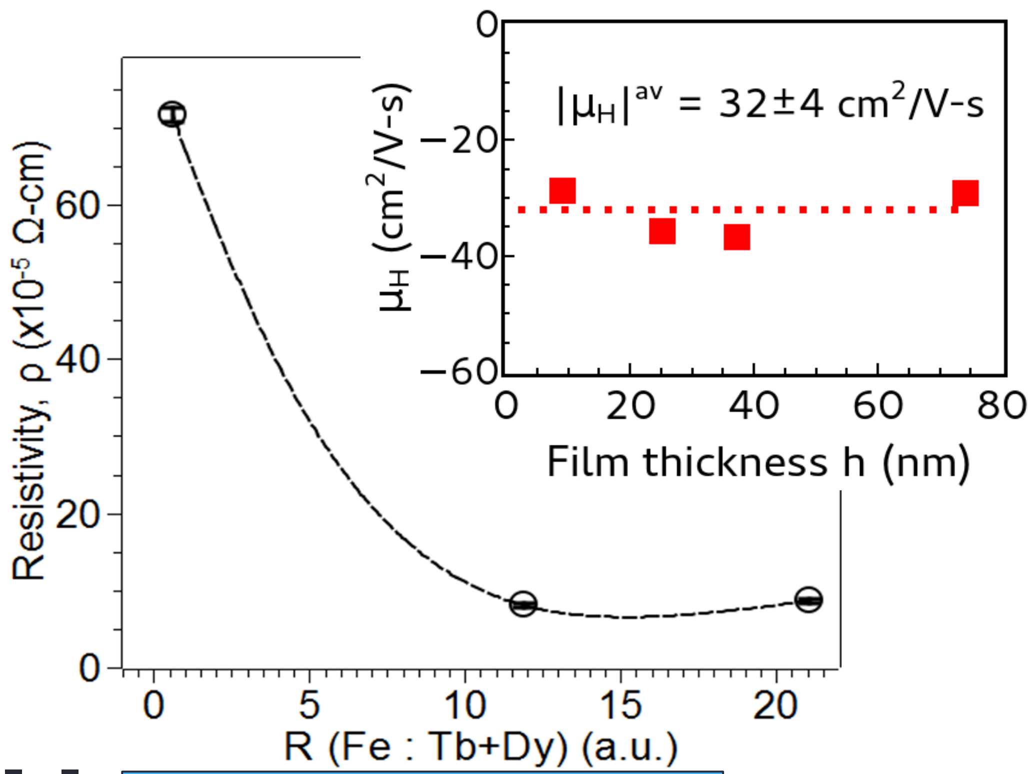
Transparent Conducting Oxide in Solar Panels and Smart Glass
Novakowski, Luke. DoD 2019. Alliance 7. 2018



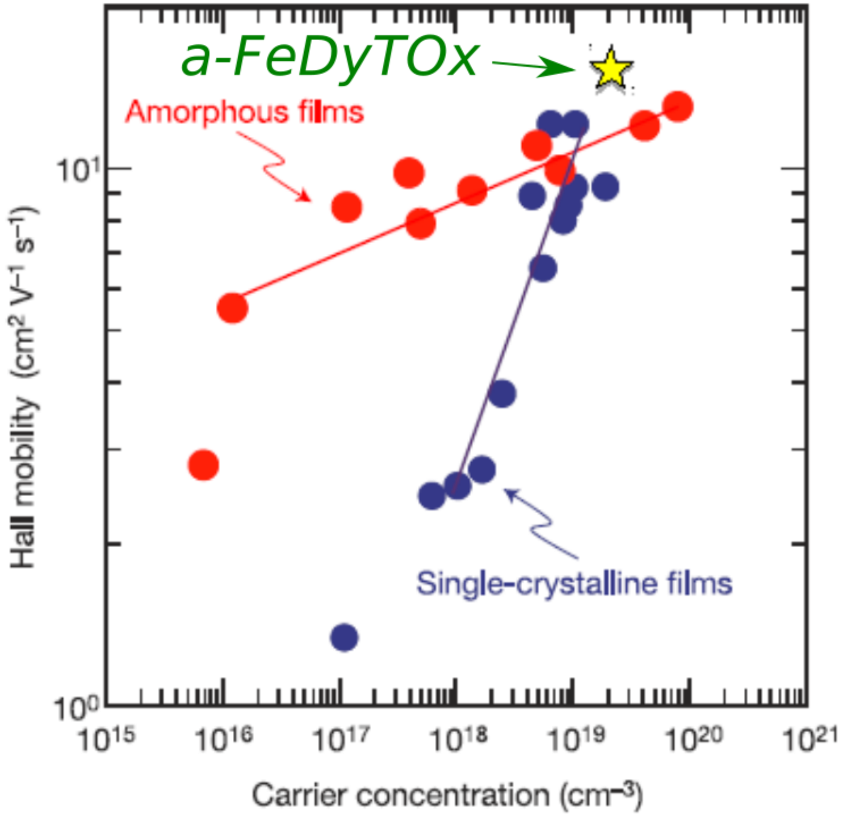
FM Conductor in Spin Valve Devices
Fischer, Inga. Integrated Quantum Science and Tech 2014.

