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Growth and Characterization of $Y_3Fe_5O_{12}$ Thin Films

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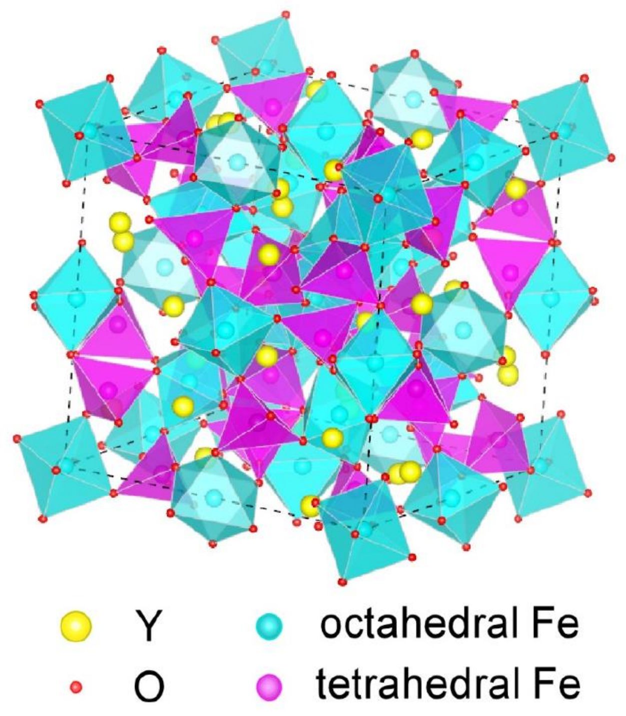
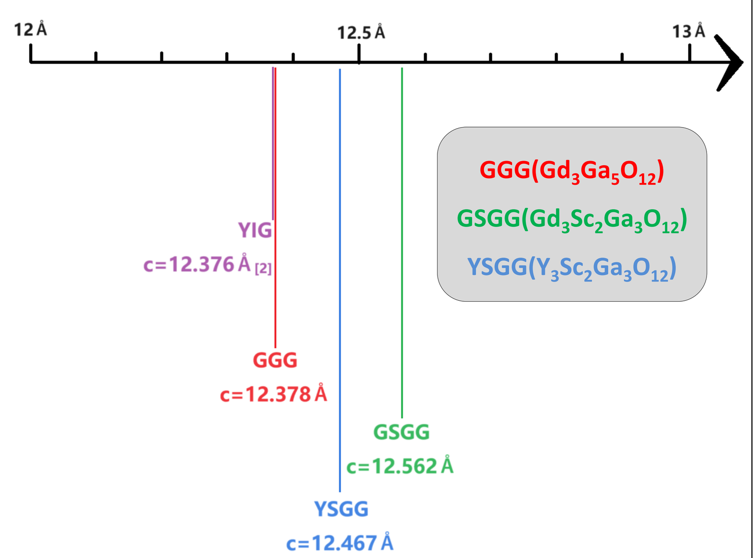
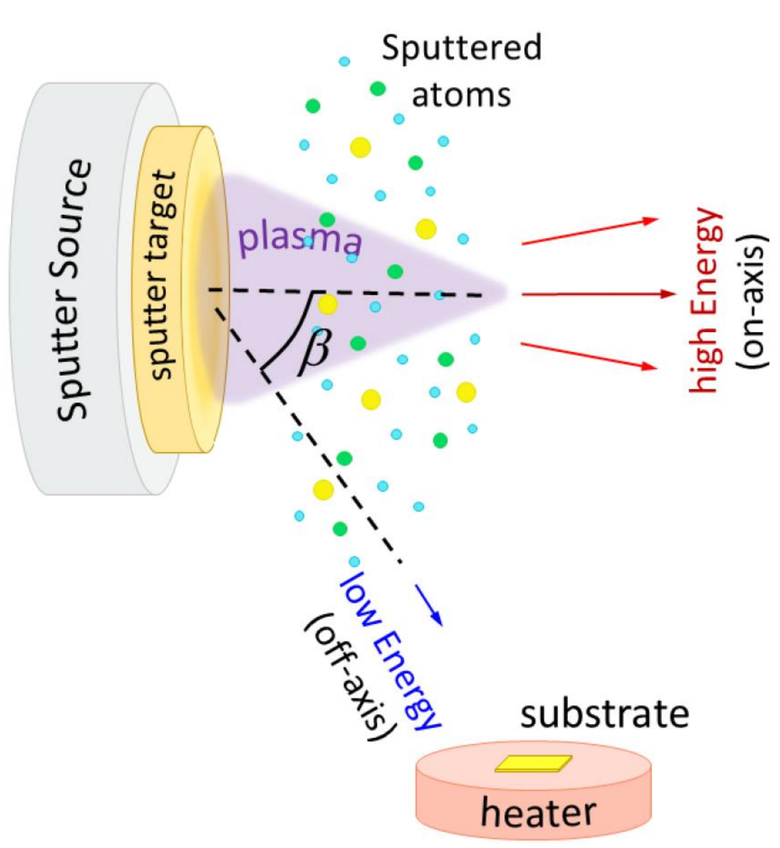
Introduction

