Innovative acoustic components based on POI wafers

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Piezoelectric-on-Insulator (POI) wafers combining single piezoelectric crystal and Silicon have received an increasing interest since the last decade. These innovative substrates are enabling the excitation of all types of waves depending on the selection of piezoelectric crystal orientation and a proper choice of substrate nature and cut. The adaptation of the Smart-Cut™ process for generating sub-micron-thick single crystal oriented layers bounded on various substrate has been successfully achieved, yielding the possibility for an industrial exploitation of the concept.

Up to date, most of the developed applications based on this type of substrates take advantage of pure shear waves exhibiting unprecedented properties, particularly considering the electromechanical coupling, wave attenuation and reflection coefficients on a single electrode. Provided as 150-mm-diameter wafers, they allow for the industrial production of SAW filters addressing the 5G telecommunication challenges.

Many demonstrations have been achieved on the whole UHF spectrum, spreading from 300 MHz to 3 GHz typically and on the S-band (2-4 GHz). The capability of the base material to provide designers repeatable and temperature stable mode characteristics is exploited for filters with bandwidths ranging from 1 to 7% using classical filter architectures and temperature coefficient of frequency (TCF) smaller the 15 ppm.K^{-1}, thus addressing most of the 5G filter demand. However, the wave guide capabilities of POI make these substrate particularly suited to also propose innovative transducer and filter structures.

In the proposed paper, we show how POI-based devices allows for addressing modern telecommunication filter demand. We particularly focus on $LiTaO_3$-Si(111) based POI including a Buried Oxide (BOx) and a Trap-Rich layer. Two piezoelectric crystal orientations have been particularly tested, i.e. $LiTaO_3$ (YXl)/42° and (YXl)/50°. The first one is generally selected to benefit from coupling factor up to 10% or even more whereas the second one are preferred to promote quality factors with anti-resonance Q ranging from 2000 to 3000 and Bode Q in excess of 5000 for the considered spectrum.

The paper shows how the mode characteristics are determined, based on synchronous resonator characterization operating from 500 MHz to 3.4 GHz. De-embedded experimental Figures of Merit are used to derive the mode characteristics at these frequencies. Across these characteristics, we demonstrate the capability of POI to provide effective solutions for addressing filters with relative bandwidths ranging from 1.3 to 5.6%. Some examples of innovative filter structures are presented to exemplify the interest of POI as wave guide, particularly allowing for building filters at various frequencies on a given wafer.

Future developments for pushing the SAW performances further in this spectral range are discussed as a conclusion.