Fe-Tb-Dy-Oxide Transport Properties

Hall Mobility and Resistivity

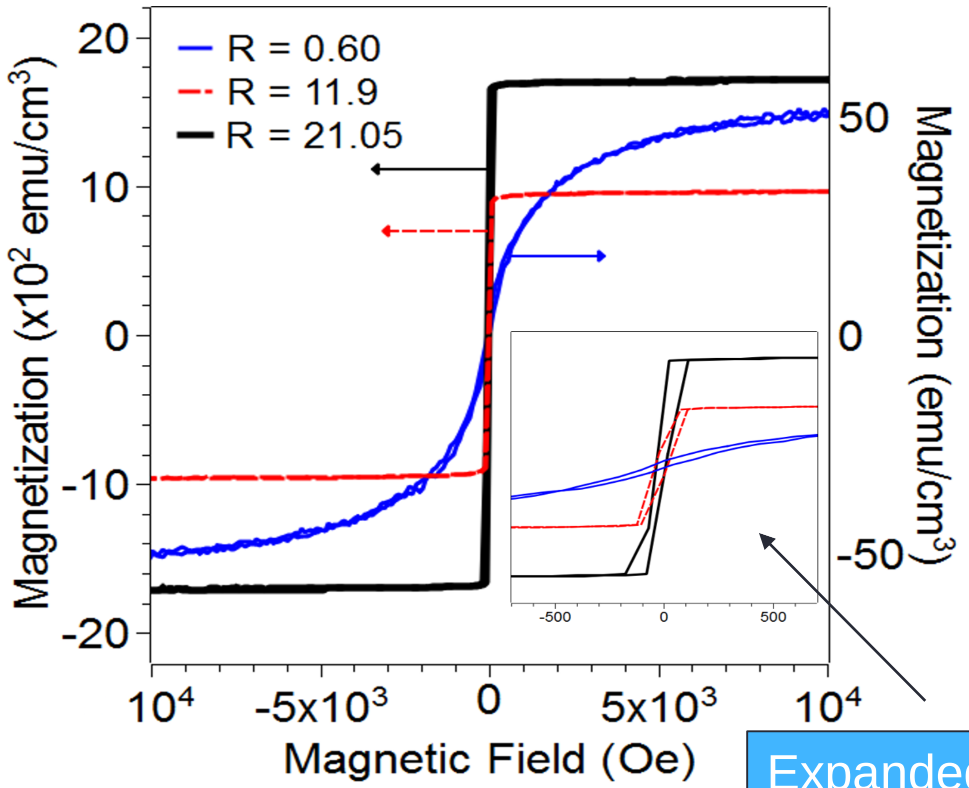


R=0.60 semiconducting and transparent.

