IBS Center for Molecular Spectroscopy and Dynamics

COLLOQUIUM

■ SPEAKER

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■ TITLE

Coaxial p/i/n silicon nanowire photovoltaic devices

■ ABSTRACT

Photovoltaic solar cells have been considered as promising sources of electricity. Both the power conversion efficiency and correlated efficiency-to-cost metric must be further increased. The efficiency or efficiency-to-cost of solar cells was degraded partly due to carrier recombination determined by material defects and incomplete light absorption determined by reflection or transmission loss. In this thesis, solutions for increasing light absorption efficiency are proposed and their broadband light absorption characteristics is demonstrated numerically and experimentally.
First, the design and synthesis of core/shell p-type/intrinsic/n-type (p/i/n) Si nanowires (NWs) with various sizes and cross-sectional morphologies is proposed. Measured photocurrent spectra exhibit well-defined diameter-dependent peaks. The corresponding external quantum efficiency (EQE) spectra calculated from these data show good quantitative agreement with finite-difference time-domain (FDTD) simulations. This comparison revealed a systematic red-shift of equivalent modes as a function of increasing NW diameter and a progressive increase in the number of resonances.
Second, laterally oriented Si NW array structures are proposed. Optical resonances in laterally oriented Si NW arrays are demonstrated by conducting finite-difference time-domain simulations. Comparison of a NW array with a single NW shows that the current density (JSC) is preserved for a range of NW morphologies. The JSC of a NW array depends on the spacing of its constituent NWs, which indicates that both diffraction and optical antenna effects contribute to light absorption.
Third, NW photovoltaic devices coated with dielectric shells are proposed. Scattering and absorption measurements on Si NWs coated with shells of SiNX or SiOX exhibit a broadband enhancement of light absorption by ~50–200% and light scattering by ~200–1000%. The increased light-matter interaction leads to a ~80% increase in short-circuit current density in Si photovoltaic devices under 1-sun illumination.
In summary, solutions for increasing light absorption efficiency are proposed and demonstrated numerically and experimentally. The results obtained from our demonstration will be useful for designing nano light absorbers efficiently operating at specific or broadband wavelengths toward the development of next-generation ultrasmall photodiodes and solar cells.

■ DATE AND VENUE

October 26, 2016 (Wednesday, 5:00-6:00 p.m.)
Seminar room 116, R&D Center