MAR12-2011-020193

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

Quantum-well and quantum-dot structures for high-efficiency photovoltaics

EDWARD YU, The University of Texas at Austin

Quantum-well and quantum-dot semiconductor heterostructures offer a variety of opportunities for achieving photovoltaic power conversion efficiencies in excess of the Shockley-Queisser limit for single-homojunction solar cells. However, realization of such efficiencies is likely to require a combination of very high quality epitaxial growth or nanostructure synthesis to minimize carrier trapping and recombination, detailed understanding and analysis of optical absorption and nonequilibrium carrier transport processes, and light trapping to enable efficient optical absorption in very thin device layers. We discuss work in which GaAs/InGaAs/InAs semiconductor quantum-well and quantum-dot solar cells are realized in designs that enable efficient collection of photogenerated carriers from quantum-wells and dots, and combined with subwavelength-scale metal and dielectric structures that enable incident photons to be scattered into guided optical modes within a thin-film device, thereby enabling increased absorption efficiency in very thin device layers. Several aspects of this work will be addressed. Measurement of electric-field-dependent photocurrent response enables design of structures in which photogenerated carriers are collected efficiently from quantum-well or quantum-dot structures in the intrinsic region of a p-i-n junction solar cell. Processing to remove epitaxially grown device layers from their original growth substrate enables metal and dielectric nanostructures to be designed and integrated with the semiconductor epitaxial layer structures to scatter incident photons into strongly guided optical modes within the semiconductor. Finally, detailed analysis of quantum-well and quantum-dot optical absorption as well as optical mode structure within the device enables optimization of the absorption and mode profiles to achieve maximum power conversion efficiency. Both computational and experimental results derived from these approaches will be described.