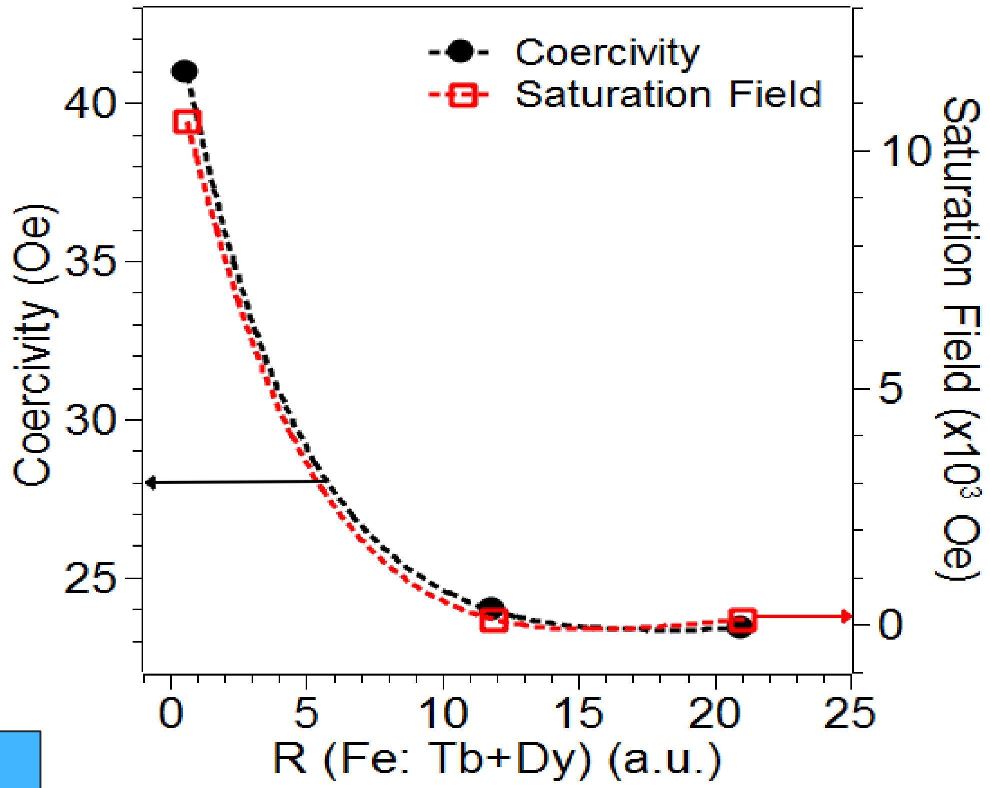


Taz et al, *Nature Sci. Rep.*, v6, (2016)
Nomura et al Nature, vol. 432, 2004

Fe-Tb-Dy- Oxide Room Temperature Magnetism



Expanded near zero field to show coercivity

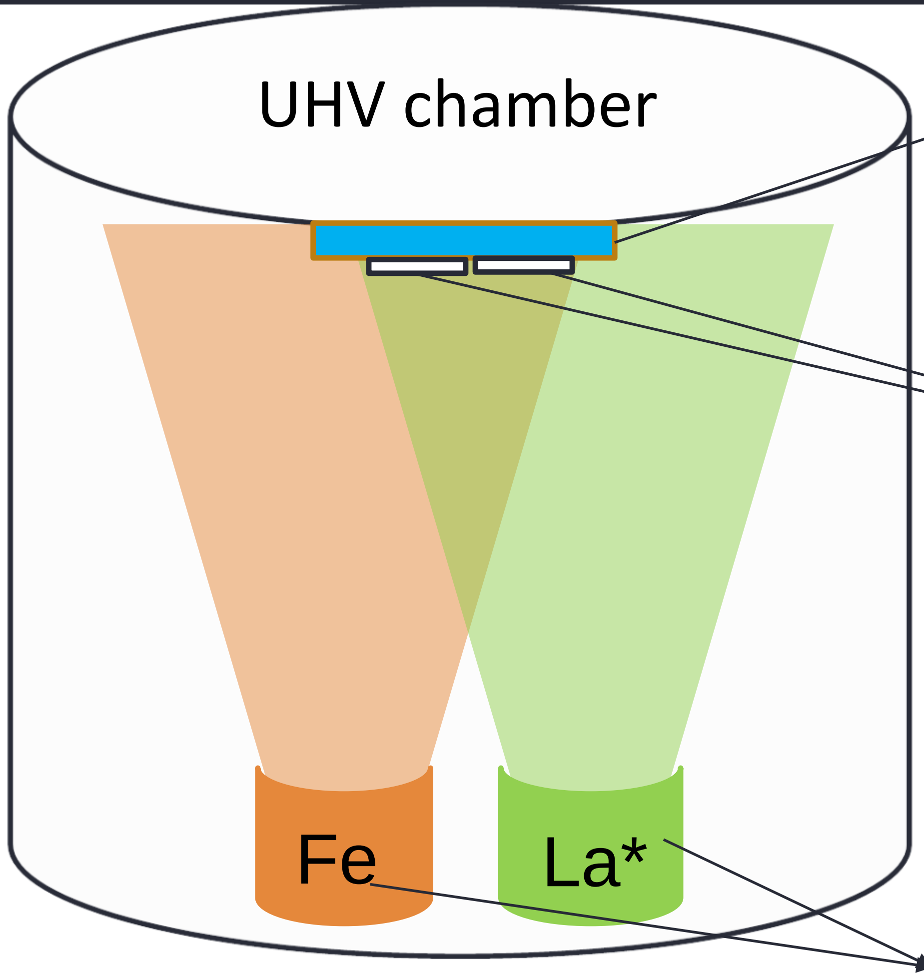


$$R_{value} = \frac{atomic\ \%\ Fe}{atomic\ \%\ of\ (Dy + Tb)}$$

Taz et al, *Nature Sci. Rep.*, v6, (2016)

Question: What role do Tb and Dy play and how do we focus on studying their individual mechanisms?

Electron Beam Evaporation System



Sample Holder

Film thickness: 15-100 nm
At % (Fe/Dy) = 0.3 – 21 (from EDS)
O_2 partial pressure: 10^{-9} – 10^{-6} Torr

Substrates:
1. Quartz
2. SiO_2(400 nm) on Si

*La =TD (Terfenol-D) or Dy

Sockets for electron beam evaporation

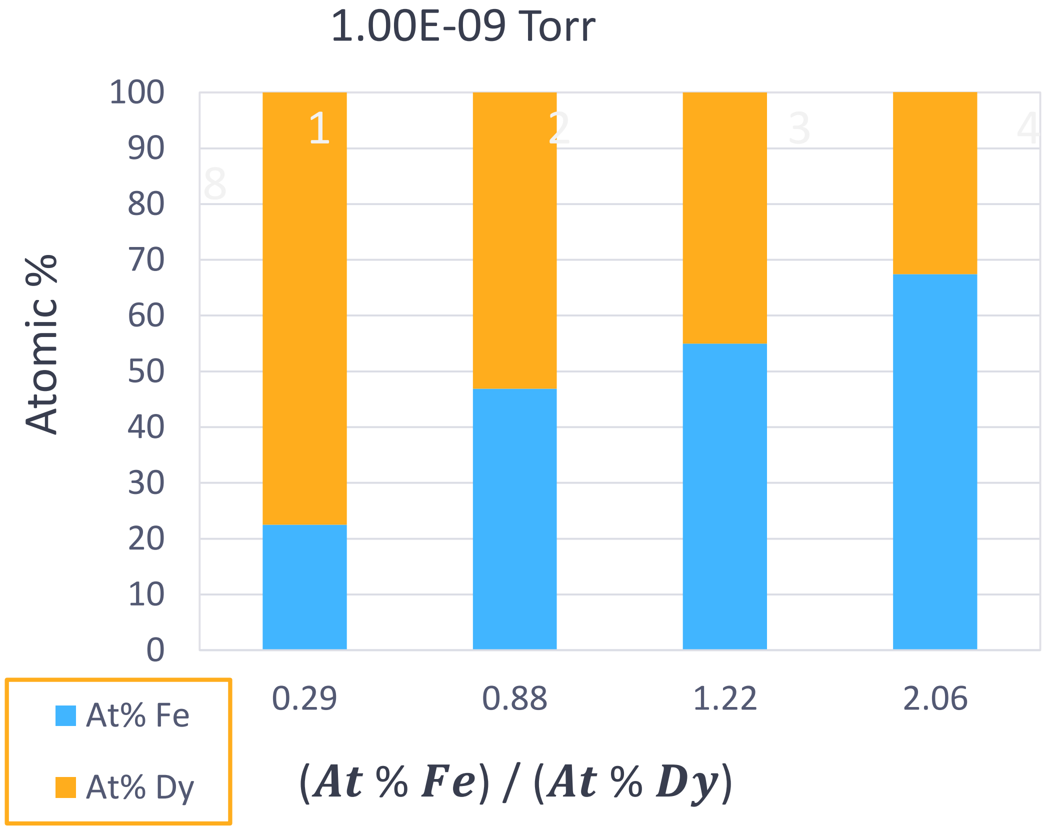
Finding #1 – Atomic % and Oxygen Pressure

