NOVEL PHYSICAL APPROACHES TO HIGH EFFICIENCY PHOTOVOLTAICS

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Abstract

Renewable energies are increasingly becoming economic around the world. And yet, higher efficiency remains of great interest because a small increment in efficiency has much greater effects on systems viability. Yet efforts to inccrease efficiency become harder as solar cell designs approach their efficiency limits. The solutions to make this progress easier are to attempt to identify new methods of reducing the well-known fundamental loss mechanisms, which are thermalisation and optical losses in short. The concepts intending to bring these new solutions are generally known as third generation concepts. These attempt to bring new solutions to bear from a range of perspectives in both organic and inorganic systems. This work reviews some advances in some of these ideas, looking at semi-empirical modelling of nanostructured quantum-confined systems, and the possibility of exploiting hot carrier phenomena, and of light management strategies reducing, in particular, the radiative recombination losses. Both concepts involve introducing anisotropies (electronic, optical, and material) and designing structures which can exploit them. These concepts are illustrated by results from the French ANR project MULTISOLSI which presents a design for multispectral solar cells on silicon. This introduces the main topic of this contribution, which is the analytical and experimental range of techniques needed to address these problems. The use of quantum confined structures requires understanding of electrical and optical physical phenomena on a meso-scale of nanometres or below. The understanding for these mesoscale dynamics relies on understanding at the underlying atomistic level. These atomistic and mesoscale levels must then be fed into the device scale level to model these third generation structures. This is therefore a multiscale approach which is necessary for the full understanding and exploitation of these next generation devices. After this introduction by surveying existing semi-empirical models and some promising results they produce, we progress to multiscale solutions capable of resolving the remaining questions. We present a COST action, MultiscaleSolar, which gathers partners in Europe and beyond. This is develop ing an experimental and theoretical European collaboration bringing an interdisciplinary approach to the question of high efficiency next generation solar cells.

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