Georgia Tech Developing Rad-Hard Chip for U.S. Government

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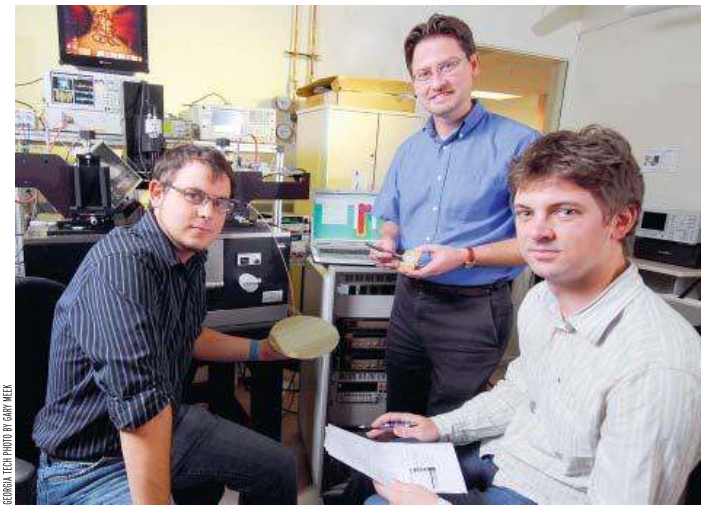
Georgia Institute of Technology (Georgia Tech) researchers are developing a new type of microprocessor designed not only to function in extreme temperatures but also to withstand the damaging effects of cosmic radiation. This effort, which is being funded by NASA and the U.S. Defense Department, has important implications for space exploration because it offers the promise of technology that can be deployed on the Moon or Mars without the added expense and weight of radiation shields.

"It would be a big win for NASA to have an electronics technology platform that they could put on the surface of the Moon or Mars without having to worry about shielding and protecting it," said John Cressler, professor in the School of Electrical and Computer Engineering at Georgia Tech in Atlanta.

Another important goal is keeping costs under control. For more than a decade commercial semiconductor manufacturers have added the metal alloy germanium to silicon chips to improve the performance of integrated circuits. An added advantage is that the silicon-germanium chips are better able to resist the damaging effects of ionizing radiation than their silicon-only counterparts.

Ionizing radiation, however, is only one of the principle types of cosmic radiation that can wreak havoc with integrated circuits. In addition, electronic equipment deployed in space is exposed to high-energy charge particles known as galactic cosmic rays.

"We have been asking whether we can find a way to mitigate the effects of galactic cosmic rays without changing the technology itself because there is a huge cost advantage for the industry if you can use a commercial, terrestrial technology and fly that into space," Cressler said.



GEORGIA TECH PHOTO BY GARY MEEK

Stan Phillips and Kurt Moen (seated left to right), doctoral students in Georgia Tech's School of Electrical and Computer Engineering, work with Professor John Cressler (standing) to study the use of silicon-germanium integrated circuits for applications in space.

Cressler is the principal investigator on a four-year, $12 million NASA program to develop silicon-germanium devices for use in lunar exploration efforts. That program, which is in its final year, is nearing its goal, Cressler said.

The Georgia Tech team's efforts to develop microelectronic devices that can withstand extreme temperatures and radiation have imporant ramifications for space exploration. "Temperature and radiation are the two parameters that spacecraft engineers struggle with," said Mohammad Mojarradi, Advanced Instrument Electronics Group supervisor at NASA's Jet Propulsion Laboratory in Pasadena, Calif. The thermal protection boxes and radiation shields currently used to protect electronic components add mass to spacecraft. If those protective layers were no longer needed, engineers could use the weight savings to add scientific instruments to a mission or to reduce a spacecraft's overall size, weight and cost, Mojarradi added.

The first challenge that faced the Georgia Tech team was learning exactly how galactic cosmic rays harm silicon germanium devices and using that knowledge to develop accurate computer programs to assist scientists in designing new devices. To gain that understanding, Cressler's team used an ion beam located at the U.S. Department of Energy's Sandia National Laboratory in Albuquerque, N.M., to fire heavy particles at microchips. They also relied on sophisticated sensors capable of measuring the results of the collision.

"That is a very challenging measurement because it happens in billionths of a second," Cressler said. Nevertheless, Georgia Tech researchers believe they have been successful in making those measurements as well as in using that information to create accurate computer simulations of the process, he added.