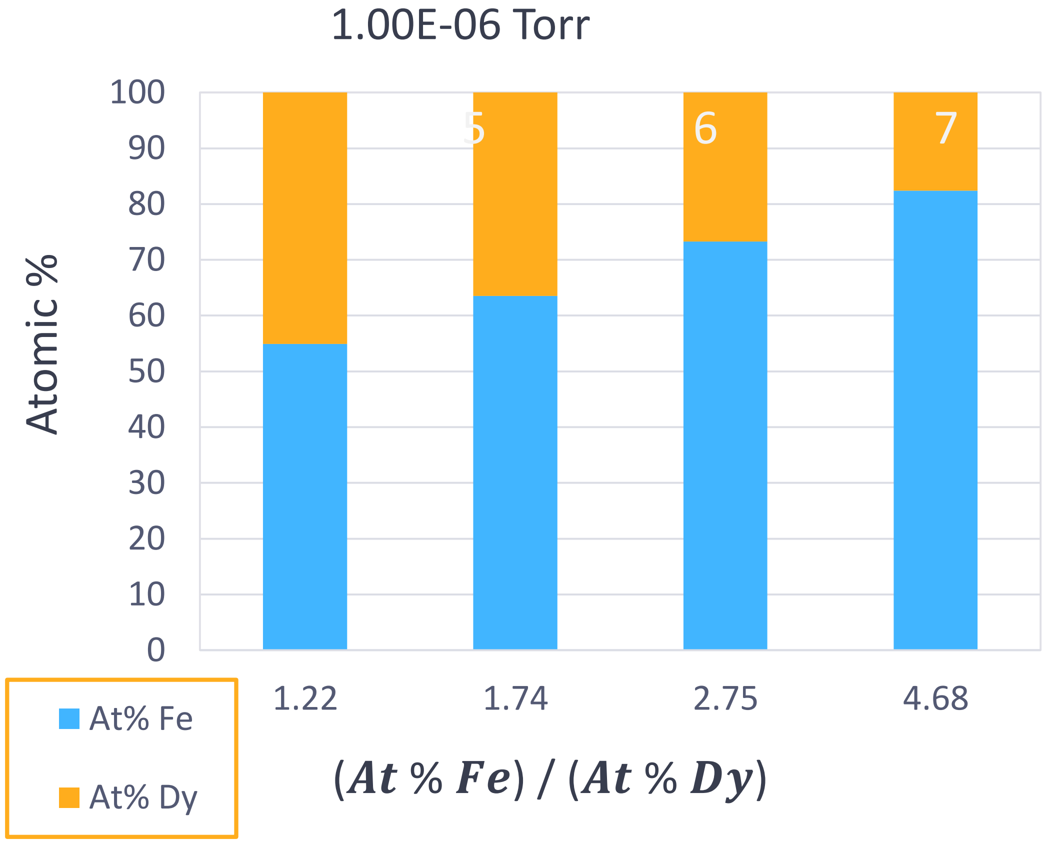
Atomic % of Fe and Dy depends on the amount of Oxygen partial pressure in the vacuum chamber during deposition.

As the oxygen partial pressure increases, the amount of Iron increases.

Expected	At % Fe/Dy 1.0E-06 Torr	At % Fe/Dy 1.0E-08 Torr	At % Fe/Dy 1.0E-09 Torr
6:1	5.33	3.08	1.34
3:1	3.43	1.41	1.97
1:1	1.61	0.77	1.61
1:3	1.1	*in progress	0.28

Total of eight Fe-Dy-Oxide samples deposited on Si/SiO2 by E-Beam Evaporation with varying O_2 partial pressure





Characterization Methods Used

Room Temperature Transport

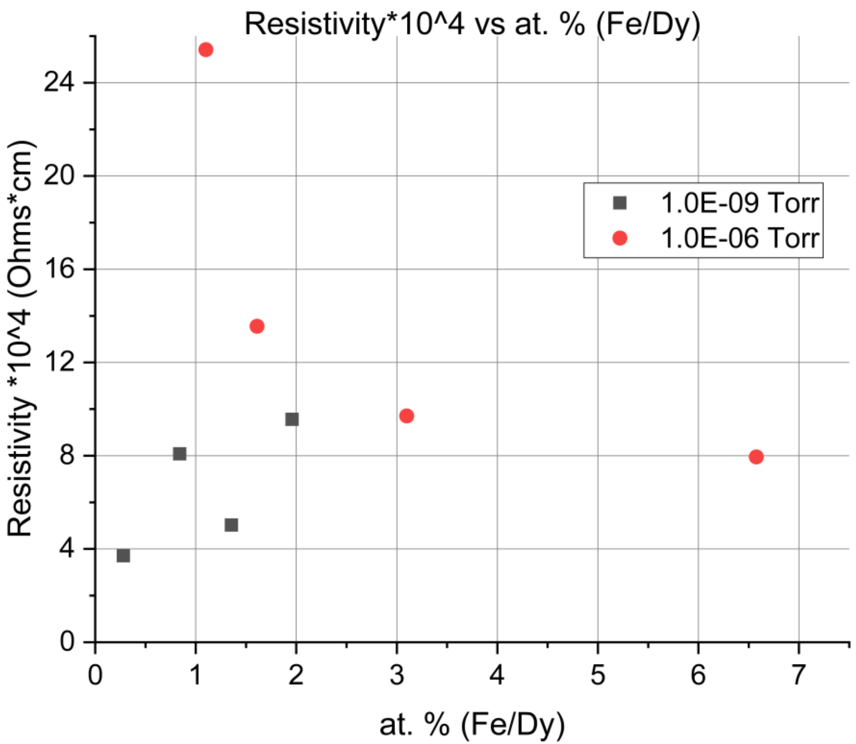
- Hall Measurement system from MMR: Resistivity and Hall effect
  - magnetic field up to 1.3 T
  - Temperature up to 700K available.

