



**Tapping  
solar energy  
could  
provide  
limitless  
power**



# SQUEEZING JUICE FROM THE SUN

The biggest energy bang for the buck comes from sunlight, and Seshu Desu's research aims to tap that immense supply of renewable energy and make it easily accessible as a flexible, large-area and low-cost, autonomous power source.

"We're attacking both sides of the problem: We want an integrated system that can generate power with solar cells and store that power more efficiently and at a lower cost," said Desu, dean of Binghamton University's Thomas J. Watson School of Engineering and Applied Science, and the head of a research team tackling how to harness the sun's energy potential.

"The solar energy we could access in one day could support the electricity needs of the Earth for a year at the present rate of consumption," Desu added. "By 2015, solar cells as power sources could be a huge industry."

Desu's research focuses on creating autonomous power systems based on flexible thin-film solar cells. Although the typical generation efficiency of these solar cells today is about 10 percent, he hopes to increase that efficiency through novel design and restructuring of the cell itself. The developing field of nanotechnology can help achieve this goal.

When materials are structured into much smaller dimensions as nanoparticles, it increases the number of surfaces. This, in turn, increases the capacity to interact with the environment without increasing the size of the basic unit.

Scientists have discovered that materials also have other unexpected and often beneficial properties when their sizes are reduced to nano levels. Desu's research will take advantage of these as yet unknown properties in constructing the next generation of thin-film solar cells, in which nanoparticles cover a large surface area to maximize generation efficiency, reduce the cost and increase reliability.

The other side of the coin in developing lower-cost power sources using solar cells is that the energy that is produced must be stored efficiently and still provide ready, reliable access for several years.

Desu compares marathon runners and sprinters to explain the current state of energy storage devices.

"Batteries are marathoners — they have high energy density but low power density," he explained. "Capacitors are the opposite because they can supply high levels of power quickly, such as when you turn on your laptop computer."

The problem with energy-dense batteries is their size and lifetime, whereas lightning-fast capacitors run down quickly. The solution is to combine

**Desu's  
research  
focuses on  
creating  
autonomous  
power  
systems  
based on  
flexible thin-  
film solar  
cells.**



*Seshu Desu*

the best qualities of both into a supercapacitor, Desu said.

"Potential for solar energy utilization can be maximized when the solar cells are integrated with high-efficient energy storage supercapacitor devices that could accommodate the accelerated power needs. We were able to produce supercapacitors with significantly high energy and power densities with extremely long cycle lifetimes using the advantages of nanostructuring as well as thin-film nanocomposite materials," he said.

"To achieve high-energy density and prevent self-discharge through open circuit reactions, we developed inorganic and organic solid-state electrolytes as gels or membranes with ionic conductors that are biologically derived."

Integrated solar-cell supercapacitor structures as autonomous power sources are also being investigated, Desu added.

Desu holds degrees in mathematics, physics, chemistry, materials science and electrical engineering. His research activity began in industry, then continued at the University of Massachusetts at Amherst and Virginia Tech. He has secured 29 patents and published 235 refereed journal papers, which have led to more than 3,500 citations.

As a professor and a researcher at both universities, Desu brought in more than \$10 million in research grants. He was department head at Amherst from January 1999 to August 2006, during

which time the department increased its research expenditures from \$3.5 million to \$8.5 million and won a coveted National Science Foundation-funded Engineering Research Center designation worth \$40 million.

A former Amherst colleague, Professor Alok Rastogi, a physicist with 35 years' experience in solar cells and nanomaterials, has joined Desu at Binghamton University to assist with this research.

The direct applications of the autonomous power system based on solar cells are found everywhere, not just in computers or electronic gadgets, Desu said.

"Research should ultimately transfer scientific innovations into useful products and processes that would benefit society. It's not just curiosity," he said.

In addition to flexible, large-area autonomous power sources, there is a growing need for highly efficient large-area lighting. For that latter purpose, some members of his group are developing ZnO-based light-emitting diodes (LED), he added.

His group has also been developing flexible thin-film medical sensing devices. Desu suggests that due to their flexibility and precision detection capacity, these sensing devices could be built into the environment. For example, if built into the walls of a shower stall, the devices would remain unobtrusive yet provide accurate monitoring of potential health threats.

"The future exists in latent form in the present," he said. "If we can identify dangerous conditions, such as cancer growth, in their latent phase, intervention is easy and less costly."

"We're trying to migrate flexible electronics into that area of application. In effect, our cars are better monitored than our bodies are," he concluded.

"Desu's research is goal-oriented — he's a real engineer who wants to solve a problem," said William T. Reynolds Jr., professor of materials science and engineering and director of the Nanoscale Characterization and Fabrication Facility at Virginia Tech.

Reynolds recalls a situation in which Desu's students were working on chemical vapor deposition of silicon-carbide thin films on silicon, and they serendipitously discovered a way to reduce defects in silicon carbide. Somewhat accidentally, they started their deposition on a

rough silicon surface. Rather than throwing out the result as a failed experiment, they looked at the outcome with fresh eyes and fit the surprise result between different layers in their thin films.

"It was something they found on the side that had interesting results," he continued. "It was a good idea that worked and is now used commonly."

Reynolds, who sat on the thesis committees for several of Desu's students, noted how they had adopted his approach to research.

"Those students were open to what they came upon because they didn't have blinders on. And at the same time, they were not randomly experimenting," he added.

"Desu doesn't expect a specific result, but takes a path toward a goal by following a strategy," Reynolds said. ■

— Katherine Karlson

## INSPIRING BOLD THINKING

An environment in which creativity is valued and the culture of innovation is promoted is essential, and not just to an entrepreneurial economy. "This same environment also encourages ground-breaking research and provides students with the best possible education," said Seshu Desu, new dean of Binghamton's Thomas J. Watson School of Engineering and Applied Science.

"The environment must be conducive to intellectual risk-taking. People must feel they are important and part of something larger than themselves. Students, graduates and undergraduates alike, must feel that they are making a difference in the world," Desu said. "Our vision has to be bold, and to achieve that vision successfully it should be translated into the aspirations of individuals in the institution."

"Desu put the best teachers, who are usually the best researchers, in front of the first- and second-year students, where at most other schools, they teach only graduate students," said Weibo Gong, professor in that department and Institute of Electrical and Electronics Engineers (IEEE) Fellow.

"He has a deep understanding of education and applies 'out-of-the-box' thinking to it. Desu recognizes that undergraduates are the backbone of the university, and he therefore puts the students first, because they are the future," Gong added.

Desu said it's essential to retain and develop faculty who have strengths in both research and teaching. "From that vantage point," he added, "I need to identify the innate potential in people within the school and provide them with the necessary resources and freedom so that they can flourish."

A former colleague at the University of Massachusetts at Amherst, where Desu was head of the Department of Electrical and Computer Engineering, described how he keyed in on the faculty to advance undergraduate education.

