Electrically tunable magnon FET controlled by ionic polymer gate

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Spin waves (SWs) and their quanta magnons in the magnetic structures offer data transmission and data processing capability without Joule heating, unlike their electronic counterparts. One main challenge to use SW for data processing is to invent a robust and energy-efficient mechanism to control the SW externally. Some techniques based on light, current, strain, and heat to control the SW have been proposed. However, some of the methods are technically difficult, energetically inefficient, and not compatible with the planner fabrication technology. We focused on the external control of SW propagation in ferrimagnetic yttrium iron garnet (YIG) in this work. The microwave excitation and detection with two coplanar waveguides (CPW) antennas are used to characterize the SW.

Firstly, an additional platinum (Pt) stripe connected to a current source is integrated between the CPW pair to demonstrate the SW frequency and amplitude modulation by current induction (Fig.1(a)). We selected a Pt stripe due to its significantly lower spin-wave absorption property[1]. The application of a current through the Pt stripe generates local Joule heating that modifies the magnetic properties of the YIG film, which in turn modulates the SW frequency (Fig.1(b))[2]. Although the proposed technique is suitable for on-chip applications and has a better performance comparing its peers, it is still energetically unfavorable comparing to present CMOS technology. We are exploring electric field-controlled SW modulation, which is difficult due to the absence of direct coupling between *E*-field and spin. We have developed an ionic polymer and YIG heterostructure (Fig.1(c)). A positive and/or negative voltage was applied across the polymeric gate during the SW measurement. Fig.1(d) implies that applying a positive voltage across the polymer suppresses the SW propagation while the negative voltage enhances the SW propagation. So, it can act as a magnon switching upon the application of positive and negative voltage. Here we have controlled the damping of the YIG/Pt heterostructure by tuning the polymeric gate.

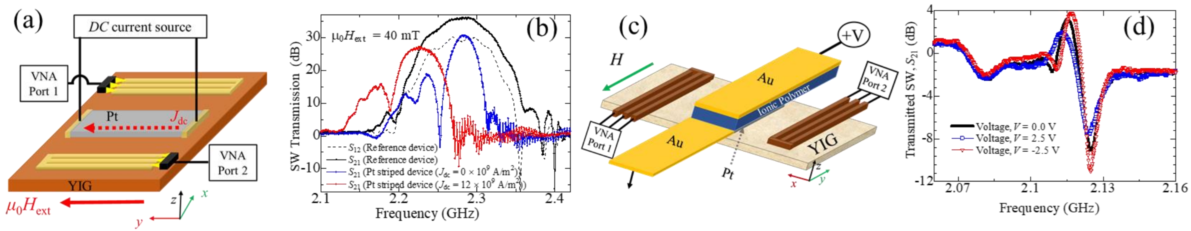

Figure 1. (a) Schematic diagram and (b) S_{21} spectra of current-controlled magnon device (c) Schematic diagram of the polymer-based magnon FET (d) S_{21} spectra under different E-field. Solid black line, red triangle and blue rectangle represents V = 0, -2.5 and +2.5 volts, respectively.

References.

[1] Sarker et al., AIP Adv 10, 015015 (2020). [2] Sarker et al., Appl. Phys. Lett. 117, 152403 (2020).