Research focuses on implementing radio frequency MEMS resonators on a silicon chip

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Semiconductor Research Corporation and Cornell University researchers are working to advance on-chip silicon development to enable new generations of smaller and more sophisticated mobile electronic devices.

The research introduces a novel micromechanical resonator design that simultaneously achieves low loss and high quality factor at RF frequencies. The combination of the new resonators with surrounding circuitry will one day allow the realization of on-chip channel-select filters and oscillators, two system components that have traditionally proven difficult to integrate on-chip.

The design highlighted in this research is a single-crystal silicon micromechanical resonator acoustically coupled to junction field effect transistor (JFET) built on a SOI substrate. The high quality factor and low loss can be attributed to the use of single-crystal silicon and an efficient high frequency transduction technique, also developed at Cornell, which circumvents the need for a separate transducer material. This transduction method also results in significantly improved temperature stability for silicon resonators, one of the main challenges to using such devices as frequency references for communication systems. The use of a JFET as the amplifying element will prove beneficial for use in low phase noise oscillators due to its low flicker noise.

While Moore's Law has enabled exponential increases in the number of transistors and functionality on a single chip with every technology generation, there are still a few critical functions that cannot be realized by using transistors alone. Narrowband RF filtering and the generation of stable clocks are important examples.

“Currently, such functions are implemented using off-chip quartz or acoustic-wave devices, and they limit the system size,” said Sunil Bhave, professor of Electrical and Computer Engineering at Cornell, who led the research team. “The most straightforward and feasible solution to this problem is to implement these functions using integrated silicon devices, which would allow us to make use of conventional semiconductor fabrication methods to reduce the size with minimal tradeoff in performance.”

This research builds upon previous developments in resonant transistors (at Cornell, MIT, EPFL and CNRS) to demonstrate a transconductance-to-bias current ratio – a meaningful efficiency metric – greater than 1 $Volt^{-1}$, which is important for low-power RF design.

“Companies designing RF solutions in CMOS-related technologies could certainly benefit from this research, but this work is ultimately about driving the development of next-generation revolutionary mobile technologies that significantly contribute to the day-to-day lives of consumers,” said Kwok Ng, Senior Director of Device Sciences at SRC. “Successful research in this area can also lead to the development of a RF frequency source fully integrated into a foundry CMOS process along with other surrounding circuitry.”

More information about the research is published in the paper titled, “Platform for JFET-based Sensing of RF MEMS Resonators in CMOS Technology,” presented today at IEEE’s 2011 International Electron Devices Meeting in Washington D.C. The paper is co-authored by Eugene Hwang, Andrew Driscoll and Sunil Bhave of Cornell.

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