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Introduction

In recent years there has been a tremendous growth in the solar energy industry. What only 5 years ago was a relatively small industry has grown to the level of ~ $18B in 2008 with a CAGR of ~30%. This growth, coupled with the recent concerns regarding global warming, has led to a strong re-invigoration of basic research and development in photovoltaics (PV). While the majority of the PV market is based on single and poly-crystalline silicon-based solar cells (Generation I), there has been a tremendous growth in the market for thin film solar cells (Generation II) based on silicon, CdTe, and $Cu(In,Ga)Se_2$ (CIGS) in which a thin absorber layer is deposited onto a low cost substrate such as glass, metal foil, or polymer. Such technologies are capable of reducing the cost of solar energy by 2-5X, though they typically suffer from a loss in module efficiency relative to Si. Within the research community, there now exists focused efforts aimed at developing technologies that can simultaneously reduce cost yet also provide breakthrough efficiencies under 1 Sun (AM1.5) and concentrated illumination by providing novel band structure concepts; the so-called generation III PV technologies.

Indeed, with the emergence of nanotechnology within the last decade, a small but growing number of researchers in this field have been considering whether one can take advantage of the unique optical, electrical, and structural/architectural properties of nanostructures, and the fact that many nanostructures may be synthesized or assembled using potentially low-cost processes, to either enhance conventional solar cells or create completely new types of PV devices and modules based on them. There is now a critical mass of researchers working in this field of nano photovolaicsi, and as such it is fitting that a full conference devoted to the topic (7047: Nanoscale Photonic and Cell Technologies for Photovoltaics) be held at SPIE Optics & Photonics in 2008 as part of the Solar Energy + Applications track.

The strategy of improving the silicon, thin film, and quantum-well solar cells via sub-wavelength, optical phenomena and nanoscale electronic structures is addressed in the first session on Nanophotonic Structures for Photovoltaics. Here, three major approaches are considered. The first involves the use of metal nanoparticles that support size-dependent surface plasmon-polariton (SPP) modes, often referred to as plasmonics. These SPPs are able to resonantly couple particular wavelengths of light depending on their size, and also provide enhanced electric fields localized in the vicinity of 10's of nanometers from the nanoparticle. Plasmonic particles and structured films can be used to couple light into wave-guided modes that can then be absorbed by ultra-thin PV converters such as quantum wells. Arrays of metal nanoparticles have also been shown to enhance the photocurrent of standard solar cells by sub-wavelength Mie and Rayleigh scattering effects. Sub-wavelength optics can also be used be used to create solar cells with enhanced performance. Small-scale conductors based on metallic and conducting oxide nanowires are also being explored as alternatives to conventional transparent conducting oxide (TCO) thin films that are primarily based on indium in oxide (ITO). These structures have the potential to provide equal or better conductivity and optical transparency using a so-called "chicken-wire" concept, in which a random dispersed or partially-aligned arrays of nanowires/tubes also allow for enhanced flexibility and potential for reduced costs via solution-based processing.

Concurrently, there is a strong interest in the community to develop novel solar cell designs based on inorganic nanostructures (Session 2: Nanostructured inorganic solar cells). This author has been exploring the possibility of developing new solar cells based on silicon nanowire grown by scalable processes directly on metal substrates. It has been shown that such structures have excellent light trapping properties due to Mie scattering, and also have the potential for efficiencies in the range of 15-18% using abundant, non-toxic materials by decoupling optical absorption from charge transport. Atwater and co-workers have also been exploring Si nanowire based cellsii, and have recently performed single nanowire solar cell measurements and determined the minority-carrier diffusion length in large scale nanowires to be on the order of microns. Indeed, recent work has suggested that the minority-carrier lifetime in silicon nanowires is limited by surface recombination rather than bulk recombination processes. Work in using antenna structures to harvest and concentrate solar energy is also of great interest, as is the realization of intermediate band solar cells using quantum dots. Efforts in using nanoparticles to form CIGS thin films and transferring of silicon nanowires using polymer matrices were presented.

The study of nanostructured organic materials for photovoltaics was also a major theme within the conference (Sessions 3 and 4: Nanostructured organic solar cells I and II). This began with a discussion on using ultra-fast optical diagnostic techniques to probe charge transport. Studies of nanoscale dye sensitized and heterojunction polymer solar cells were provided by several talks in the conference, as well as means of forming patterned polymer nanostructures. Promising results on scaling of polymer-based solar cells to large- area mini-modules were also presented, and studies of the nanoscale electric properties of polymer cells were discussed, among other great presentations in these sessions. The conference concluded with a series of poster presentations that strongly contributed to the overall success of the conference.

Overall, the conference provided an excellent forum for the interchange of advanced photonic and device concepts in photovoltaics, and it is hoped will continue to do so at future SPIE Optics and Photonics events. I would like to thank the conference Program Committee for their support, as well as the session chairs, authors, and SPIE staff for their help in making this a successful conference.

Loucas Tsakalakos