Toward Larger-Area Magnonic Platform Materials: 3-Inch, Nanometer-Thin YIG Films

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Nanometer-thin yttrium iron garnet (YIG) films

Base material

→ for future nanoscale devices as building blocks for magnonic networks for spin-wave-based data processing.

Fabrication on 3-inch wafers

→ enables a multitude of nanoscale spin-wave devices on the same wafer

for the academic sector

→ for investigations of spin-wave properties of different chip designs on the same material.

for the engineering and manufacturing area

→ to achieve high technology readiness levels (TRL) of three or more.

The challenge

→ material homogeneity over the entire wafer diameter of 3 inches

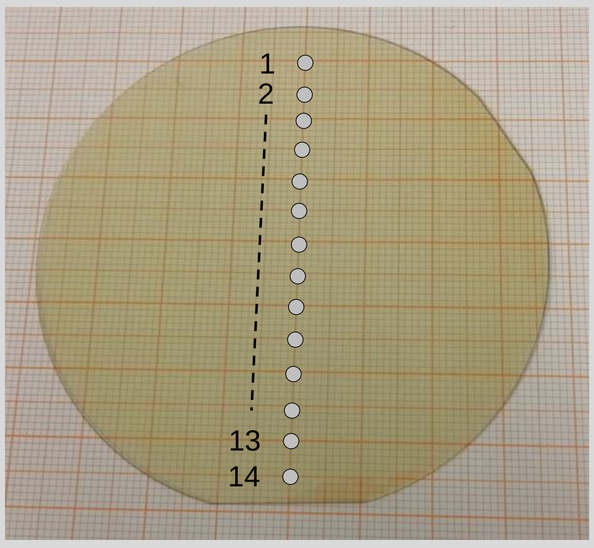
→ preservation of unique properties compared to small sample geometries.

Microwave properties of best YIG films

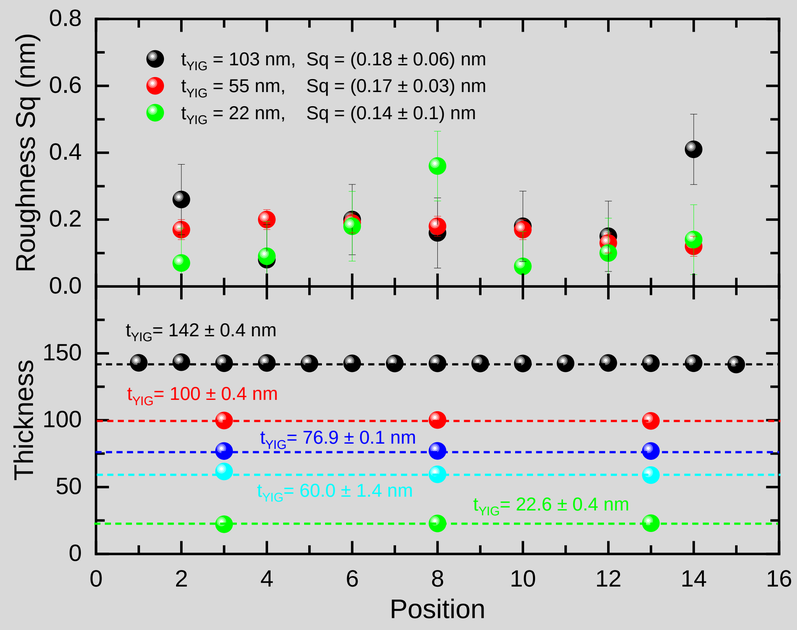
* 12 GHz

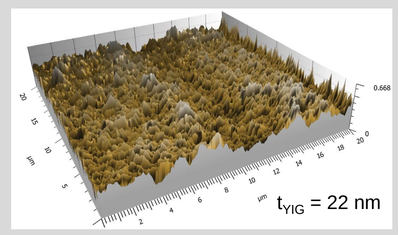
Thickness (nm)	$\Delta H_{p\text{-}p,\,0}$ (Oe)	$\Delta H_{p\text{-}p}$ @15 GHz (Oe)	$\alpha_{\|\|}$ (× 10^{-4})	Deposition method	Reference
103	0.4	1.2	1	3“ LPE	This work
75	1.9	2.2	0.5	Sputtering	[1]
56	1.3	1.6*	0.6	PLD	[2]
55	0.3	1.4	2	3“ LPE	This work
22	6.4	6.9	1	Sputtering	[3]
23	1.2	2.4	2	PLD	[4]
20	1.4	2.6	2	PLD	[5]
18	1.4	3.5	3	1“ LPE	[6]
21	0.6	1.4	1	1“ LPE	[7]
22	0.6	1.8	2	3“ LPE	This work

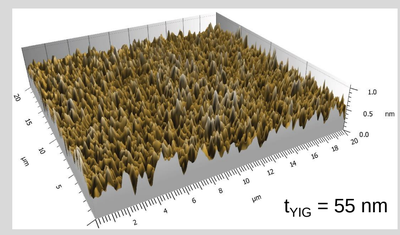
Film topology along the entire diameter of 3-inch YIG wafers grown on (111) GGG substrates

