Abstract

High Performance Ultrathin Nanostructured Silicon and III-V Photovoltaics

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Unconventional approaches to exploit materials can create novel engineering designs, device functionalities, and cost structures, each with significant practical values in the next generation photovoltaic technologies. In particular, ultrathin forms of single-crystalline silicon and gallium arsenide (GaAs) derived from wafer-based and epitaxially-grown source materials represent an excellent materials candidate for high performance, low cost photovoltaic systems due to many unique advantages such as superior materials properties, reduced materials consumption, relaxed requirements of materials purity, as well as ability to form large area devices on unlimited choices of module substrates through printing-based deterministic materials assemblies. In this talk, I will provide an overview of recent advances in materials design and fabrication pathways for high performance ultrathin single-crystalline silicon and GaAs solar cells, and heterogeneously integrated unconventional module designs, with a special emphasis on strategies of nanoscale photon management for enhancing the performance of printed optically thin solar cells and their mechanically flexible modules. First, I will talk about a composite photovoltaic system that can improve the absorption of longer wavelength photons for ultrathin (~8 μm) nanostructured silicon solar cells by synergistically exploiting spectral upconversion and plasmonic light manipulation in a reconfigurable platform where individual module components can be independently optimized and strategically combined. Secondly, I will present high efficiency, ultrathin (emitter + base = 200 nm) GaAs solar cells that incorporates bifacial photon management schemes based on front-surface dielectric photonic nanostructures of TiO_2 and co-integrated rear-surface reflector to maximize the absorption and photovoltaic performance without compromising the optimized electronic configuration of planar devices. Optimal design rules for these ultrathin, nanostructured silicon and GaAs solar cells and their integrated modules on a flexible substrate will be discussed based on systematic studies of optical and electrical properties and photovoltaic device performance of printed nanostructured solar cells in experiments as well as numerical calculations.

Biography

Dr. Jongseung Yoon is an assistant Professor in the Mork Family Department of Chemical Engineering and Materials Science at the University of Southern California. He received a Ph.D. degree in Materials Science and Engineering from the Massachusetts Institute of Technology in 2006, and B.S. degree in Polymer Science from Seoul National University in 1996, respectively. Prior to joining USC, Prof. Yoon was a Beckman Institute Postdoctoral Fellow at the University of Illinois at Urbana-Champaign. His current research focuses on tailoring and understanding novel electrical, optical, electrochemical, and thermal properties of nanostructured inorganic single-crystalline semiconductor materials and exploiting them as synergistic materials building blocks into unusual format device implementation in areas ranging from photovoltaics, photoelectrochemical water splitting, to flexible/stretchable optoelectronics for skin-mountable/implantable sensing and therapeutic systems. Prof. Yoon is a recipient of DARPA Young Faculty Award in 2012 and Hanwha Non-Tenure Faculty Award (Korea) in 2015.