High frequency fundamental quartz resonator using quartz on quartz wafer

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The rise of New Space has driven the demand for compact and high-performing components in nanosatellites. In 2017, Kubena et al.[1] demonstrated high performance resonators (Q.f=2.9×10^{12}Hz) with a complex collective process involving quartz on silicon wafer (3”) to obtain thin suspended plates. We present a simplified process using quartz on quartz wafer (4”) to achieve thin suspended plates allowing the collective fabrication of high efficiency resonators.

The use of fundamentals coupled with innovative design holds the potential for several improvements: a high Q.f product (**≈1.0×10^{13}Hz**), a greater compactness (**<10mm²**), a reduction of the motional resistance (**Rm≈50Ω**) which is linked to plate thickness, and a possible significant improvement in acceleration sensitivity (**<2ppt/g**). To achieve this performance, new manufacturing processes need to be developed, combining DRIE etching, a well-known, mastered process[2], with quartz-on-quartz wafers.

This work investigates the feasibility of the processing to fabricate a quartz-MEMS resonator using quartz on quartz wafer. In this process, the top quartz wafer is 15 µm thick, in order to obtain thin suspended plates, the bottom wafer (Z-cut quartz) is chemically etched. As the usual chrome-gold etching mask is ineffective on the top wafer, a protective layer is added. Once the gold-gold interface and protective layer have been removed, the standard process can start. In fig. 1, electrodes can be seen after deposition on the plate. A final DRIE step must be performed, in order to transform the plate into a self-suspending resonator.

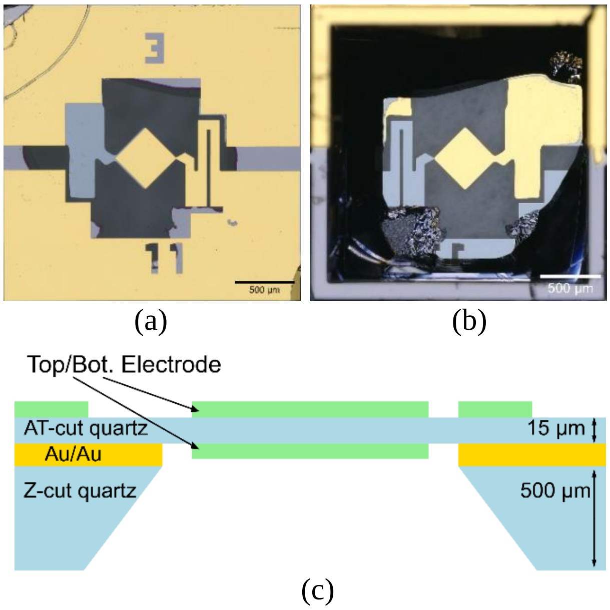

Fig. 1: (a) Topside electrode of the resonator. (b) Bottomside of the resonator. (c) Cross-sectional view of the resonator at the stage of sub-figures (a) and (b).

In conclusion, we demonstrated the validity of utilizing a quartz-on-quartz wafer and a simple collective process to realized thin suspended plates. Several hundreds of resonators can be manufacture on 4’’ wafer. Characterizations is going on to validate both the design and the manufacturing process and will be presented to validate this approach.

[1] R. L. Kubena et al., "A Fully Integrated Quartz MEMS VHF TCXO”, Joint Conference EFTF/IFCS, pp. 68-71, 2017

[2] P. Chapellier, P. Lavenus, R. Levy and O. L. Traon, "10 MHz Length-Extension Mode Quartz MEMS Resonator for Frequency and Time Applications," IEEE EFTF/IFCS, 2021