Interface properties in composite nanosystems for energy harvesting

Alberto Vomiero [1,2]

1 Division of Materials Science, Department of Engineering Sciences and Mathematics, Luleå University of Technology, 97187 Luleå, Sweden
2 Department of Molecular Sciences and Nanosystems, Ca' Foscari University of Venice, Via Torino 155, 30172 Venezia, Italy

Abstract (300-word limit)

Composite nanostructures can be efficiently applied for Sunlight conversion and, more in general, for energy harvesting and generation of solar fuels. In most of the applied systems, like photodetectors, excitonic solar cells, and (photo)-electrochemical cells to produce solar fuels, nanomaterials can play a critical role in boosting photoconversion efficiency by ameliorating the processes of charge photogeneration, exciton dissociation, and charge transport. A critical role in such processes is played by the structure and quality of the interface, which needs to be properly assembled to obtain the desired functionality. Specifically, the structure of the interface determines the electronic configuration of the conduction and valence band in semiconducting composites, altering the electronic and optoelectronic properties of composite nanostructures and quantum systems. Several strategies can be pursued to modify the interface of composite systems, aiming to maximize energy harvesting and storage, including broadening light absorbance to reduce solar light losses, fastening exciton dissociation and charge injection from the photoactive medium to the charge transporting materials, reducing charge recombination during charge transport and collection at the electrodes. A few examples of the application of nanocomposites will be discussed, including all-oxide coaxial p-n junction nanowire photodetectors and solar cells, core-shell quantum dot fluorophores for high-efficiency luminescent solar concentrators, composite sulfides for hydrogen generation, and low bandgap semiconductor for selective solar absorption. Emphasis will be given to the role of interface engineering in improving the efficiency of energy conversion in different systems, spanning from electric power generation from Sunlight to chemical fuel production, to conversion of heat lost through thermoelectric materials.

Keywords: p-n junction nanowires, quantum dots, luminescent solar concentrators, solar cells, selective solar absorbers.

Recent Publications (maximum 5)

1. Ghamgosar, P. et al. Nano Energy 2018, 51: 308.
2. Zhao, H. et al. Energy & Environmental Science, 2021, 14: 396.
3. Zhou, Y. et al. Advanced Energy Materials, 2016, 6: 1501913.
4. Solomon, G. et al. Advanced Energy Materials, 2021, 11 (32): 2101324.
5. Taranova, A. et al. Nature Communications 2023, 14: 7280.

Biography (150-word limit)

Alberto Vomiero (PhD in Electronic Engineering, 2003) holds the chair of experimental physics at the Luleå University of Technology, Sweden and the chair of industrial engineering at Ca' Foscari University of Venice. He is leading two research groups working on composite nanomaterials for environmental applications. He published >250 papers and 6 book chapters. He is former Marie Curie international outgoing fellow of the European Commission, and fellow of several Societies. He is associate editor of Nano Energy (Elsevier) and editorial board member of Small (Wiley), Scientific Reports (Nature Publishing Group) and other journals. Since 2024 he is co-Chair-holder of a UNESCO Chair on Technologies and Materials for Green and Energy Applications (AID4GEA).

Email: alberto.vomiero@ltu.se