Devices Increase Potential For Flexible, Light-Weight Power

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Scientists and engineers at the Air Force Research Laboratory's Materials and Manufacturing Directorate have made significant advancements in developing flexible, organic-based solar cells and photodetectors that can be used in a variety of Air Force systems.

Collaborative efforts between the directorate's Polymer Branch and Airbase Technologies Division are focused on exploring a diverse range of near-term applications for the technology, which include power generation for military tent structures and mobile military units, and eventually, power for satellites and communication systems.

Highly efficient, flexible solar cells are needed for a variety of potential Air Force systems for conversion of solar energy to electrical power.

Historically, the development of solar cells and photovoltaic devices has been limited to the use of crystalline silicon wafers or thin film deposition of other inorganic materials, a process that typically requires expensive manufacturing technologies.

The development of low-cost methodologies for the production of solar energy conversion devices is a critical enabling technology for a variety of Air Force applications.

Through a combination of fundamental research and development programs and external contractual efforts, scientists and engineers from the Materials and Manufacturing Directorate are exploring the use of organic and inorganic/organic hybrid materials and device architectures for flexible solar cell designs.

Researchers from the directorate's Polymer Branch have focused on a number of materials related issues for improving the devices' power conversion efficiency, a characteristic that demonstrates the amount of energy from the sun that can be converted to electrical power.

They have demonstrated that these devices can be significantly improved by controlling the nanoscale morphology of the film, and by developing new materials and film architectures with better response properties.

Directorate scientists have explored two techniques for device development: one based on an all-polymer/organic material approach, and another dye sensitized, organic/inorganic material hybrid approach.

In the all-polymer approach, two organic materials, an electron donating material and an electron accepting material, are partnered to make a percolating structure with two interpenetrating networks.

When optical energy reaches the electron donating material, a charge is transported through the electron accepting material to electrodes, which much like a battery, collect the electrons and deliver a voltage to a system.

"The introduction of alternative electron accepting materials has yielded a three-fold improvement in solar cell efficiency," said Dr. Michael Durstock, a scientist from the Polymer Branch.

In addition, existing collaborations with the directorate's Airbase Technologies Division support the directorate's program to develop an efficient, flexible prototype device.

Work accomplished under a contract with Michael Graetzel from the Swiss Federal Institute of Technology in Lausanne, Switzerland through the European Office of Aerospace Research and Development, yielded a dye sensitized flexible solar cell with over 10 percent conversion efficiency.

This approach was based on the light sensitization of a nanoporous titania film. By controlling the nanoscale morphology of this titania film, as well as the ruthenium metal complex used as the light sensitizer and the electrolyte, which acts to regenerate the complex, researchers have demonstrated efficient device performance.

"Research conducted by Michael Graetzel has achieved a milestone that had not previously been achieved in flexible cells," Durstock said.

Other efforts of the Airbase Technologies Division are focused on replacing conventional electrical power generators at deployed airbases with a more distributed system of power generation.

By incorporating the solar cell technology in tent structures researchers expect to lighten the logistical burden of deployment and to facilitate agile combat.

By bringing promising technology candidates into the advanced technology development stage and transferring them to industry for full-scale production, the transition is made from basic research to application.

Special operations personnel could also benefit from light-weight, flexible solar cell technology through reduced weight of equipment and supplies carried into the field. By combining solar cell technology with rechargeable batteries, the overall weight of the required supplies and their electrical power systems will decrease.

Finally, solar arrays and photodetectors for space satellites provide much longer-term applications if the most stringent requirements of the space environment can be overcome.

The Materials and Manufacturing Directorate, in collaboration with the Air Force Research Laboratory's Space Vehicles Directorate, has initiated primary space irradiation and durability testing on organic materials for photovoltaic devices.