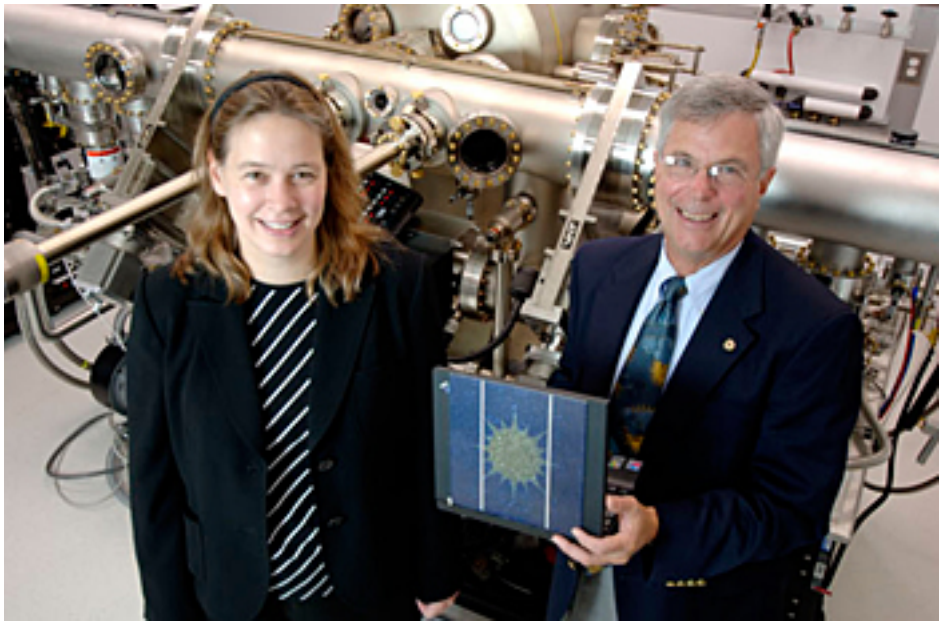
UD-led team sets solar cell record, joins DuPont on $100 million project



UD researchers Christiana Honsberg and Allen Barnett

Using a novel technology that adds multiple innovations to a very high-performance crystalline silicon solar cell platform, a consortium led by the University of Delaware has achieved a record-breaking combined solar cell efficiency of 42.8 percent from sunlight at standard terrestrial conditions.

That number is a significant advance from the current record of 40.7 percent announced in December and demonstrates an important milestone on the path to the 50 percent efficiency goal set by the Defense Advanced Research Projects Agency (DARPA).

In November 2005, the UD-led consortium received approximately $13 million in funding for the initial phases of the DARPA Very High Efficiency Solar Cell (VHESC) program to develop affordable portable solar cell battery chargers.

Combined with the demonstrated efficiency performance of the very high efficiency solar cells' spectral splitting optics, which is more than 93 percent, these recent results put the pieces in place for a solar cell module with a net efficiency 30 percent greater than any previous module efficiency and twice the efficiency of state-of-the-art silicon solar cell modules.

As a result of the consortium's technical performance, DARPA is initiating the next phase of the program by funding the newly formed DuPont-University of Delaware VHESC Consortium to transition the lab-scale work to an engineering and manufacturing prototype model. This three-year effort could be worth as much as $100 million, including industry cost-share.

The ground-breaking research was led by Allen Barnett, principal investigator and UD professor of electrical and computer engineering, and Christiana Honsberg, co-principal investigator and associate professor of electrical and computer engineering.

The two direct the University's High Performance Solar Power Program and will continue working to achieve 50 percent efficiency, a benchmark that when reached would mean a doubling of the efficiency of terrestrial solar cells based around a silicon platform within a 50-month span.

“The University of Delaware is very proud of the achievements of Allen Barnett and Christiana Honsberg, both their research and their work in leading the consortium,” UD President Patrick T. Harker said. “We are grateful to DARPA for its confidence in the University and very much look forward to working with DuPont and our other partners in industry, government and academia on this project, which will have wide application and will be of particular benefit to our men and women in the service.”

“UD has become an important center for renewable energy research, and we applaud the efforts of the University-led consortium,” UD Provost Dan Rich said. “This project is of vital importance, particularly given the pressing need for alternative sources of energy.”

"The University is committed to the advancement of leading-edge research that solves important problems and results in the invention of new technologies aimed at enhancing society," Carolyn Thoroughgood, vice provost for research and graduate studies at UD, said. "This project highlights the quality of research at UD and also demonstrates the value of

collaboration."

“The achievement of this benchmark is a major step forward in the ongoing development of low-cost solar photovoltaic technology,” Rhone Resch, president of the Solar Energy Industries Association, said. “Furthermore, we applaud DARPA for making a strategic investment in American's energy security. We anticipate that this project will result in a wide range of commercial solar applications that will benefit the U.S. military and American consumers alike.”

"Many of us have been working with programs to take us to a real photovoltaic energy future. This project is *already* working in that future. DARPA has leapfrogged the 'conventional,' demonstrating that creativity and focus can significantly accelerate revolutionary research-bench concepts toward reality, demonstrating this does not have to take decades,” Lawrence L.

Kazmerski, director of the U.S. Department of Energy's National Center for Photovoltaics at the National Renewable Energy Laboratory in Golden, Colo., said. “This is a first step-but a significant one in making sure our energy future is what we know it should look like."

The consortium's goal is to create solar cells that operate at 50 percent in production, Barnett said. With the fresh funding and cooperative efforts of the DuPont-UD consortium, he said it is expected new high efficiency solar cells could be in production by 2010.