- $Y_3Fe_5O_{12}$(Yttrium Iron Garnet, YIG) is a ferrimagnetic insulator with outstanding low magnetic damping.
- Due to these properties, YIG is an ideal material for magnon transport [1].
- We grow YIG thin films down to the scale of nanometers on three different substrates (GGG,GSGG, and YSGG) using off-axis sputtering.
- X-ray diffraction (XRD) measurement, vibrating sample magnetometer (VSM), and ferromagnetic resonance (FMR) measurement are used to characterize the quality of the films.





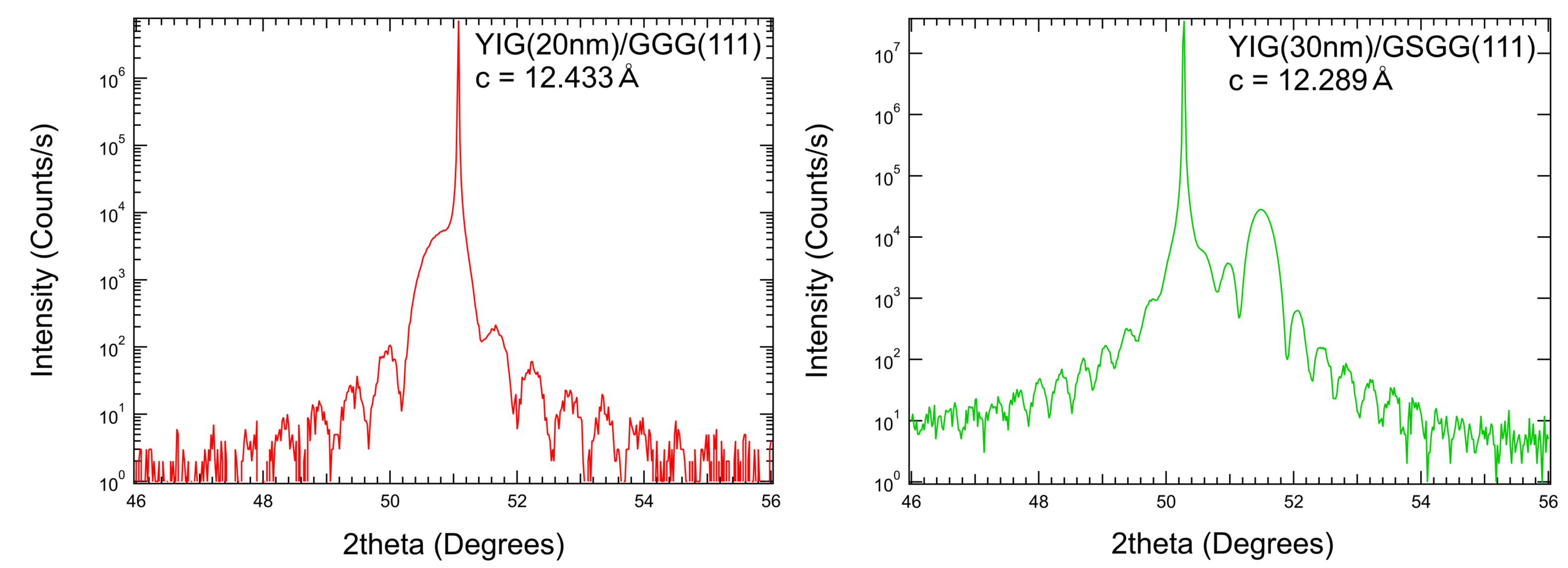
Off-axis Sputtering

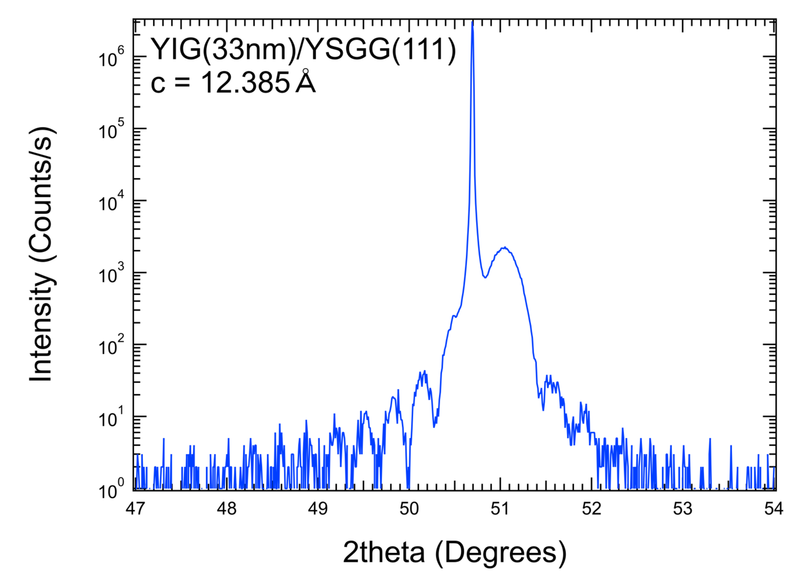


- Films are grown using off-axis sputtering.
- Off-axis sputtering has the advantage of using lower energy ions, reducing the damage in the film due to bombardment.
- A low growth pressure of 11.5 mTorr allows us to ensure good cation stoichiometry of our films.
- We heat the substrate to 650°C to give ions enough mobility to epitaxially order.
- We grow in Ar + 1%O_2 environment to minimize any oxygen vacancies.