With the knowledge obtained, Georgia Tech engineers have developed new devices designed to withstand galactic cosmic radiation. "We have demonstrated several new ideas which we are very excited about," Cressler said. "We are not 100 percent there yet."

Nevertheless, the team has designed new circuits, which involve modifications at the transistor level and at the circuit level, and is currently fabricating them. Once the new devices are produced "we will pack them up and go to a radiation beam facility and test out the idea," Cressler said. "Within the next six to nine months we hope to have some definitive answers." The answers will be of interest not only to NASA but also U.S. defense agencies and aerospace firms. The Georgia Tech team has received funding to investigate the use of silicon-germanium technologies in order to create devices capable of operating under extreme temperature and radiation by the Defense Threat Reduction Agency, the Defense Advanced Research Projects Agency, the Jet Propulsion Laboratory and the National Security Council.

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Report: Commercial Spaceflight Investment on the Rise

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U.S. firms seeking to open space to private citizens saw a modest 6 percent growth in 2008 with over a quarter of a billion dollars in total collective revenue last year, though investment in the emerging personal spaceflight industry rose more than 20 percent since January 2008, according to highlights of an annual report commissioned by the Commercial Spaceflight Federation.

Carissa Christensen, co-founder and managing partner of the Alexandria, Va.-based Tauri Group, a market research firm that prepared the report, said the findings were based on interviews with 22 U.S. commercial spaceflight companies, including most members firms of the Commercial Spaceflight Federation.

Commercial Spaceflight Federation President Brett Alexander said the report shows a dramatic change in the industry over the past several years.

"This survey reveals modest, but increasing, revenues from commercial spaceflight activities, including growing deposits and contracts for government development activities," he said Oct. 6. "But the real highlight is the sizable investment that is not government related. Growing investment from private equity funds and other investors has turned longtime skeptics into people who are taking notice." According to the report, U.S. commercial spaceflight was a $261 million industry in 2008. More than three-quarters of that revenue — or about $211 million — came from "hardware sales, development and support services." Within this category, $126 million was generated through services to mostly government clients that were leveraged for use in commercial spaceflight vehicles; some 19 percent, or $39 million, came in the form of second-tier revenue directly supporting spaceflight, such as vehicle development and training; and another 21 percent, or $45 million in revenues, came from mostly government work leveraged to develop organizational capacity, the study found.

In addition to indirect revenues, personal spaceflight services generated $50 million in direct revenue and deposits, an increase of more than 25 percent over the previous year, the study found. This category includes Russian Soyuz flights booked through Space Adventures of Vienna, Va., and deposits taken by New Mexico-based Virgin Galactic and others for suborbital flights.

Christensen noted that in previous years, the study included indirect revenue derived from non-spaceflight activities that member companies engaged in to make ends meet. In 2006 and 2007, that figure hovered around $24 million. In 2008, it exceeded $1 billion, an increase Christensen attributes to a compositional shift in the evolving spaceflight industry.

"The past couple years have been interesting because when you listed all the companies doing commercial spaceflight … they had almost no other revenue," she said. "Now that number has exploded because new firms have come into the market. Some of the companies that are acting as vendors or providing services like training or engineering are very big companies."

For example, this year's report saw the addition of El Segundo, Calif.-based Wyle Laboratories and Sparks, Nev.-based Sierra Nevada Corp., two diversified contractors with around $1 billion or more in revenue.

Christensen noted that the federation's member companies secured $1.2 billion in total investment commitments through the end of 2007, with about one-fourth of that money received and spent. To date, cumulative investment has grown to $1.46 billion, a 20 percent increase over the period ending in December 2007, with almost half of the investment funds already spent and some $830 million available, Christensen said.

"This, to my mind, is what sets this industry, at this stage, apart from previous waves of entrepreneurial vehicle development," Christensen said. "The fact that there is about a billion and a half dollars from credible sources committed to this industry is very meaningful."

Individuals and angel investors are the biggest source of industry capital, providing more than 50 percent of investment to date, the study found. Private equity follows close behind at 30 percent, while government backers comprise 15 percent of commercial funding sources. Christensen noted that 4 percent of capital came from industry reinvestment, up from a little over 1 percent a year ago.

Christensen said the U.S. commercial spaceflight industry employed 1,186 workers in 2008.

Christensen noted the report focused only on companies seeking to develop or support commercial human spaceflight activities. For this reason, the Tauri Group did not include revenue or data from Dulles, Va.-based Orbital Sciences Corp. because the company focused primarily on NASA cargo delivery services to the international space station in 2008.

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