Magnetic Characterization

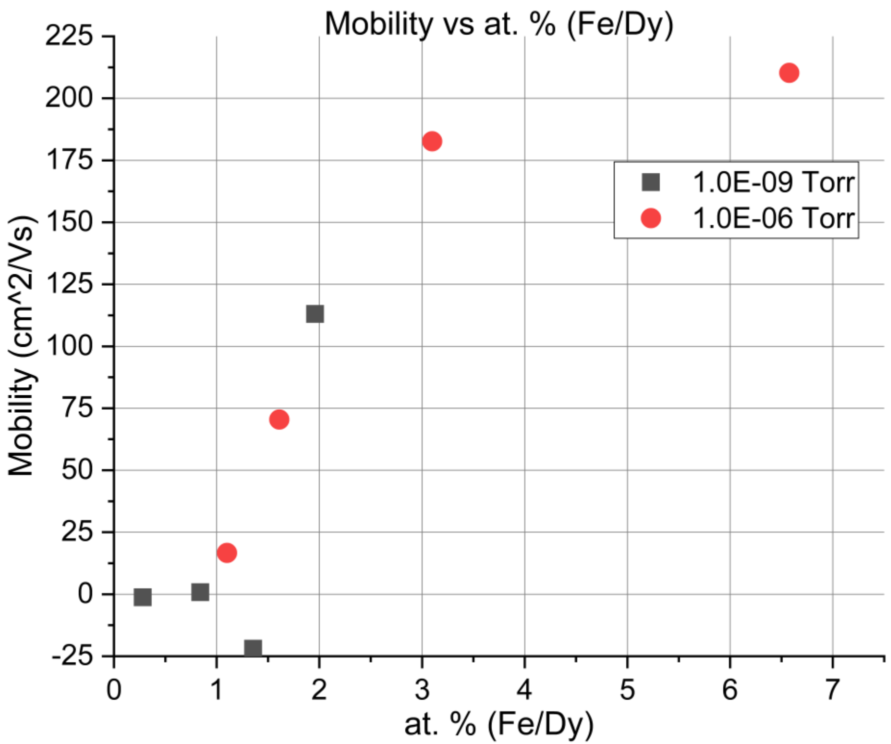
- **Quantum Design PPMS Vibrating Sample Magnetometry**
- **Superconducting Quantum Interference Device (SQUID)**

Finding #2 Low Resistivity and #3 High Mobility

As more Dysprosium is incorporated, samples become more insulating.

