$LiTaO_3$/Silicon composite wafers for the fabrication of low loss low TCF high coupling resonators for filter applications

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SAW devices are widely used for radio-frequency (RF) telecommunication filtering and the number of SAW filters, resonators or duplexers is still increasing in RF stage of cellular phones. Therefore, a strong effort is still dedicated to reduce as much as possible their sensitivity to environmental parameter and more specifically to temperature. Several contributions have been developed for proposing composite wafers combining several materials to compensate the natural thermal drift of pseudo surface acoustic waves (PSAW) on lithium tantalate. For all the proposed technologies, solidly bounding heterogeneous materials is a quite complicated issue as thermal budget must be limited to avoid irreversible damage of the wafers.

Bounding processes have been developed at FEMTO-ST and CEA-LETI using either Au/Au or direct bonding techniques for the fabrication of composite wafers combining materials with very different thermoelastic properties, yielding innovative solutions for about-zero temperature coefficient of frequency (TCF) bulk acoustic wave devices. In the present work, this approach has been applied to (YX*l*)/42° lithium tantalate plates, bounded onto (100) silicon wafers and thinned down to 25 µm. The leading idea already explored by other groups as mentioned in introduction consists in impeding the thermal expansion of the piezoelectric material using silicon limited expansion. 2 GHz resonators have been built on such plates and tested electrically and thermally, first by tip probing. Although wave parameters was found only half the expected ones (coupling factor of about 4%) partly due to unoptimized electrode height, a dramatic reduction of the TCF is observed for all the tested devices, allowing to reduce the thermal drift of the resonators down to a few ppm.K^{-1} within the standard temperature range. This result has been confirmed using packaged devices in 3×3 mm² ceramic packages, yielding similar results and even temperature compensation for some of the tested resonators. We also propose an analysis of the frequency-temperature behavior of the device to improve the resonator design to use these wafers for industrial applications.

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