

Spatiotemporal Imaging of Magnetization Dynamics at the Nanoscale

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Primary CNF Tools Used: AJA Ion Mill, AJA Sputter 3, DISCO Dicing Saw, Filmetrics R50, Glen 1000 Resist Strip, Heidelberg MLA 150 Maskless Aligner, KLA P7 Profilometer, Westbond 7400A Ultrasonic Wire Bonder

Abstract:

We fabricated an RF antenna on sapphire substrate and microwave coplanar waveguide on LAFO chip for probing the magnon propagation in LAFO using our scanning NV setup. The fabrication process is done and mainly based on lift-off photolithography technique and thin film deposition.

Summary of Research:

Magnonic devices are promising candidates for next generation information processing technology for their low loss through transmission and tunable properties through electric and magnetic field [1]. We aim to image magnon propagation directly between different materials and are starting with simple propagation process in single LAFO layer. The experiment setup can be found in Figure 1, where the magnon is launched and received through a coplanar waveguide (CPW) and propagates in-plane on LAFO; the antenna below provides an interference field with the magnon stray field and make the optically detected magnetic resonance imaging possible through scanning NV; and NV center does the stray field readout from the green laser; also a global field is applied for bias on the NV ESR frequency. In this way, we can launch the magnon in a desired frequency range, and do the ODMR imaging and interference through global antenna at the same frequency [2]. The exact NV scanning measurement setup can be found in Figure 2, in which we use a rotating electromagnet for global bias field and a piezo-stage for LAFO sample moving and imaging. For the fabrication process of

the CPW and antenna as in Figure 3, we first clean the LAFO pieces and do lithography on the chips, then do the ion milling for defining the propagation area on LAFO, and do another lithography and sputtering for the coplanar waveguide fabrication. For the antenna, we just do a one step lift off and the sputter and we can fabricate them on the sapphire substrate (and finally dicing). The actual fabrication result can be found in Figure 4.

Conclusions and Future Steps:

We fabricated antennas and CPW for magnon propagation imaging based on the scanning NV setup. We will perform the scanning measurement and do propagation between layer experiment in future.

References:

- [1] P. Pirro, V. I. Vasyuchka, A. A. Serga, et al., "Advances in coherent magnonics," *Nature Reviews Materials* 6, 1114–1135 (2021). DOI:10.1038/s41578-021-00332-w
- [2] T. X. Zhou, J. J. Carmiggelt, L. M. Gächter, et al., "A magnon scattering platform," *Proceedings of the National Academy of Sciences* 118, e2019473118 (2021).

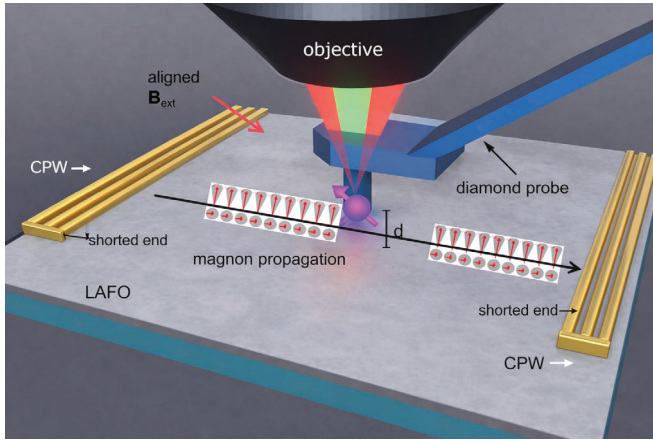


Figure 1: General setup for magnon propagation imaging using scanning NV.

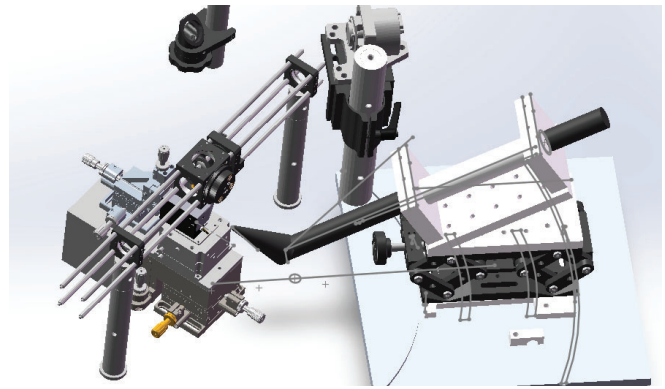


Figure 2: NV scanning setup.

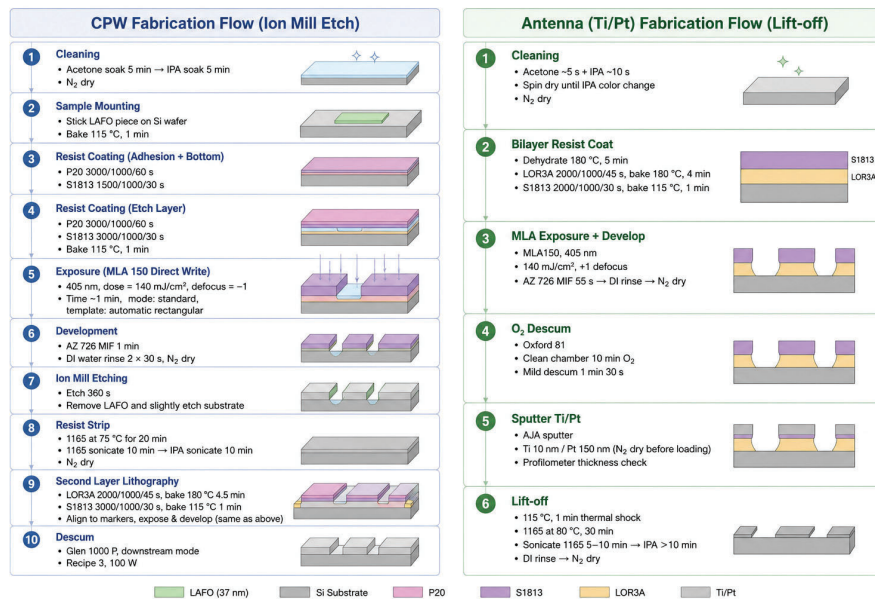


Figure 3: Fabrication process flow.

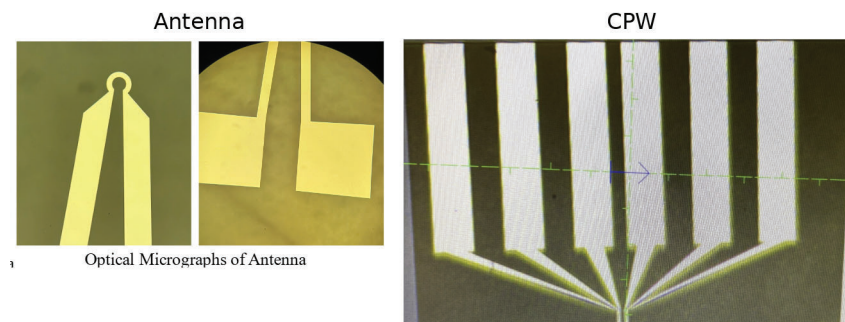


Figure 4: Device result.