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Editorial

Nanostructured Solar Cells

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Nanostructured materials, such as nanowires, nanorods, and quantum dot structures, are being studied and developed for solar cell applications since they have enabled the fabrication of high efficient and low-cost devices. It is believed that there are mainly two approaches to reduce the cost per kilowatt-hour of electrical energy generated by solar cell devices. Firstly, one can aim to increase the efficiency of the device, usually by pursuing new cell designs that can take full advantage of high-quality absorber materials. Secondly, one can pursue cost reductions while maintaining the efficiency of the device, often done by exploring novel manufacturing approaches but also sometimes with new cell designs and perhaps by exploiting lower-quality, cost attractive materials and processes. From either perspective, nanostructuring of inorganic solar cells offers the possibility of reducing the cost of photovoltaics by allowing smaller amounts of lower-grade photovoltaic semiconductor materials to be used or improving the photoelectric conversion efficiency by making more light and charge carriers to be harvested. The device physics, including carrier/exciton separation, charge extraction, and recombination, is strongly influenced by the nanostructure. Research in various fabrication methods and their influence on the device physics has also provided insight on how to increase efficiency limits. Additionally, the synthesis of solar cells by solution-based methods or fabrication pathways using less traditional, abundant materials is identified as a promising route to wide-scale photovoltaic electricity generation. Nanostructured solar cell geometries are highlighted as essential in this approach.

The use of dyes as sensitizers in solar cells has also been the target of current active research, due to the low production cost, adaptable optical properties, and high performance. However, several issues are still to be solved regarding long-term stability, and an expected improvement in the conversion efficiency is also needed so they can be suitable for large-scale applications.

This special issue selects 7 papers about different nanostructured solar cells. It consists of 4 papers on dye-sensitized solar cells (DSSC) addressing its variety of material properties such as dyes, electrodes, and others, the photoelectric properties, and the ageing effect by the impedance spectroscopic method. The issue also covers perovskite solar cells, n-Si/PEDOT:PSS organic-inorganic heterojunction-based hybrid solar cells, and nanostructured ultrathin silicon solar cells covering a variety of related aspects towards achieving efficient and stable nanostructured PV devices.

For example, P. Bhatt et al. discussed the effect of ageing on the performance of dye-sensitized solar cells (DSCs). Based on a detailed degradation study of DSC by

electrochemical impedance spectroscopy (EIS), they suggested that the DSC should be used under low illumination conditions and around room temperature for a longer life.

Y. Chen et al. demonstrated a new approach to design, simulate, and fabricate whole-wafer nanostructures on a dielectric layer on a thin c-Si solar cell for effective light trapping. By employing periodic nanostructured dielectric arrays on 40 μm thin c-Si, they could suppress the reflection loss below 5% over a wide spectra and angular range and demonstrated 32% improvement in short circuit current and 44% relative improvement in energy conversion efficiency in a crystalline silicon solar cell with only a 2.9 μm ultrathin absorber layer.

C. Lyons et al. synthesized a new chromophore containing a coplanar dihexyl-substituted dithienosilole (CL1) and displayed an energy conversion efficiency of 6.90% under AM 1.5 sunlight irradiation in dye-sensitized solar cells. Similar fill factor and open-circuit voltage are presented for a new synthesizer with N719. The charge transfer resistances are presented comparable, indicative of similar recombination rates by the oxidised form of the redox couple. Using time-dependent density functional theory, studies are performed to ascertain the absorption spectrum of the dye and assess the contribution of various transitions to optical excitation. Good agreements are reported between experimental and calculated results.

While X. Sun et al. reported that an increase in the porosity of the mesoporous TiO_2 (mp-TiO_2) film leads to an improvement in the performance of the perovskite solar cells (PSCs), P. Ren et al. employed phloxine B and bromophenol blue as the sensitizers of dye-sensitized solar cells, and the devices were characterized using UV-Vis spectra, FT-IR spectra, fluorescence spectra, and current-voltage characteristics. K. Moolsarn et al. employed carbonized hair/PEDOT:PSS composites (CxP) with varied carbon contents from $x = 0.2$ to 0.8 g, as counter electrode (CE) for a dye-sensitized solar cell (DSSC). And last but not least, C. Zhang et al. demonstrated that annealing temperature has a great influence on the PEDOT:PSS material properties and the corresponding device performance. By optimizing the annealing temperature, the conductivity of the PEDOT:PSS film doped with Triton X-100 and EG could be enhanced by a factor of more than three orders.

The objective is to provide an opportunity for interdisciplinary researchers to share their latest research achievements in nanostructured solar cells and let the potential readers learn some insightful concepts in this exciting field of photovoltaic energy concepts. We hope this research progress can inspire more advanced ideas for the future development of such novel concepts of PV devices. We would like to extend our heartiest gratitude to all the authors who submitted their work for consideration in our special issue and to the reviewers for their critical feedback.

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