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Editorial

Multiscale Modeling of Photovoltaic Devices

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Renewable energy sources are among the most important ingredients for the development of a human society with sustainable environmental footprint. Among these, photovoltaics (PV) plays a key role and is therefore a field of intense research. The key parameters of a solar cell technology includes not only the energy conversion efficiency but also the operating lifetime and the overall cost of the energy produced. The latter must also be compared with other energy sources. The optimization of all these different aspects involves research across the whole photovoltaics value chain, starting from material science up to system optimization. Development of new solar cell device concepts is as important as search for new materials with more suitable optoelectronic properties or improved approaches for PV module design and integration in power distribution systems. This requires a comprehensive view on PV technology across all scales, from the atomic to the macroscopic and industrial scale.

An important aspect of PV research and of development of new devices and systems, is theoretical modeling as an indispensable tool for both basic understanding and device optimization. This involves modeling also on all scales, from the microscopic properties of materials and nanostructures up to the behavior of PV modules.

During the last decade, multiscale approaches have seen increasing interest for application in numerical simulation of electronic devices. In particular, modeling and understanding of advanced photovoltaic devices are expected to benefit from multiscale modeling, which allows describing consistently both macroscopic device behavior and local microscopic processes governing light absorption, loss mechanisms, carrier transport, and extraction. In fact, many advanced PV concepts rely on effects or contain structural features that are insufficiently described by standard numerical simulation approaches or semianalytic models, both regarding electronic and optical properties. The different length scales of the electronic and optical degrees of freedoms specifically lead to an intrinsic need for multiscale simulation, which is accentuated in many advanced photovoltaics concepts including nanostructured regions. Moreover, the active layers in solar cells generally require to have a certain thickness and a large overall device area, in order to absorb a sufficient amount of light.

This special issue is an attempt to collect articles on modeling of PV devices and systems on all scales. It includes two experimental articles, one shedding some light on photoreflectance measurements when probing above the pump beam energy and the other discussing morphology in hybrid lead halide perovskite solar cells. One article describes numerical modeling of Cu_2O on Si tandem cells based on a semiempirical approach. A further contribution shows a physics-based model of a quantum dot solar cell, including a comparison with experimental data. The remaining two papers deal with system relevant aspects, namely, power point tracking and electrical inverters for connecting PV modules or power plants with appliances.

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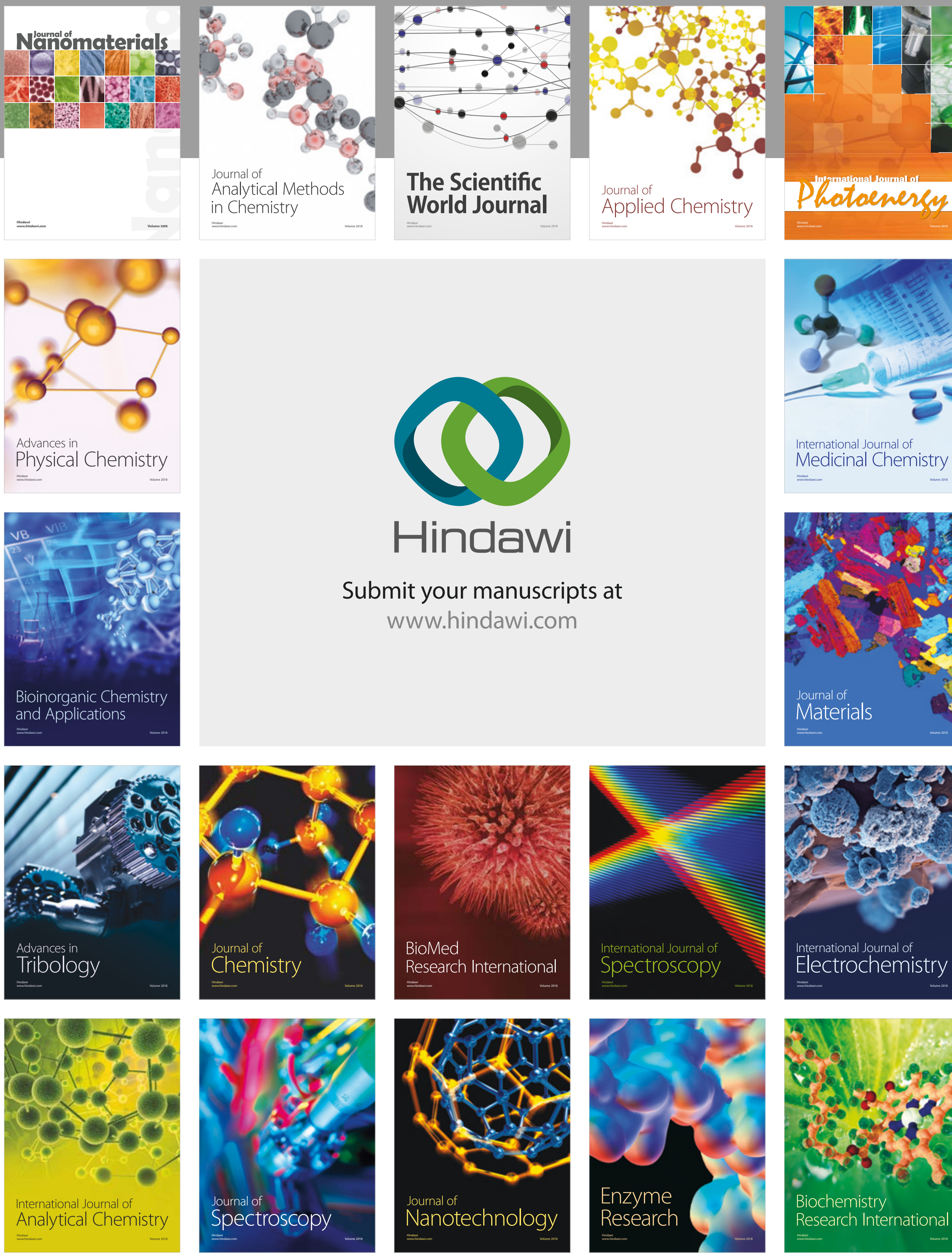
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