Fully integrated and reconfigurable magnonic devices for "Beyond 6G"

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The advancement of integrated magnon technology for high-frequency signal processing [1] is facing significant challenges, such as the integration of low-power solutions for applying a bias field and the tuning of the local effective field controlling spin waves (SWs) propagation.

Here we report on a novel technology platform for magnonic devices which are: (i) self-standing (i.e. they do not require external bias fields by bulky magnets), (ii) fully integrated (i.e. compatible with usage as stand-alone devices inside consumer electronics), (iii) reconfigurable. The basic concept is exploiting permanent and soft micro-magnets mounted on movable parts of microelectromechanical systems (MEMS) to tune the bias field to a magnonic conduits placed in proximity, by changing the distance between the micromagnets and the conduit. In this way fundamental signal processing units (frequency filters, phase shifters and time delay lines) with tunable features can be implemented.

In the talk I'll report on the first example of stand-alone fully integrated magnonic device which does not need any external electromagnet to operate in the 2-10 GHz frequency range and can be integrated on a silicon chip. This proof-of-concept device features a CoFeB conduit flanked by NiFe flux concentrators and SmCo permanent micromagnets capable to apply a variable field (up to about 25 mT) in the central region of the conduit, depending on the distance between the flux concentrators and the permanent magnets. Inductive antennas are then used to implement the electric input and output of the RF signals (see figure 1). By combined VNA and BLS measurements we demonstrate that the device can be operated as a tunable phase shifter with a phase change of about 180 deg for a relative displacement of 10 μm of the flux concentrators and permanent micromagnets. Finally, I'll report on first hybrid MEMS-magnonic devices implementing on-chip reconfigurability of RF signal processing.

This work has been carried out in the framework of the EU M&MEMS project [3].

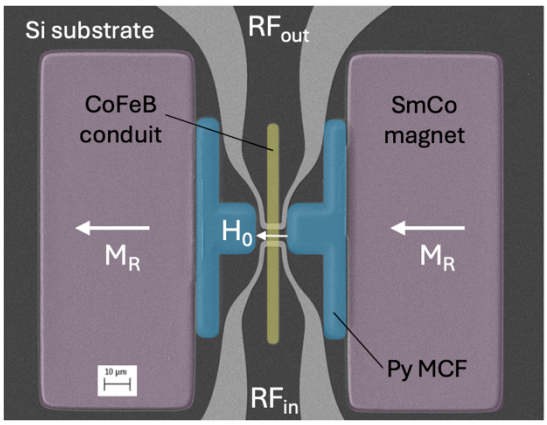

Figure 1: a) Concept of hybrid magnonic-MEMS devices; b) SEM image of a standalone magnonic device integrated on silicon with full electric-in electric-out RF signals.

[1] A. Barman et al., "The 2021 magnonic roadmap", 2021 J. Phys.: Condens. Matter 33, 413001.
[2] M. Cocconcelli et al., "Tuning magnonic devices with on-chip permanent micromagnets", https://arxiv.org/abs/2406.03206
[3] https://mandmems.eu/ (EU Project 101070536 — MandMEMS)