Using Nanocavity Plasmons to Improve Solar Cell Efficiency

Bruno Soares, Sumeet Mahajan, Andrew Campbell, Neil Greenham, Stefan Guldin, Sven Huettner Ulli Steiner, Jeremy Baumberg
Department of Physics , University of Cambridge, United Kingdom
Tel: +44(0)1223761669, Fax: +44 (0)1223 764515, e-mail: b.f.soares@phy.cam.ac.uk

ABSTRACT
Although in principle very promising, photovoltaic technology has so far failed to deliver robust high efficiency modules at affordable prices. Despite considerable research, high efficiency silicon based cells remain expensive, while the more recent organic photovoltaics are still struggling with low efficiencies and short lifetimes. Meanwhile, over the last few years, the study of localized plasmons [1,2] has also received great attention due to the high field enhancements associated with confined fields , with a wide range of applications possible, from optical switches to substrates for surface enhanced Raman spectroscopy (SERS).

Here we discuss how combining the structures normally used in photovoltaic devices with metallic cavities supporting localized plasmons can lead to considerable improvements in the performance of solar cells. In particular we show how by changing the shape and size of spherical voids on a metallic surface, one can tune the plasmon modes to obtain significant absorptions across the solar spectrum [3]. By coating one such nanocavity surface with a sub 100 nm-layer of semiconductor, we can create a nanostructured solar cell, where the localised Mie modes efficiently couple light into the semiconductor layer. As the plasmons electric field enhancement is largest very close to the surface, significant absorption can be maintained even when the semiconductor thickness is reduced to below the typical exciton diffusion length. In addition minority carrier transport is improved. That means we can beat the usual balance between light absorption and exciton recombination loses, and so significantly increase the overall efficiency of the photovoltaic devices.
Keywords: plasmons, solar cells, nanostructured surfaces.

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