

# Multi Layer MEMS Transformer and MEMS Filter

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Multi metal layer fabrication technology is crucial in future developments of RF-MEMS devices. This is due to high density requirement of the devices while keeping their Q-factor high [1,2]. In this paper, the use of surface micromachining techniques for fabricating multi metal layer RF MEMS devices is presented. Two types of these devices, namely micro-transformer and micro-filter are exemplified.

## I. MICRO-TRANSFORMER

MEMS transformer fabricated in IMEN-UKM is a square spirally interwinding planar coil, as depicted in Fig. 1. It consists of two coil structures stacked on top of each other and connected by vias. The metal used is aluminum ( $\rho_{sh}=26.5 \text{ m}\Omega/\text{sq}$ ), which is deposited by multi layer deposition technique using vacuum evaporation (Evaporated MML method). Fig. 2 shows the resistance characteristics of the device for various metal thicknesses, when excited up to 1 Mhz operating frequency. It is shown that the increase of metal thickness significantly affects the decrease of coil resistance. As shown in Fig. 3, the maximum gain is found at frequency range between 3 and 5 MHz for all metal thicknesses. It can also be seen that increasing metal thickness increases gain. The transformers work effectively at frequency range between 1 and 10 MHz due to the high capacitive effects of the stacked structured coil.

## II. MICRO-FILTER

MEMS bandpass filter fabricated in IMEN-UKM is a two-resonator system, which manipulates electrical coupling between two symmetrical clamped-clamped micromechanical resonators. The filter depicted in Fig. 4 has center frequency of 180 kHz, coupling capacitance of 17.7fF, bandwidth of 400 Hz, 20-dB shape-factor of 3.6, and insertion loss of 8-dB. Fig. 5 shows a close-up view of the multi-stacked aluminum layer of the resonator, which is fabricated using the same technique as the MEMS transformer presented above. Fig. 6 plots the transmission characteristics of the filter. It is observed that the Q-factor depends on the resonator's motional resistance, operating frequency, filter bandwidth, and tolerable passband ripple.

### Acknowledgment

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### References

- [1] C. P. Yue and S. S. Wong, "Physical modeling of spiral inductor on silicon," IEEE Trans. on Electronic Devices, vol. 47, Issue 3, 2000.
- [2] F. D. Bannon, III, J. R. Clark, and C. T. -C. Nguyen, "High frequency micromechanical filters," J. Solid-State Circuits, vol.35, no. 4, pp. 512-526, April 2000.

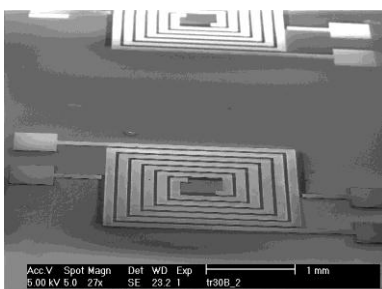


Figure 1. Multi-stacked MEMS transformer

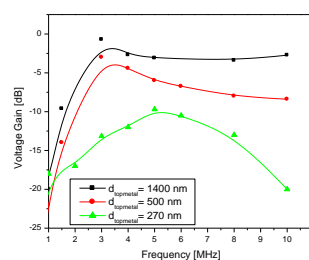


Figure 2. Output gain vs. frequency

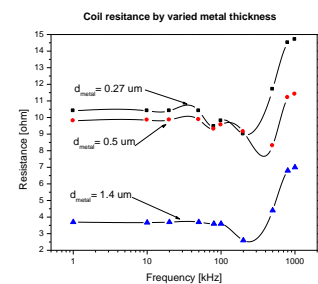


Figure 3. Resistance vs. frequency

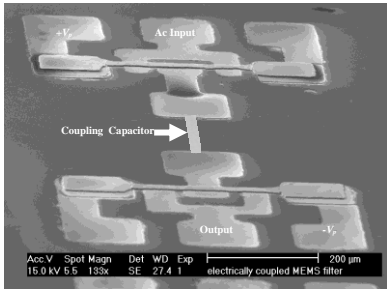


Figure 4. MEMS bandpass filter

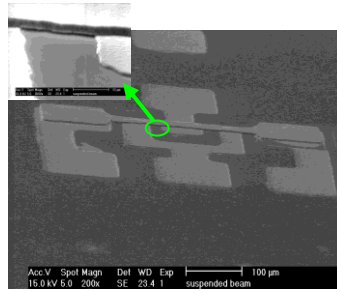


Figure 5. Close-up of the resonator's suspended beam structure

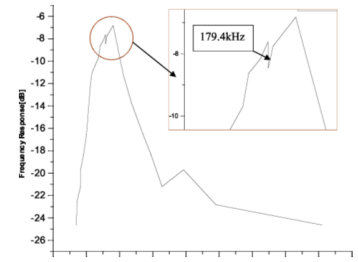


Figure 6. Frequency response (dB) vs. frequency (kHz)