Nanostructured Low Work Function n-Electrodes for Polymer Photovoltaics

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http://www.engineering.unl.edu/academicunits/electricalengineering/faculty-staff/asgarpoor.shtml

Abstract:
The goal of this project is to develop new electrode materials made of rare-earth sulphides which have low work function and are nearly transparent to improve the efficiency of organic photovoltaics (OPV). Specific dye molecules or conjugated polymers are utilized to provide the solar power absorption medium in OPVs OPVs are of great interest to society because of their potential low manufacturing cost compared to their inorganic counter parts to harvest solar energy. However, the efficiency of OPV is low, mostly due to their narrow absorption spectrum, electron-hole recombination losses, low hole and electron mobilities and junction losses. I propose to develop samarium monosulphide nanowire forest textured electrodes for polymer PV because of their matching work function to the valence band energy level of most conducting polymers. The rationale for the nanostructure design is that nanowires imbedded in the polymers will provide a shorter diffusion path length for the low mobility electron-hole pairs generated in the polymer for rapid charge collection. In contrast to other textured electrodes which are always used as the negative electrodes, the proposed electrodes will be applied as the positive electrode to enhance the holes collection from the photo-excited polymers. This study will advance the understanding of the recombination and transport mechanisms in hybrid nanowire-polymer PV devices. Such knowledge is expected to open new possibilities in the design of PV absorber medium and provide a better understanding of how energy level matching and textured electrodes affect the performance of OPV devices.

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Utilization of solar energy through photovoltaics (PV) or solar power harvester is increasingly recognized as an essential component for stable global energy production. While currently available technology such as multi-junction inorganic PV devices have shown solar energy conversion efficiencies as high as 40%, costs associated with device fabrication and tracking optics is prohibitive for large scale implementation. Organic photovoltaic (OPV) devices exploit inexpensive organic molecules as the solar energy absorber media. Though they have the lowest cost per watt peak (W_p), their efficiencies reach at most 6%. One of the major efficiency limitations of OPV lies in the inefficiency to transport the charges generated in the organic media to the outside circuit. While these technologies are promising, the balance between cost and efficiency still has not met the DOE target ($\$0.33/W_p$). The goal of this proposal is to improve the efficiency of OPV by developing samarium sulfide nanowire-textured electrodes to enhance the charge transfer for OPV devices. This proposal addresses the synthesis of these advanced materials, the measurement of their electrical properties and solar conversion efficiency of OPV devices with such nanostructured electrode design, and the evaluation of the electrode design. Furthermore, the research results are expected to advance our understanding of nanotextured electrode design for other organic based electronic devices. These results will also served as the preliminary data for external proposals to continue detailed studies of other low work function electrode materials and nanowire electrode design for other organic dyes and polymer systems used in OPV devices.