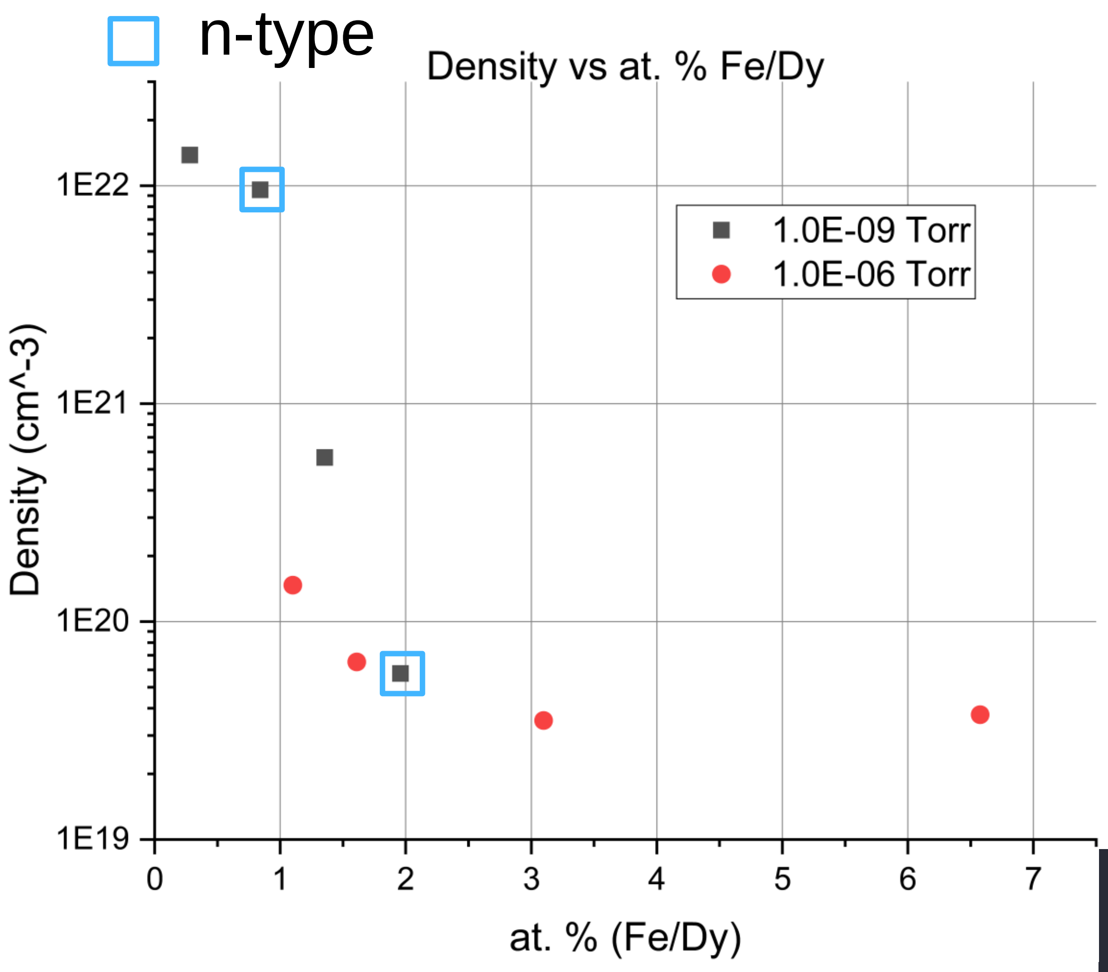


Anomalous Hall effect contributes to high value, particularly in Fe rich samples

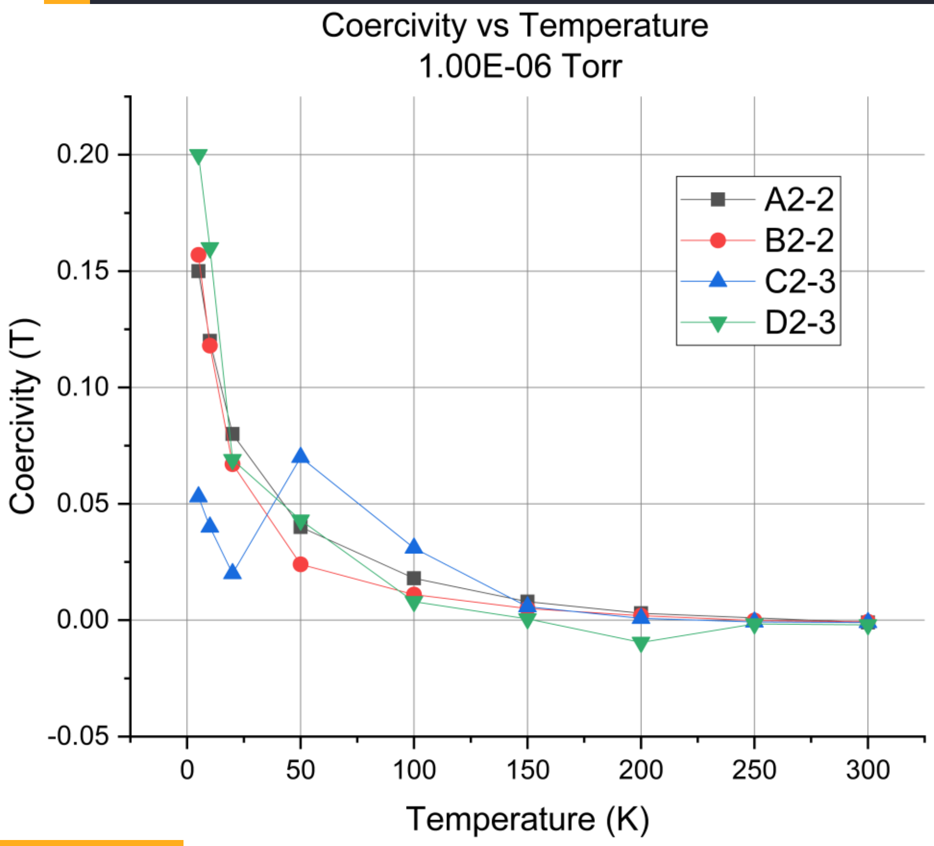


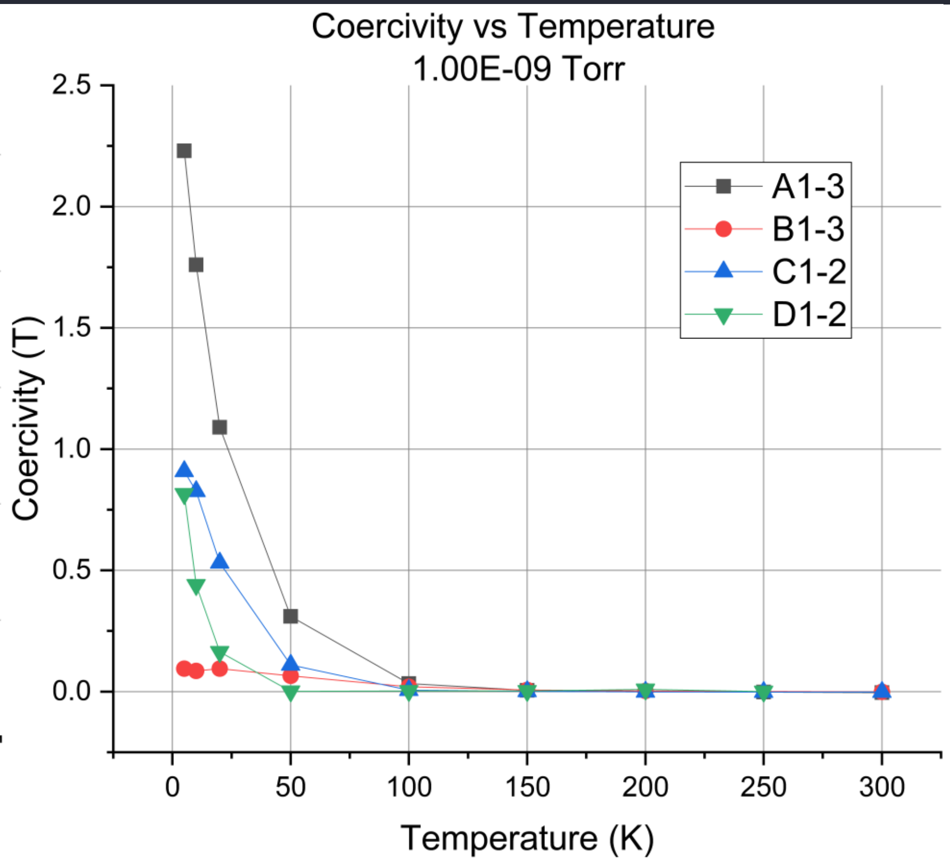
Finding #4 Carrier Concentration and Dysprosiyum

- **Dy-rich films** (R value < 2.5) tend to have high carrier concentrations (10^{20}-10^{22} cm^{-3}). Concentration strongly depends on the amount of Dy in the film.



