Electromagnetic Induction Readout Silicon-on-Insulator MEMS Resonant Magnetometer

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We report an electromagnetic induction readout MEMS resonant magnetometer. It benefits from a CMOS-compatible process and promises lower power consumption compared to devices based on Lorentz force action since no bias current is needed. This readout mechanism has been reported for a bulk-mode square-plate resonator[1]. Our device holds multiple benefits over the bulk-mode design including simpler fabrication process (3 vs 6 masks), lower drive voltage requirements (5V vs 50V), smaller foot print (700μm×600μm vs 2mm×2mm), and higher sensitivity due to the larger displacements afforded by designing with compliant flexural beams.

As shown in Fig. 1, our design here resembles a double-ended tuning fork, of which one end is left uncoupled. This forms a U-shaped open-loop, between which a current is induced due to the interaction of the magnetic field (B) applied normal to the plane of fabrication with the tines driven to vibrate in anti-phase. The top surface of the detection loop is covered with metal to lower the path resistance of the induced current. The tines are driven into the anti-phase resonance via comb drives on each vibrating tine. The induced current is combined differentially at the two ends of the detection loop and enlarged by a transimpedance amplifier. Fig. 2 shows the measured frequency response. We simplified the measurement setup to calibrate the sensitivity of the device by fixing the magnetic field using a permanent magnet while increasing the DC drive voltage (V_d). We then transformed this characteristic to plot output voltage (V_{out}) vs. B as shown in Fig. 3. The slope of the best fit line defines the sensitivity of the MEMS magnetometer (17.7mV/T).

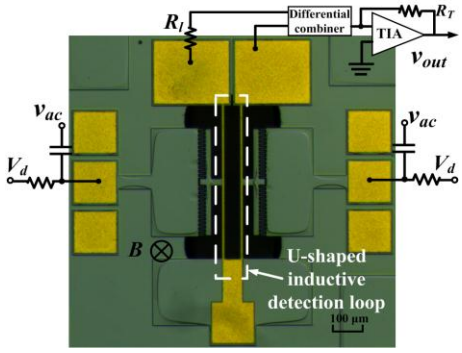

Fig. 1: Magnetometer with biasing setup

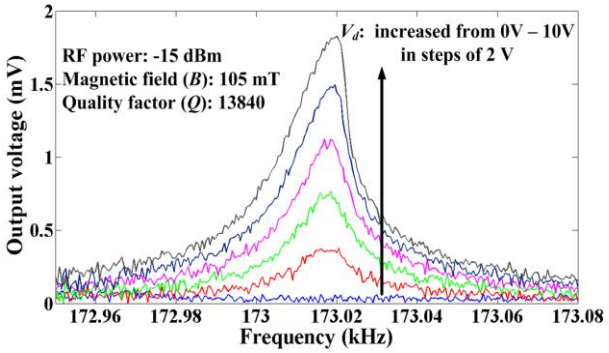

Fig. 2: Measured voltage frequency response of the magnetometer with increasing DC drive voltage.

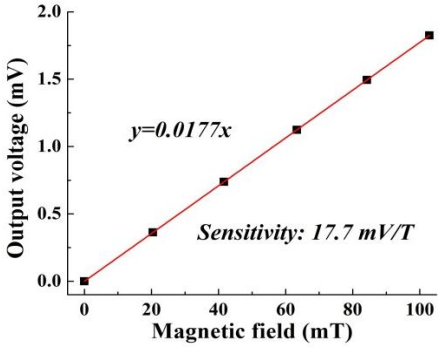

Fig. 3: Calibrated output voltage as a function of B field referenced to a DC drive voltage of 5V.

[1] G. Wu, *et al*. "Resonant magnetic field sensor with capacitive driving and electromagnetic induction sensing" , IEEE Electron Device Lett, vol. 34, p.:459-461, 2013.