Crystal Structure

XRD

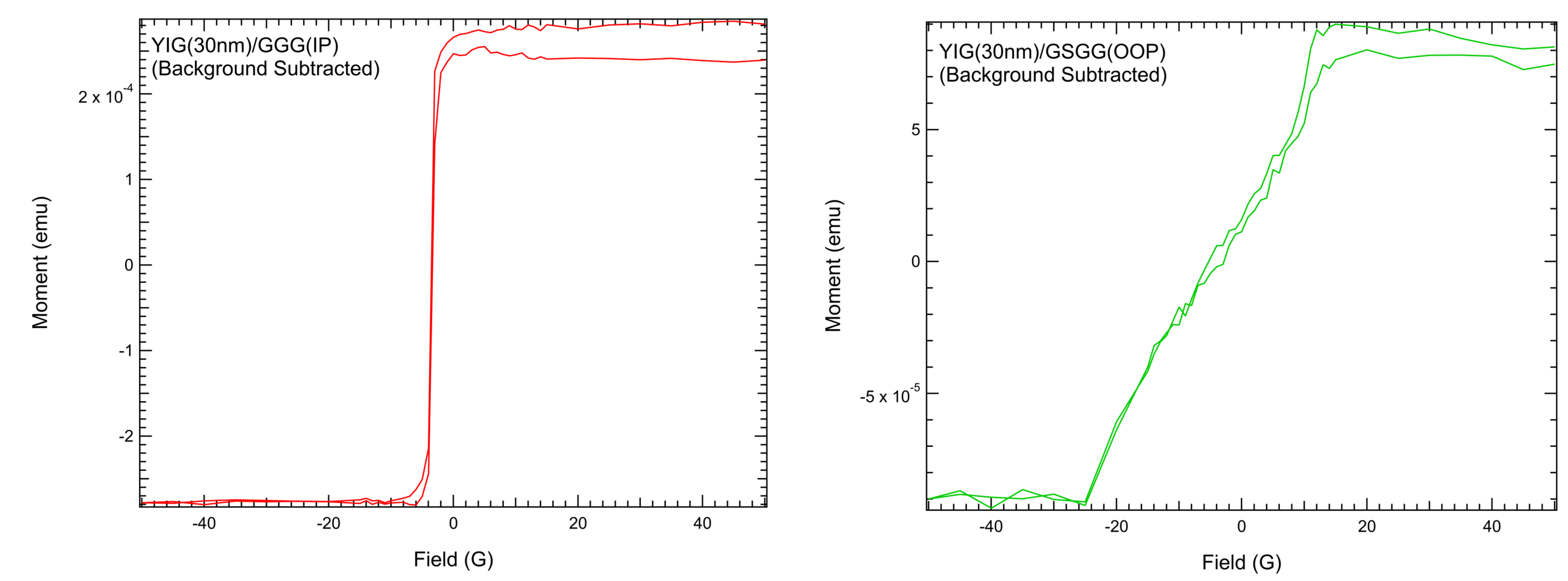


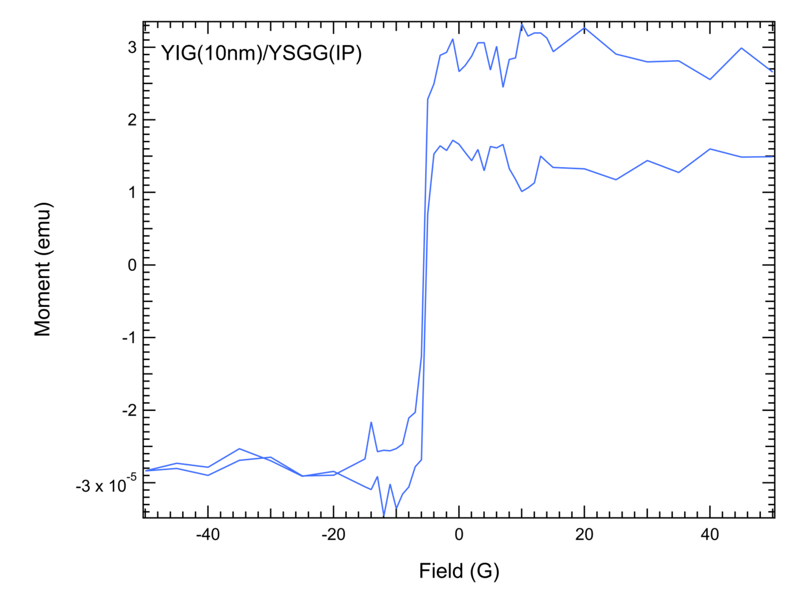


- Each XRD shows a clear substrate peak (the highest peak) and a film peak (the second highest peak).
- Laue Oscillations(the periodical waves) are strong.

