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SiGe circuits may pass muster for moon missions

By David Lammers

Austin, Texas — IBM Corp. and the Georgia Institute of Technology are testing the performance of silicon germanium transistors at temperatures near absolute zero. The work could aid efforts to create systems capable of operating in lunar temperature extremes.

The team, based at the university's cryogenics center in Atlanta, announced last week that an IBM SiGe bipolar transistor ran at frequencies above 500 GHz at 4.5 Kelvin. The transistor operates at about 350 GHz at room temperatures.

Georgia Tech professor John Cressler said he was scheduled to meet this week with NASA engineers to discuss the use of SiGe BiCMOS circuits on the moon, as well as for Martian exploration and interplanetary space probes. Lunar temperatures range from 120°C in the sunshine to as low as –230°C (43 K) in the deep-shadowed craters at the moon's poles.

"Deep cryogenic temperatures scare almost any circuit designer to death," Cressler said. For the Apollo missions and lunar rovers, NASA was forced to enclose electronics in "a big oven to keep the systems shielded," he said.

NASA hopes radiation-hardened SiGe electronics will enable robotics systems with distributed architectures that could network at lunar ambient temperatures, with higher reliability and reduced launch weight. Cressler's Georgia Tech group also is working on SiGe circuits for phased-array radar, mainly for terrestrial defense. Automotive radar for intelligent highways and collision-avoidance systems uses bipolar SiGe.

"I can imagine space-based radar systems that would benefit from these

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NASA eyes SiGe

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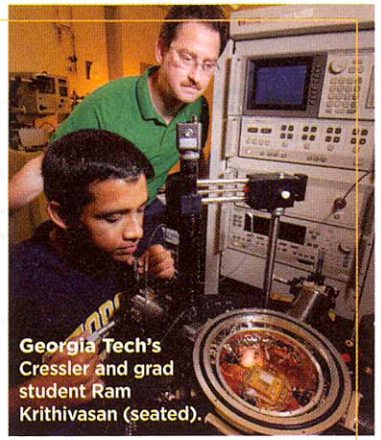
lower temperatures," Cressler said.

David Ahlgren, a senior engineering manager at IBM's silicon germanium technology development group, said the experiments show a path to higher frequencies for SiGe, opening new applications. Developed in the mid-1980s for mainframe processors, SiGe has moved to communications apps, including multiplexers for optical networking, RF and millimeter-wave circuits, and analog devices.

IBM's current-generation SiGe BiCMOS process, now in early production in Burlington, Vt., has a maximum operating frequency of 210 GHz for the heterojunction bipolar transistor. One opportunity for the technology is ultra-wideband ICs operating at 60 GHz.

The next-generation technology, which the Georgia Tech team used, will move to maximum frequencies above 300 GHz. At those speeds, adaptive cruise control and crash-mitigation systems become feasible at lower costs than for gallium arsenide and other III-V compound semiconductors, Ahlgren said.



Georgia Tech's Cressler and grad student Ram Krithivasan (seated).

Silicon CMOS semiconductors often fail at near-zero conditions because the dopants fail to ionize, said University of Florida professor Rob Fox, who studied CMOS operation at 77 K, using liquid nitrogen, for his doctoral thesis. With SIGe, the IBM-Georgia Tech experiment shows, performance improves for bipolar transistors at near-zero, liquid-helium temperatures.