The highly efficient VHESC solar cell uses a novel lateral optical concentrating system that splits solar light into three different energy bins of high, medium and low, and directs them onto cells of various light sensitive materials to cover the solar spectrum.

The system delivers variable concentrations to the different solar cell elements. The concentrator is stationary with a wide acceptance angle optical system that captures large amounts of light and eliminates the need for complicated tracking devices.

The VHESC would have immediate application in the high-technology military, which increasingly relies upon a variety of electronics for individual soldiers and the equipment that

supports them. As well, it is hoped the solar cells will have a large number of commercial applications.

Today, the American soldier carries a pack that weighs nearly 100 pounds of which about 20 pounds are the three-day supply of batteries needed to power their gear. The DARPA program aims to dramatically reduce the battery logistics pipeline and provide the soldier with more power at reduced weight, thus improving mobility, survivability and the availability of advanced electronic technologies on the battlefield. With the dramatically higher efficiency of the VHESC technology, solar rechargers could be integrated into common battlefield devices such as night vision goggles, radios and GPS navigation systems.

Barnett and Honsberg said that reaching the 42.8 percent mark is a significant advance in solar cell efficiency, particularly given the unique small and portable architecture being used by the consortium and the short time - 21 months - in which it was developed.

Modern solar cell systems rely on the concentration of the sun's rays, a concept similar to youngsters using magnifying glasses to set scraps of paper on fire. Honsberg said the previous best of 40.7 percent efficiency was achieved with a high concentration device that requires sophisticated tracking optics and features a concentrating lens the size of a table and more than 30 centimeters, or about 1 foot, thick.

The UD consortium's devices are potentially far thinner at less than 1 centimeter. “This is a major step toward our goal of 50 percent efficiency,” Barnett said. “The percentage is a record under any circumstance, but it's particularly noteworthy because it's at low concentration, approximately 20 times magnification. The low profile and lack of moving parts translates into portability, which means these devices easily could go on a laptop computer or a rooftop.”

Honsberg said the advance of 2 percentage points is noteworthy in a field where gains of 0.2 percent are the norm and gains of 1 percent are seen as significant breakthroughs.

“This achievement is the direct result of the new architecture we developed under the DARPA program,” Barnett and Honsberg said. “By integrating the optical design with the solar cell design, we have entered previously unoccupied design space leading to a new paradigm about how to make solar cells, how to use them, and what they can do.”

During the first 21 months of the VHESC program, a diverse team of academia, government lab and industrial partners, led by UD, was focused on developing the technology basis for a new extremely high efficiency solar cell. The rapid success of that effort has enabled the present transition to a focus on prototype product development.

The team's novel approach provides for affordability and also flexibility in the choice of materials and the integration of new technologies as they are developed.

Barnett credits the early success of the program to the team approach taken to solving the problem. Partners in the initial phase included BP Solar, Blue Square Energy, Energy Focus, Emcore and SAIC. Key research contributors included the University of Delaware, National Renewable Energy Laboratory, Georgia Institute of Technology, Purdue University, University of Rochester,

Massachusetts Institute of Technology, University of California Santa Barbara, Optical Research Associates and the Australian National University. “What we've done,” he said, “is create a virtual lab by having all of these companies, universities and national laboratories in the consortium. This has given us access to a broad range of capabilities in terms of expertise and equipment.”

That approach is exemplified by the fact that the record-breaking system features three types of solar cells-one made by industry (Emcore), one by the National Renewable Energy Laboratory and one by UD.

“This is a solar cell that works,” Barnett said, adding, “This technology has the potential to change the way electricity is generated throughout the world.”

Barnett believes the 50 percent efficiency mark is just the beginning. “Our best inventions are in front of us,” he said. “The consortium has been a super team, and has worked to develop new devices and architectures based on a breakthrough design paradigm.”

Honsberg said the efficiency potential for solar cells is significantly higher still, which leaves

“large room for improvement.” She said she enjoys the engineering challenge, particularly in a field in which “we create things that make a difference.”

The newly formed DuPont-University of Delaware VHESC consortium will be made up of industrial partners, national laboratories and universities.

“The new consortium will build upon the considerable technical successes of the first phases of the VHESC program and provide the strong industry-led and product-focused leadership required to ultimately bring the VHESC product to commercialization,” Barnett said. “We look forward to working with DuPont and others to continue our progress in developing this novel solar power research.”

UD offers one of the nation's broadest research programs in photovoltaics. It is home to the High Performance Solar Power Program in the Department of Electrical and Computer Engineering and the Institute of Energy Conversion, a multidisciplinary laboratory devoted to the research and development of thin film photovoltaic solar cells.

Honsberg is developing one of the nation's most complete courses of study for solar power systems, which is partially sponsored by the National Science Foundation's Integrative Graduate Education and Research Training (IGERT) program.

Barnett earned a doctorate in electrical engineering from Carnegie-Mellon University, is a Fellow of the Institute of Electrical and Electronic Engineers (IEEE), was awarded the IEEE's William R. Cherry Award for outstanding contributions to the advancement of photovoltaic science and technology and won UD's Karl W.

Bšer Solar Energy Medal of Merit in 2001 for “pioneering high-performance, thin-crystalline silicon solar cells, founding and leading a world-class enterprise for the commercialization of solar electric products, and outstanding continuing service to the solar electric power community.”

Honsberg earned a bachelor's degree in electrical engineering in 1986, a master's degree in

1989 and a doctorate in electrical and computer engineering in 1992, all from UD.

She was an associate professor in the Centre for Photovoltaic Engineering at the University of New South Wales from 1993-2000 and an associate professor of electrical and computer engineering at Georgia Tech before joining the UD faculty in 2004.

Photo by Carlos Alejandro