

TERRESTRIAL SOLUTIONS, EXTRATERRESTRIAL UTILITY

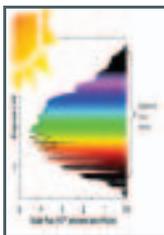


Bill Schaff with a new MBE machine

With the summer 2003 launch of the two Mars Rovers packed with scientific instruments developed at Cornell, the university's contribution to extraterrestrial activities has received a great deal of attention. However, while the locus of space sciences on campus may be the Space Sciences Building, it is not the only place at Cornell where

technologies of importance in space are being developed. Two of these technologies have recently come from the fourth floor of Phillips Hall, a hotbed of innovation on campus, where electrical engineers are developing solutions to terrestrial problems that have extraterrestrial utility.

William J. Schaff is a Senior Research Associate, Electrical and Computer Engineering, doing research in MBE (molecular beam epitaxy) growth and characterization of III-V compound semiconductors for microwave electronic and photonic devices, is collaborating with Wladek Walukiewicz at the Lawrence Berkeley National Laboratory (LBNL) to develop an InGaN (indium gallium nitride) solar cell with theoretical efficiencies twice that of the current best solar cell. Although many technical issues remain to be solved before the new solar cell can actually be built, Schaff and the other researchers involved are confident of success.



InGaN multi-layer solar cell able to capture almost all of the energy available in sunshine

Through a quirk of nature, a number of semiconductor materials are able to convert photons (i.e., light) into electrons (i.e., electricity). Single material solar cells have been built for years, but their efficiency is low (efficiency is how much of the available solar energy striking a solar cell is converted into usable electricity). This is because a semiconductor most efficiently converts

light into electricity when the light's energy matches the semiconductor's energy level, known as its "bandgap." Multijunction solar cells (those with multiple layers) are able to capture more of the light's energy and, as a result, are of higher efficiency than single-layer solar cells.

The most efficient existing solar cells contain three layers of different materials (Ge, GaAs and GaInP). It is difficult to combine these three materials into a single device. The new Cornell-LBNL solar cell has the advantage that it will be constructed using a single family of materials. Each layer will contain different proportions of indium and gallium, varying progressively from InN at the bottom (no gallium) to GaN at the top (no indium). Because all of the layers will be made from the same family of materials, it should be possible to have many more than three layers, allowing the theoretical achievement of efficiencies better than 70 percent.

The new solar cell will be extremely well suited for use in space. Materials in the GaN family are extremely tough; resistant to heat and cosmic rays, they are ideal for solar cells for satellites and spacecraft. To slow their deterioration under the harsh conditions of space, current solar cells must be coated with special materials; these are coatings that also reduce their efficiency. The cost to send anything into space is related to its weight and volume; higher efficiency in a solar cell means the same power with less volume and lower weight. As newer generations of satellites demand more electricity to power their many components, these new solar cells will be able to deliver that power without drastic increases in the size of the solar power source. Applications are not limited to space. The toughness of the new solar cells means that they will also be useful in so-called concentrators, which use mirrors to focus light from a large area onto a solar cell.

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Kevin Kornegay

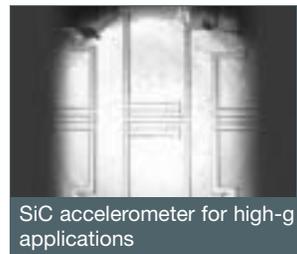
Next door to Schaff, Kevin T. Kornegay, Electrical and Computer Engineering, is also doing research in areas of relevance to space. When he is not leading Cornell University's Autonomous Underwater Vehicle team to victory, as he did in the summer of 2003, Professor Kornegay directs the Advanced Integrated Microsystems Research Group

(AIMS) and the Cornell Broadband Communications Research Laboratory. One project of the AIMS group is the development of microelectromechanical systems (MEMS) for harsh environments. There are very few environments harsher than space, except perhaps, the environment inside of the engines of the machines that take us there.

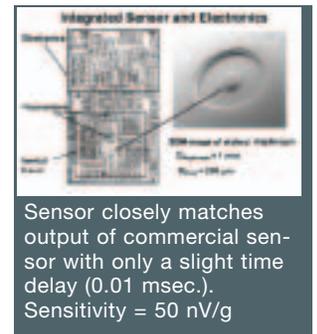
In order to make a sensor as robust as possible, the research group chose to build their MEMS sensor on SiC (silicon carbide) instead of silicon. Extremely tough, able to withstand harsh environments and high temperatures, an excellent conductor of heat, and similar in electrical properties to silicon, SiC is an ideal material on which to build a sensor for harsh environments. However, the same properties that make SiC so tough also make it very difficult to process. Thus, despite the tremendous promise of such SiC sensors, when the AIMS group started their work, there was no way to incorporate both the sensor's MEMS structures and its logic circuits onto a single chip. Kornegay's group set out to find a way to do so, and they succeeded.

The group developed a process for making an integrated SiC sensor and electronics, and under a gift from the Goodrich Corporation, successfully built the first device—a pressure sensor with an integrated amplifier. The technology is very flexible and will enable building any MEMS sensor in SiC that can already be built in silicon. Robust SiC MEMS sensors will be useful in a broad variety of applications, including aerospace where pressure and other sensors are needed to monitor the performance of rocket and jet engines. Other applications include the high-g accelerometers for supersonic ballistic munitions, environmental monitoring of hazardous chemicals, high-voltage electric power generation, and any other industry in which a sensor must operate in the presence of high temperatures, destructive radiation, or caustic chemicals.

There is a great deal of commercial interest in this new technology. Cornell Research Foundation is currently negotiating with several companies interested in a license to the patents pending on these new technologies.



SiC accelerometer for high-g applications



Sensor closely matches output of commercial sensor with only a slight time delay (0.01 msec.). Sensitivity = 50 nV/g

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