Finding #4 Coercivity and Oxygen

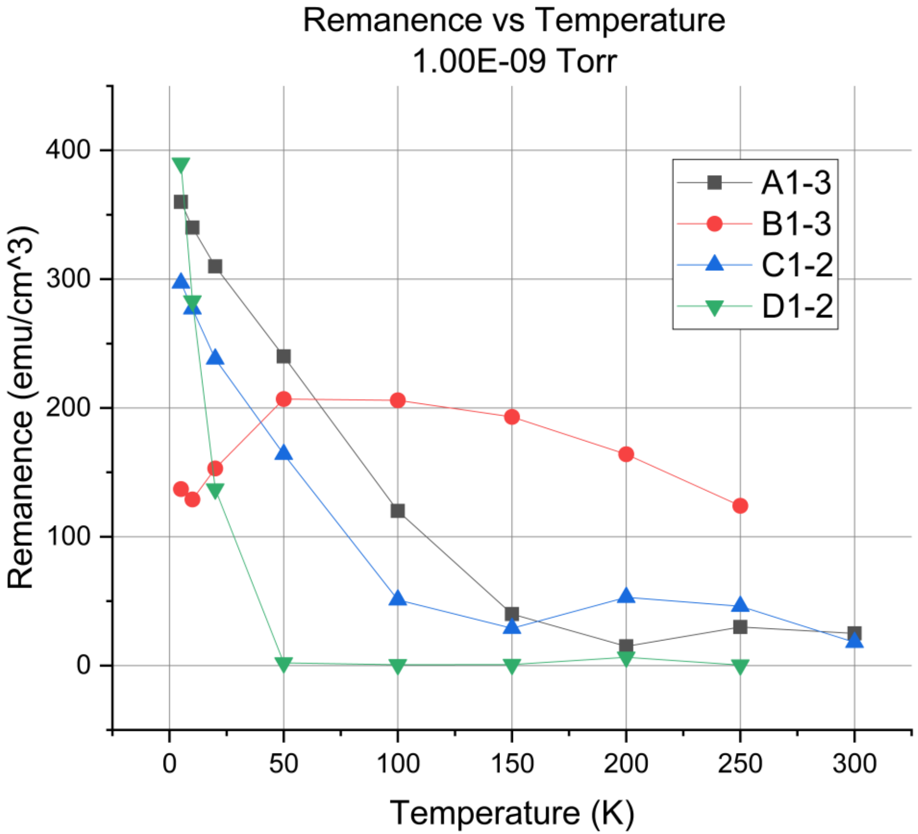


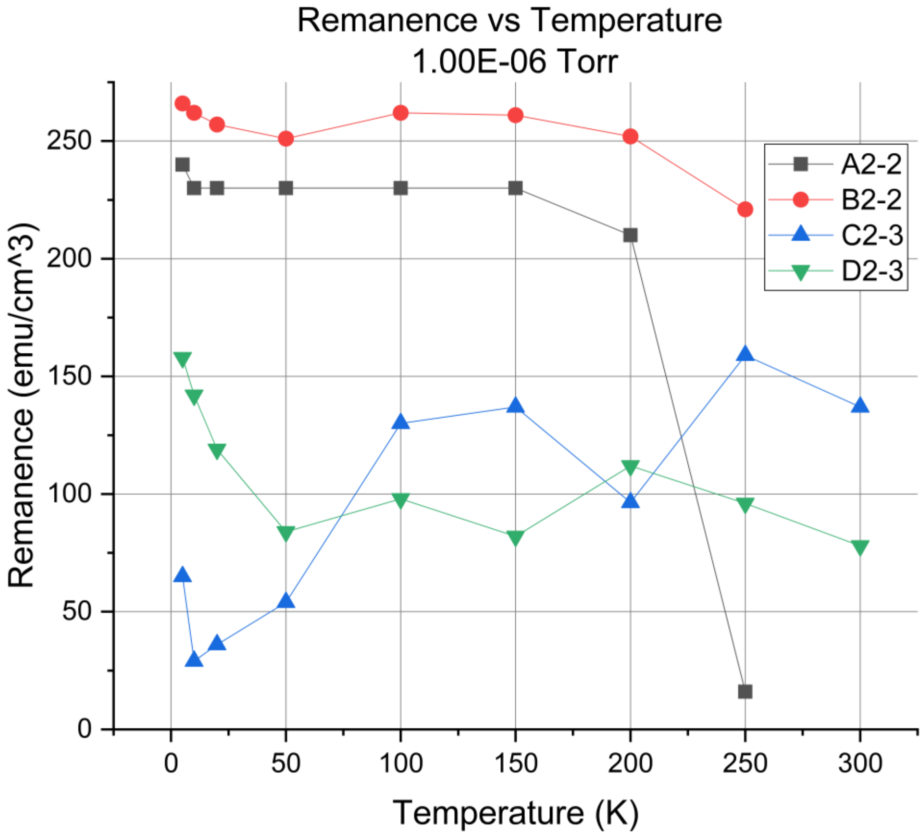


Coercivity at temperatures with counter clockwise hysteresis <u>X10 greater</u> for samples deposited at <u>lower oxygen partial pressure.</u> Possible that coercivity increases with dysprosium

Finding #5 Remanence: Highest Value and Decay

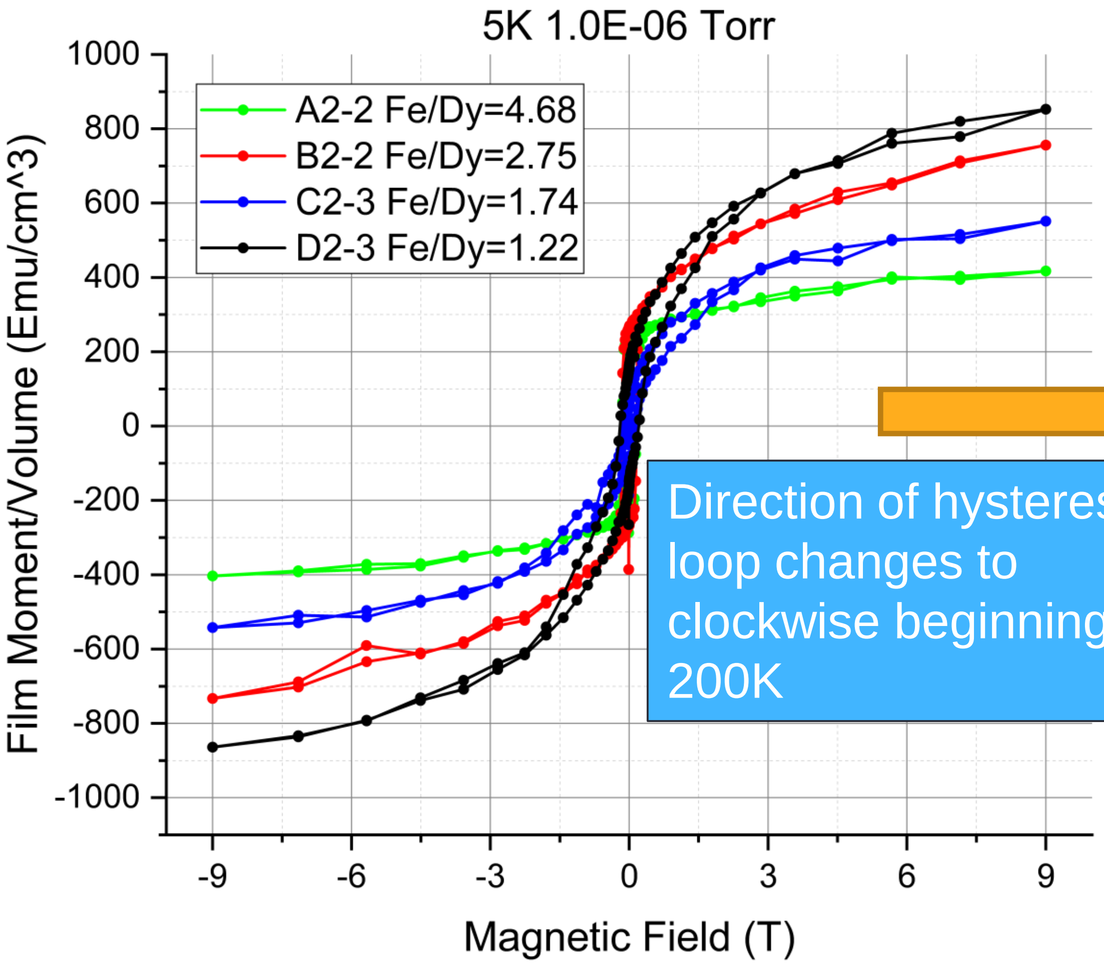
Remanence at low temperature is greater for samples with more Dy, but decays faster than for samples deposited at 1.00E-06 Torr with less Dy.



