High Frequency-Low Loss SAW Resonators Built on Nano-Crystalline Diamond-Based Substrate

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The interest of surface acoustic wave devices (SAW) operating in radio-frequency range is their very high compactness, low losses and high quality factor. Thus, they are very interesting components for the stabilization of ultra-low noise on-board oscillators operating in direct bands. The need for working frequency beyond 3 GHz has lead SAW manufacturers to develop multilayer diamond-based waveguides providing higher phase velocity than conventional single-crystal materials, typically ranging from 7 to 12 $km.s^{-1}$ for elliptically polarized waves. The very problem in this approach is the excitation and detection of acoustic waves requiring a high quality piezoelectric layer of less than one micrometer thick with physical properties as close as possible to the tabulated ones. An ultimate control of the film thickness and roughness is required to control dispersion and diffusion losses.

In this work, we investigated a structure based on Nano-Crystalline Diamond (NCD). The waves are launched and detected using a Zinc Oxide film deposited atop the diamond layer, yielding notable dispersive properties of the device. In this way, technological developments have been achieved (NCD growth, piezoelectric layer deposition, e-beam and optical lithography) to build SAW devices taking advantage of NCD films to try and benefit from their suspected low acoustic damping. Results show the possibility of developing devices operating between 2 and 3 GHz at minimum, having losses lower than 10 dB. At last, devices whose dimensions are compatible with conventional lithography processes, show resonances at more than 4 GHz with less than 8 dB of insertion loss, what is, at the knowledge of the authors, the best experimental result for such devices. To compare with previous results, a device operating near 3 GHz has been used to stabilize an oscillator. Short term stability has been measured at 10^{-8} s^{-1} and a phase noise floor was observed at -170 dB at 3 MHz from the carrier. Although not yet meeting the expected requirements, these results show the impact of loss reduction and general device improvement and allow for preparing future work near 5 GHz.