

Spin-wave propagation in YIG/VO₂ heterostructure controlled by a low current densityAleksei A. Nikitin^a, E. Lähderanta^b, and S. van Dijken^a^a: Department of Applied Physics, Aalto University School of Science, 00076 Aalto, Finland;^b: Department of Physics, LUT University, 53850 Lappeenranta, Finland.

Energy-efficient manipulation of spin waves (SWs), or their quanta, magnons, is a central requirement for magnonic computing technologies [1]. Unlike conventional electronics, magnonic devices encode information in the SW amplitude or phase, offering the prospect of substantially reduced Joule heating while enabling operation at higher frequencies. Active control of SW transport can be achieved through coupling to electric currents, voltages, or optical excitations [2,3,4]. Among them, current-based electrical control is attractive due to its compatibility with on-chip integration and device miniaturization. However, most current-driven mechanisms for SW manipulation require large current densities on the order of 10^6 – 10^8 A/cm², thereby negating the low-dissipation advantages of magnonic systems.

In this work, we have shown highly efficient electrical control of SW propagation in YIG films integrated with a VO₂ stripe. Figure 1 illustrates the magnonic device. The influence of passing an electric current through the stripe on SW transport is evaluated by measuring the S_{21} scattering parameter (see Fig. 2). A small applied current triggers the insulator-metal transition in VO₂, leading to an abrupt resistivity change of more than 3 orders of magnitude. This phase transition strongly alters the SW dispersion in the adjacent YIG film, resulting in a substantial reduction of the group velocity and suppression of SW transmission by 22 dBm. Additional measurements (not shown) performed with the device rule out other mechanisms that could, in principle, contribute to this attenuation. Simultaneously, thermal contribution shifts the SW transmission spectrum toward lower frequencies. The combined action of these mechanisms results in an overall signal suppression by 40 dB. These findings establish current-induced phase transitions in correlated oxides as a low-power mechanism for controlling SW transport, paving the way toward highly-efficient magnonic devices.

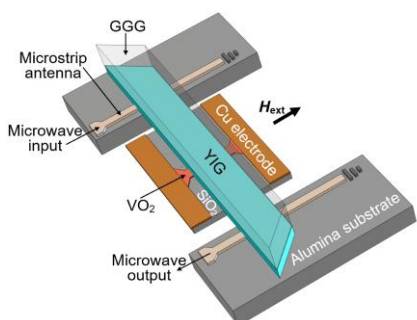


Figure 1. Schematic of the device comprising a 5.7- μ m-thick YIG film, a 650-nm-thick and 300- μ m-wide VO₂ stripe, and antennas separated by 5 mm.

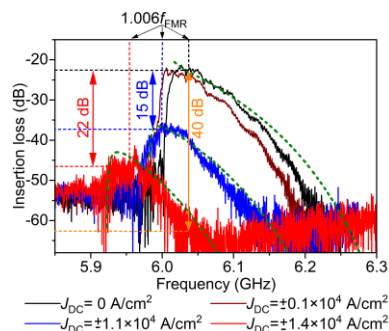


Figure 2. Real parts of S_{21} spectra measured under different current densities. Green dashed lines represent theoretical calculations.

[1] A. V. Chumak, et al, *Roadmap on spin-wave computing*, IEEE Trans. Magn. **58**, 0800172 (2022).

[2] M. S. Sarker, et al, *Current-controlled magnon propagation in Pt/Y₃Fe₅O₁₂ heterostructure*, Appl. Phys. Lett. **117**, 152403 (2020).

[3] Z. Wang, et al, *Control of spin waves in a thin film ferromagnetic insulator through interfacial spin scattering*, Phys. Rev. Lett. **107**, 146602 (2021).

[4] A. N. Kuznetsov, et al, *Optical control of spin waves in hybrid magnonic-plasmonic structures*, Sci. Adv. **11**, eads2420 (2025).

3rd Transnational Round Table on Magnonics, High-Frequency Spintronics, and Ultrafast Magnetism