Strain-Tunable Spin Wave Propagation in a CoFeB Waveguide on a Suspended Piezoelectric MEMS Bridge

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Advancements in tunable magnonic systems hold great promise for enhancing radio frequency (RF) signal processing. Spin-wave-based devices offer improved energy efficiency and miniaturization due to their shorter wavelengths compared to electromagnetic waves [1]. However, a major challenge is the need for an internal magnetic bias field to enable and modulate spin-wave propagation.

In this work, we present a fully integrated, self-standing magnonic phase shifter. A CoFeB waveguide is patterned onto a suspended piezoelectric micro electro-mechanical structure (MEMS) bridge, with RF transducers enabling all-electrical spin-wave excitation and detection. Applying a voltage to the MEMS actuator induces mechanical tension, generating stress in the CoFeB conduit, which, due to its magnetostrictive properties, alters spin-wave propagation. This results in a spin-wave band shift and phase variation, reaching values of respectively 960 MHz and 490° at V_{MEMS}=15 V, H_{ext}=50 mT.

Exploiting the intrinsic anisotropy of the CoFeB conduit, spin-wave propagation in the Damon–Eshbach configuration is achieved without an external magnetic field. Phase and frequency tunability are realized at H_{ext}=0 mT with voltages up to 8 V, reaching shifts of 170° and 1.3 GHz. Higher voltages suppress spin-wave propagation by exceeding the intrinsic anisotropy field. The MEMS actuator thus functions as a phase shifter up to 10 V and a switch beyond this threshold. The reversibility of strain-induced effects is confirmed by signal restoration upon voltage reduction.

These findings demonstrate the feasibility of strain-controlled magnonic devices, paving the way for the development of tunable RF attenuators and filters through the integration of magnonics and MEMS technology.

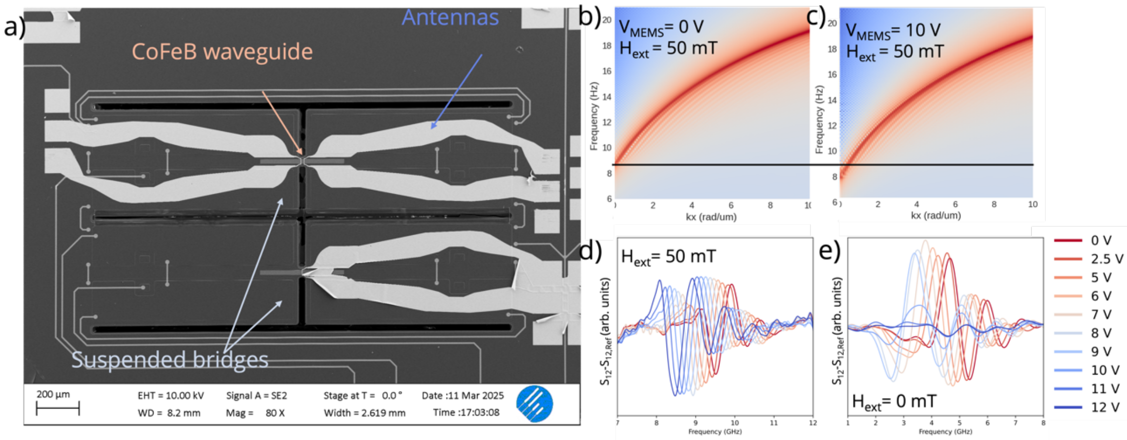

Figure 1. a) SEM image of the device; **b)** and **c)** simulation of the dispersion relation of the SW in the waveguide in the absence of MEMS actuation and under an applied voltage of 10 V; **d)** and **e)** transmitted spin wave signal measured with a VNA as a function of the applied voltage to the piezoelectric structure, under external magnetic fields of 50 mT and 0 mT, respectively.

References

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