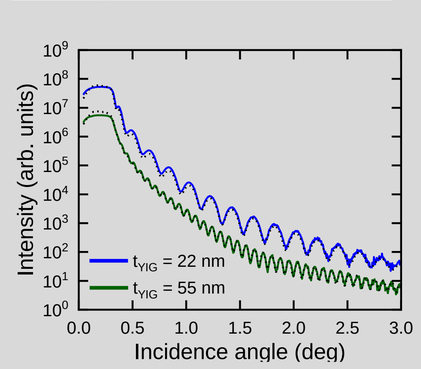


Measurement positions



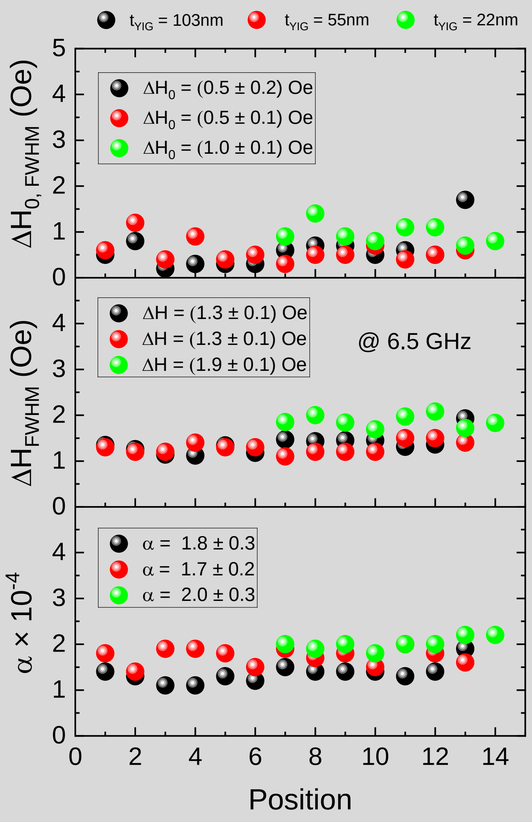


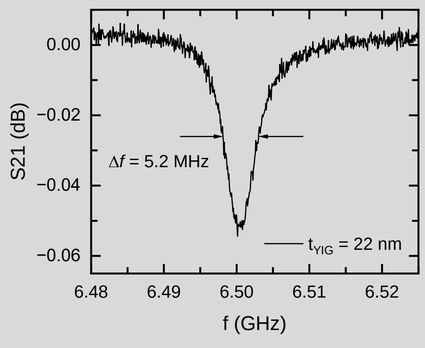


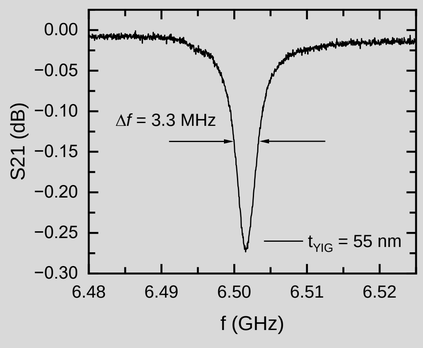


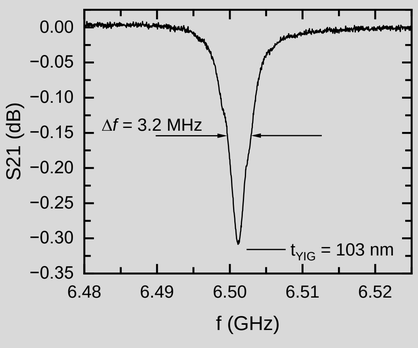
RMS roughness (top) and XRR plot (bottom) for selected positions of 3“ YIG film samples

FMR characteristics for sliced chips along the entire diameter of 3-inch YIG wafers









FMR absorption spectra close to 6.5 GHz

Conclusions

- High-perfection 3-inch YIG films with a thickness down to 20 nm using liquid phase epitaxy (LPE).
- Homogeneous thickness, surface roughness and FMR properties over 3-inch film diameters.
- Lowest absolute damping for the entirety of samples over 3-inch wafers vs reported solitary samples.
- Comparable Gilbert damping coefficients α but lowest reported inhomogeneous line broadening ΔH_0.
- Further optimized growth conditions will allow reliable fabrication of 3-inch YIG films for applications.

References

[1] Ding et al. 2020, IEEE Magn. Lett. **11**, 5502305
[2] Hauser et al. 2016, Sci. Rep. 6:20827
[3] Chang et al. 2014, IEEE Magn. Lett. **5,** 6700104
[4] Howe et al. 2015, IEEE Magn. Lett. **6,** 3500504
[5] d‘Allivy Kelly et al. 2013, Appl. Phys. Lett. **103,** 082408
[6] Beaulieu et al. 2018, IEEE Magn. Lett. **9**, 3706005
[7] Dubs et al. 2020, Phys. Rev. Mat. **4**, 024416

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