Research Highlights

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New GaN MEMS Resonator Is Temperature-Stable up to 600 K

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A team at MANA has demonstrated a highly temperature-stable GaN resonator that boasts high-frequency stability, high Q factor and the potential for large-scale integration with silicon technology.

The finding could result in faster 5G electronics devices thanks to better integration of GaN-based micro-electromechanical and nano-electromechanical systems (MEMS/NEMS) with the current semiconductor technology.

The GaN resonator was fabricated on a silicon substrate, and had a low temperature coefficient of frequency (TCF) of several ppm/K (parts per million per degree Kelvin) and high quality (Q) factors without degradation up to 600 K.

The millimeter-wave 5G system that is driving the much-anticipated “internet of things” requires increasing modulation complexity to improve data bandwidth. But conventional quartz oscillators are limited by their inability to integrate well with semiconductor electronics. Using MEMS/NEMS for reference oscillators is one way to achieve high resonance frequencies with less phase noise and high temperature stability.

Silicon-based MEMS resonators usually have a large negative TCF of around -30 ppm/K. Temperature compensation techniques, including geometry modification, impurity doping and multilayer structures, have been proposed to improve the TCF, but these degraded the system's Q factors.

The MANA team used elastic strain engineering, a technique to modulate the strain at the heterojunction of the resonator structure, which helped to store energy and thereby increase Q factors.

In contrast to conventional flexural modes, the internal thermal stress at high temperatures improved the TCF of the GaN MEMS resonator by over 10 times, without losing the high Q factor.

Group III nitrides have been excellent wide bandgap semiconductors for high-frequency electronics in the 5G era. The integration of such MEMS with electronics is therefore promising for IoT sensors and communications devices.

This research was carried out by Liwen Sang (MANA Independent Scientist, WPI- MANA, NIMS) and her collaborators.

Reference

“Self-Temperature-Compensated GaN MEMS Resonators through Strain Engineering up to 600 K”
Liwen Sang, Huanying Sun, Xuelin Yang, Tie-Fu Li, Bo Shen, and Meiyong Liao.
Journal: 2020 IEEE International Electron Devices Meeting (IEDM). (2020)
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