Expands the Use-Efficiency and Accessibility of Frequency Spectrum Resources through Very-Large-Scale-Integration of Multi-Frequency and Multi-Band Filter Arrays Covering UHF and SHF

This bulk acoustic resonator incorporates nanofabrication techniques to realize extreme frequency scaling of integrated filters to super-high frequency (SHF) and extremely-high frequency (EHF) spectrums while enabling very large-scale integration (VLSI) of multi-band filters on a single chip. In order for a two-way communication device to handle an incoming signal, an internal structure, such as an acoustic filter or duplexer, must select and pass the signal content through electrical and mechanical resonance at certain frequencies, then suppress destructive interference at other frequencies. For instance, mobile phones consist of several small scaled filters that perform frequency selection within a range of radio wave frequencies, allowing users to connect to a wireless network. The incoming radio wave frequencies reside in the ultra-high frequency (UHF), SHF or EHF spectrum. However, available bulk acoustic resonators, such as the film bulk acoustic resonator (FBAR) or the solidly mounted resonator (SMR), operate using piezoelectric thin films and are ineffective beyond a certain frequency in this spectrum. Therefore, FBAR and SMR are not capable of co-integration of multi-frequency and multi-band filters on a single chip.

Researchers at the University of Florida have developed an insulator-based -3D acoustic resonator that surpasses the limitations with pure piezoelectric thin-film counterparts, FBAR and SMR. This device allows manufacturers to lithographically vary fins' sizes in order to operate at specific frequency ranges, enabling more efficient spectrum analysis to accommodate the increasing demand for reliable wireless connections. Since these fins vary in dimension, an array of devices with different frequencies over UHF, SHF, and EHF spectrum can be co-integrated on a single, small chip.
Application

Fin bulk acoustic resonator that processes UHF, SHF, and EHF signal frequencies in wireless communication systems through an integrated array of filters and duplexers.

Advantages

- Enables very large-scale integration (VLSI), permitting multi-frequency and multi-band filters on a single chip.
- Enhances power-handling and linearity by increasing device volume through the third-dimension (substrate depth), eliminating consumption of planar chip area.
- Relies on a single deposition of piezoelectric film on semiconductor/insulator fins with different lateral dimensions, allowing for a simple nanofabrication process for co-integration of multi-frequency and multi-band filters.
- Integrates with solid-state electronics or photonics components, reducing the form factor of the radiofrequency front-end module.
- Prevents communication interference among intelligence and military, increasing reliability when transferring classified information.
- Enables frequency scaling of integrated acoustic filters to SHF and EHF regimes, making it possible to reduce the size of usable devices.

Technology

This bulk acoustic resonator processes incoming signal resonances to filter different frequencies of radio waves. The internal structure of the device consists of nano-scaled insulator fins that vibrate in correspondence to an incoming wave. The fins are formed in the substrate with various lateral dimensions and covered on their peripheral faces with piezoelectric thin film. This configuration enables extreme frequency scaling of the resonator to SHF and EHF spectrum while sustaining required performance metrics, including insertion-loss, electromechanical coupling and power handling. Manufacturers can compile different sizes of these fins onto a small-scale semiconductor chip, forming an array of fins that interact with each vibration.

Inventors

Roozbeh Tabrizian, Ph.D., is an assistant professor in the Department of Electrical and Computer Engineering at the University of Florida. Dr. Tabrizian has a bachelor’s degree in electrical engineering from the Sharif Institute of Technology and a Ph.D. in electrical and computer engineering from the Georgia Institute of Technology. His research activities include theoretical and experimental investigation of phononic devices, resonant micro- and nano-systems, and mixed-domain physical sensors. Dr. Tabrizian earned the NSF CAREER award in 2018.

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