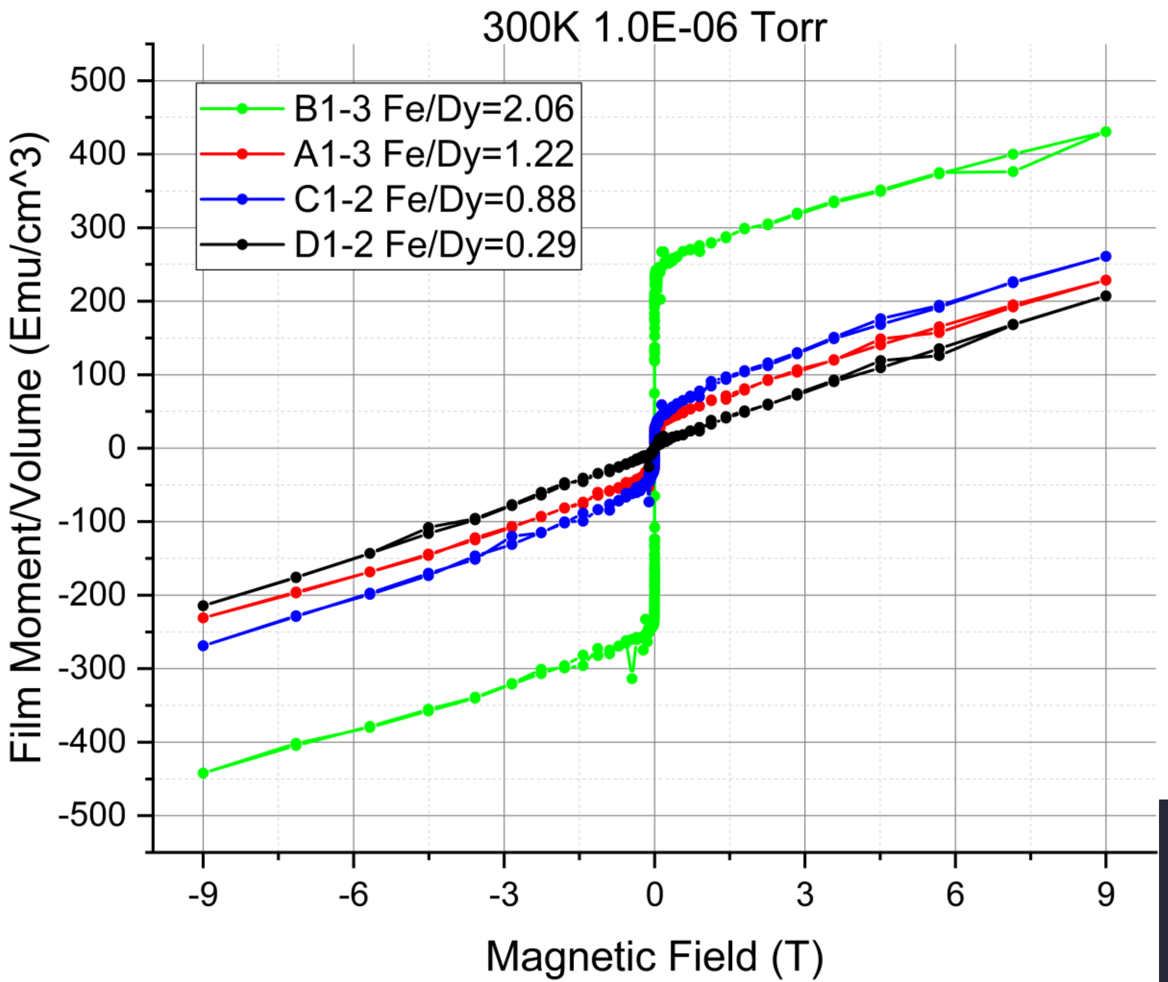


Finding #6 Clockwise Hysteresis above 200K

Counter-clockwise



Clockwise



Direction of hysteresis loop changes to clockwise beginning at 200K

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This work has shown interesting results which, while in preliminary stages, could be applied to tunable materials for electronic devices.

We plan to repeat these measurements and explore new options in deposition methods. This would allow for more control of the amount of incorporated lanthanides.