U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

INDUSTRIAL TECHNOLOGIES PROGRAM

Self-Assembled Biomimetic Nanostructured Anti-Reflection Coatings for Highly Efficient Crystalline Silicon Solar Cells

Solar energy is clean, abundant, and renewable, yet it is vastly under-utilized in the commercial world, mainly due to the high manufacturing and installation costs of photovoltaic (solar cell) modules. Current production of solar cells is dominated by crystalline silicon modules (> 98% market share); however, due to the high refractive index of silicon, more than 35% of incident light is reflected back. Various antireflection coatings (ARCs), such as vacuum-deposited silicon nitride films, have been developed to reduce reflective losses and increase efficiency for silicon-based photovoltaics. Unfortunately, high manufacturing costs and limited antireflection performance of these coatings have impeded development of solar cells that can be made truly economically competitive with fossil fuels.

This nanomanufacturing concept definition study will further develop the structure-property relationship understanding and performance testing of biomimetic nanostructured ARCs produced by a robust templating nanofabrication platform that combines the simplicity and cost benefits of bottom-up self-assembly with the scalability and compatibility of top-down microfabrication. The proposed research is aimed at enabling economically feasible and more efficient silicon-based photovoltaic technology while testing the coating stability in various simulated environments. The research plan has four specific objectives: (1) further optimize transparent, self-cleaning, biomimetic nanostructured ARCs on a commercial silicon solar cell, (2) characterize the efficiency of crystalline silicon solar cells with templated ARCs on both silicon and glass encapsulation layers, (3) determine the environmental tolerance of the ARCs by accelerated and long term aging studies and (4) determine the feasibility of integrating this technology into commercial solar cell production.

The investigation may lead to significant breakthroughs in reducing manufacturing cost and increasing conversion efficiency of crystalline silicon solar cells, while developing a commercially viable technology for immediate use in the public sector. Applications of this solar cell technology range from terrestrial solar cells on individual homes and businesses to satellite, space shuttle and space station applications, among many others. The evaluation of conversion efficiency and material stability of silicon cells with templated ARCs in earth and space-like environments represents the most critical step in fulfilling the ultimate promises of the new nanofabrication platform for increased energy efficiency. The creative and original components of this research plan rely on the integration of the above four objectives and the unique collaboration between Savannah River National Laboratory and the University of Florida.

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