GEORGIA TECH RESEARCH

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For Immediate Release

August 8, 1989

Color & B/W Available

7692 or 2908 or 2940

THE POWER OF LIGHT: CHEMICAL PROCESS SHOWS PROMISE FOR MAKING LOW-COST SOLAR CELL MATERIALS

Georgia Tech researchers have reported promising results using a chemical process that may offer greater control for fabricating low-cost solar cell materials. If perfected, the technique could help lower the cost of generating electricity directly from sunlight.

Not long ago, each watt of power produced by solar cells cost about $100. Today, the cost has dropped to roughly $5 per watt -- but it must be reduced to $1 per watt before solar energy can compete with existing power sources, says Dr. Ajeet Rohatgi, director of the solar research program at the Georgia Institute of Technology.

"My projection is that around 1995, it could happen," Rohatgi said. "Already, we've seen walkway lights, patio lights, calculators and wrist watches that are solar-powered. As the cost goes down, the market will open up."

Single-crystalline silicon, a relatively expensive material, is often used to make solar cells because of its theoretically high efficiency. But improved fabrication techniques have begun to make less expensive materials more attractive to solar researchers. At the same time, researchers hope to achieve much higher efficiencies by stacking two or more solar cells made from low-cost materials. By placing one solar cell on top of a second cell made from complementary materials with different bandgaps, Rohatgi said, it is possible to absorb a much larger percentage of the solar spectrum and improve efficiency.

Rohatgi is using a highly-controlled process called metal-organic chemical vapor deposition (MOCVD) to make low-cost cadmium telluride solar cells that challenge the highest reported efficiency for this material. Inexpensive solar materials are usually made through techniques such as electro-deposition, a simple process similar to applying gold plating to jewelry.

"Very few people have used MOCVD to make polycrystalline, thin-film solar cells from cadmium telluride," Rohatgi said. "I thought if I used a nice, clean system that allows me to control all the parameters, maybe I can gradually improve the performance, through a fundamental understanding of loss mechanisms."

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The MOCVD process is more costly, but potentially more versatile than electro-deposition, Rohatgi said. Since chemical reactions inside the instrument can be controlled by manipulating temperature, flow rate and pressure variables, Rohatgi believes MOCVD may provide a useful method for learning how to boost the efficiency of inexpensive, thin-film cells.

Ultimately, Rohatgi hopes to produce and provide guidelines for high-efficiency, single-junction, tandem or stacked solar cells. Georgia Tech researchers are considering tandem cells made from cadmium zinc telluride coupled with copper indium diselenide or similar compounds.

"There are two approaches to decreasing the cost of solar energy," said Steven Ringel, a graduate student working with Rohatgi. "One is developing very high-efficiency materials which are expensive -- single-crystalline gallium arsenide and silicon, for example. The alternate approach is to allow for lower efficiency, but use cheaper materials."

Working in collaboration with scientists from the Ametek Applied Materials Laboratory in Harleysville, Pa., Rohatgi recently presented his findings on cadmium telluride solar cells at a conference sponsored by the Solar Energy Research Institute (SERI). He reported that cadmium telluride solar cells fabricated on glass substrates through MOCVD resulted in 9.7 percent efficiency. Similar cells made by Ametek researchers using electro-deposition were about 11.0 percent efficient, and these are believed to be among the world's best cadmium telluride solar cells.

During the MOCVD process, a carrier gas such as hydrogen transports organic metal sources into a furnace-like reactor, where chemical reactions lead to thin film deposition onto inexpensive substrate materials. Since deposition growth can be controlled to a few atomic layers, Georgia Tech researchers hope this process will help them better understand the characteristics of low-cost materials.

In the past, Rohatgi said, most solar researchers emphasized silicon, so little is known about the nature of less expensive materials. Georgia Tech researchers will conduct basic materials and device characterization research to learn more about the loss mechanisms and efficiency potential for low-cost, polycrystalline materials.

Silicon has been used to make solar cells that are about 22 percent efficient, and scientists believe silicon solar cells could someday become 25 percent efficient when powered by a "single sun," or 31 percent efficient when subjected to sunlight concentrated through a lens. But solar cells must become economically feasible to compete with existing power sources.

Previously a solar energy researcher for Westinghouse Corp., Rohatgi now directs Georgia Tech's three-tiered photovoltaic research program, which involves materials characterization, computer modeling and device fabrication using a broad spectrum of materials. Fabrication methods include MOCVD and Molecular Beam Epitaxy (MBE). The program, which includes a silicon solar cell fabrication facility, operates as part of Tech's new Microelectronics Research Center.

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