Vectorial Observation of the Spin Seebeck Effect in NiFe₂O₄ Thin Films with Varying Magnetic Anisotropy

Zhong Li, Amit V. Singh, Jan Krieff, Sudhir Regmi, Ankur Rastogi, Abhishek Srivastava, Tim Mewes, Timo Kuschel, Günter Reiss, and Arunava Gupta

1 Center for Materials for Information Technology, The University of Alabama, USA; 2 Department of Physics & Astronomy, The University of Alabama, USA; 3 Center for Spinelectronic Materials and Devices, Department of Physics, Bielefeld University, Germany; 4 Materials Science and Technology Division, ORNL, USA

Motivation

- Grow nickel ferrite (NiFe₂O₄ or NFO) thin films on different substrates, e.g., MgGa₂O₄ (MGO), and CoGa₂O₄ (CGO), with different orientations [(100) and (110)]
- Enhance thermally generated spin voltage at Pt/NFO interface
- Study the strain dependence of magnetization reversal for different substrates
- Explore a new alternative vectorial magnetometry technique to observe the details of magnetization reversal

Methodology

- Pulsed laser deposition (PLD)
- Typical setup of longitudinal spin Seebeck effect (LSSE) measurement

Experimental setup

- Pole pieces
- Inclined stage
- Motor
- Target

Characterizations

- X-ray pattern of NFO thin films (~450 nm) on MGO and CGO substrates of different orientations
- VSM results of normalized in-plane magnetization versus magnetic field for NFO/MGO (110) and NFO/CGO (110), respectively. The magnetizations are measured with the in-plane magnetic field applied in two perpendicular directions for all samples.
- FMR measurements of in-plane angular dependence of resonance field, H_{res} at 20 GHz for NFO/MGO (110) and NFO/CGO (110), respectively.

Angular dependence of bidirectional LSSE

- Longitudinal spin Seebeck effect measurements at various angles along two perpendicular directions (X & Y) for NFO/MGO (110) and NFO/CGO (110), respectively. The represented angles are those between X (Y) direction and the applied field H.

Reversal process of magnetization vector

- The NFO/MGO (110) reversal process of magnetization vector for angles of the external magnetic field γ from 0° to 150°. The magnitude \( V_x = (V_x^2 + V_y^2)^{1/2} \) and the azimuthal rotation angle \( \gamma = \arctan(V_y / V_x) \).
- The NFO/CGO (110) reversal process of magnetization vector for angles of the external magnetic field γ from 0° to 150°.

Conclusion

- Bidirectional SSE measurements were carried out simultaneously for the first time.
- The lattice mismatch between the film and the substrate leads to strain anisotropy in the NFO thin film, which is higher for MGO substrate than CGO substrate.
- The voltages obtained from bidirectional SSE measurements reveal the complete reversal process of magnetization vector, demonstrating a new alternative vectorial magnetometry for studying magnetization reversal.

References


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Contacts

Email: zhong.li@ua.edu
Website: zhli.people.ua.edu

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