Magnetization

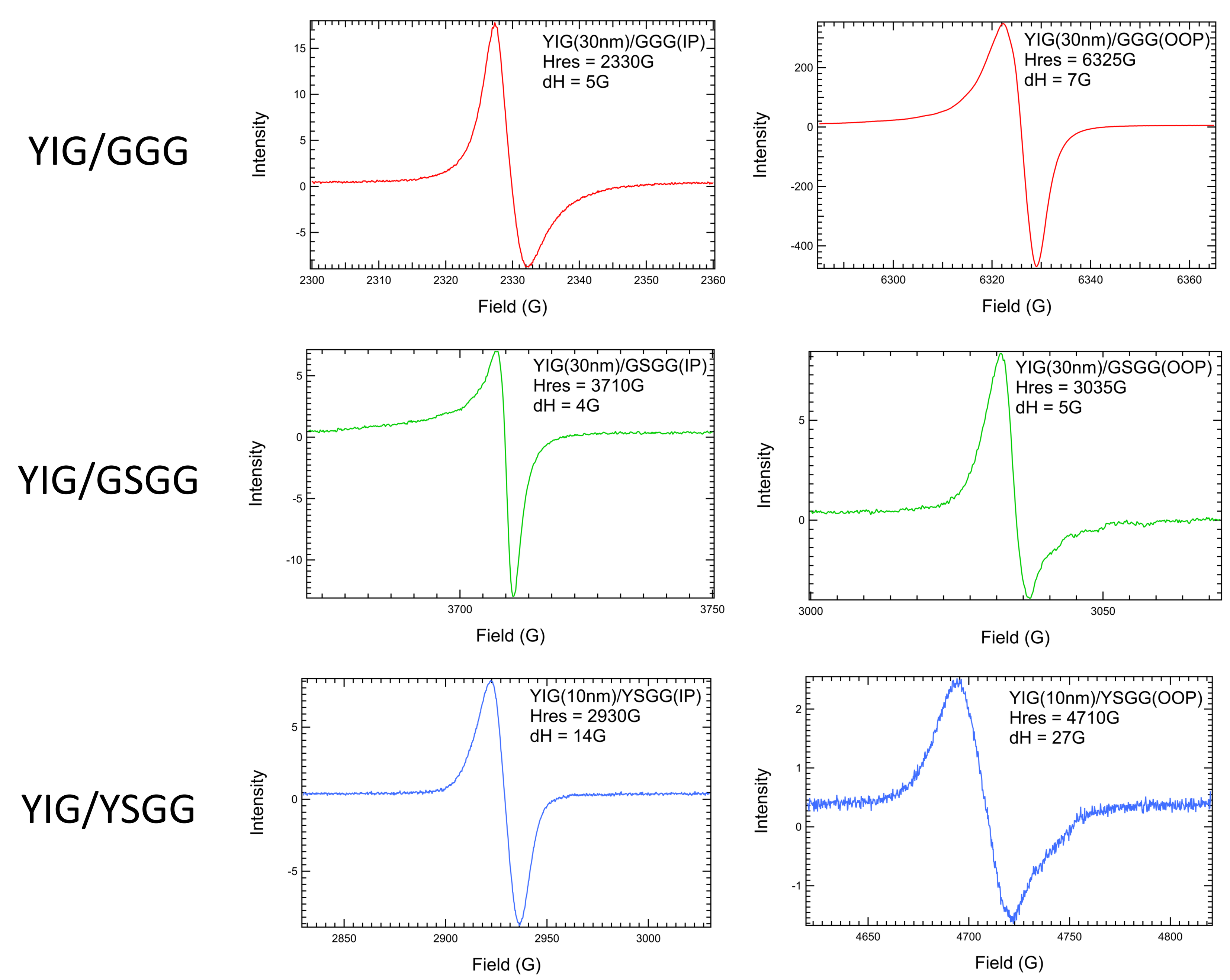
VSM





- Due to the crystal structure, YIG has magnetic anisotropy. In bulk YIG, the easy axis lies IP, but by applying a large enough strain, we change the crystal structure and be able to tune the easy axis to be OOP.

FMR Measurements



- Expressed in the first derivative of the microwave absorption, the symmetry and low peak-to-peak line width confirm high quality YIG films.

Conclusion

- Using off-axis sputtering, we are able to grow high quality YIG films, evidenced by XRD, VSM, and FMR measurements.

Future Works

- We will make Platinum device on the top of the YIG layer we grew to test magnon transport properties of YIG.

References

[1] Wei, XY., Santos, O.A., Lusero, C.H.S. et al. Giant magnon spin conductivity in ultrathin yttrium iron garnet films. Nat. Mater. 21, 1352–1356 (2022). https://doi.org/10.1038/s41563-022-01369-0
[2] Wu, M. (2010). Nonlinear Spin Waves in Magnetic Film Feedback Rings. Solid State Physics - Advances in Research and Applications, 62, 163–224. https://doi.org/10.1016/B978-0-12-374293-3.00003-1

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