SAW devices on GaN/Si operating in the GHz frequency range

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ABSTRACT

Most SAW devices currently working, are manufactured on quartz, lithium tantalite or lithium niobate substrates. On these materials it is hard to increase the operating frequency of SAW devices beyond 2 GHz. Many applications are demanding SAW based filters at higher frequencies than the classical technologies can offer. The cellular phone is evolving from the third generation (3G) to the fourth generation (4G) system with an expected frequency within the 3-6 GHz range. For other applications like wireless local area networks (WLAN), for high speed computer interconnections, there are envisaged filter structures operating around 5 GHz. The increase of the operating frequency for SAW based sensors is also important, because their sensitivity is proportional with the square of the resonance frequency.

The progress in manufacturing of high quality piezoelectric semiconductor layers like AlN and GaN, on sapphire, diamond and more recently on high resistivity silicon, creates the possibility to manufacture SAW devices on these materials. The compatibility with conventional semiconductor technologies, as well as MEMS processes and nanolithography was ensured. Compared with sputtered AlN, crystalline GaN offers the major advantage of monolithic integration with other passive and active circuit elements like HEMT transistors. Also the radiation hardness and high temperature tolerance of GaN make this material appropriate to operate even in harsh environments.

We will present the manufacturing of SAW structures on commercially obtained GaN/Silicon wafers having a thickness of the GaN layer of about 1 μm and a 0.2 μm buffer layer between the silicon substrate and the GaN layer. The SAW test structures consist in two face to face interdigitated transducers (IDTs), placed at different distances. Using a TiAu metallization, 80 nm thick and advanced e-beam lithographical techniques, IDTs with fingers and spacing in the range 150…300nm, have been obtained on the GaN layer. On wafer measurements of the S parameters have demonstrated the operation above 5 GHz. The frequency response of the devices is analyzed.

There will be also presented some FBAR structures manufactured on GaN/Si, using very thin and reliable membranes obtained by micromachining techniques, The FBAR structures have resonance in the 4-6 GHz frequency range.

The SAW as well as the FBAR GaN/Si based structures, working in the GHz frequency rang, can also be used in sensing applications, with the advantage of an increased sensitivity.