Ultrafast carrier dynamics on nanostructured materials

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The influence of the morphology of the material (structure, roughness, composition) on the ultrafast opto-electronic interactions is investigated on inorganic, organic and hybrid materials.

Wide band gap semiconductors are important due to their optical response at ultraviolet wavelengths. ZnO with a nominal band gap at 3.37 eV is one of them. Specially prepared ZnO surfaces alter significantly the mechanical thermal and optical properties. These newly developed surfaces offer possibilities in a cross disciplinary variety of applications ranging from photovoltaic elements to bio-active materials.

In order to understand a variety of properties of such materials one needs to investigate the primary processes that occur following their excitation. A variety of intrinsic and extrinsic defects (impurities, vacancies and others) introduce a high degree of complexity in the ultrafast electronic and lattice interactions. These ultrafast properties are investigated by using pump-probe experiments [1]. It was found that electron scattering and trapping occurs more efficiently to the nanostructured surface than on a flat ZnO film. This is attributed to the defects and imperfections that are introduced by the micro-conical shape and the nanometer-sized roughness.

In continuing experiments we investigate the influence of the characteristics of nanostructured hybrid (organic-inorganic) solar cells on their photovoltaic response and long term performance. The photoresponse mechanism is based on the ultrafast photogeneration, dissociation and recombination of excitons as well as transport of the generated charge towards the electrodes. The effect of the composition of the material as well as the structural/morphological characteristics of the photoactive layer and the overall architecture on the above mechanisms is being investigated.

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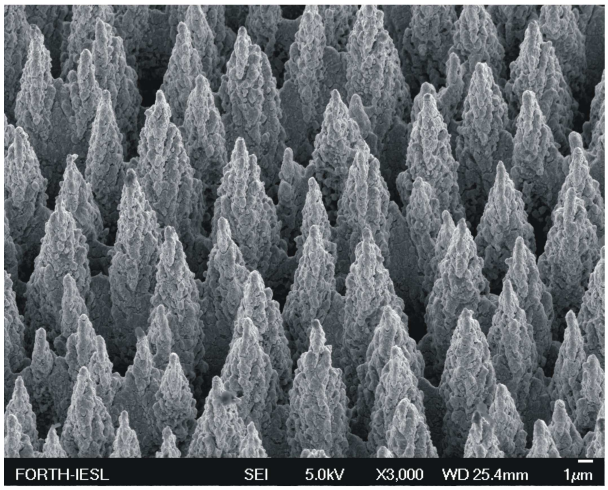

Fig. 1 An example of a specially prepared and processed surface: ZnO thin films deposited with Pulsed Laser Deposition on a Si substrate whose surface has been treated with femtosecond lasers so as to form micro-cones.

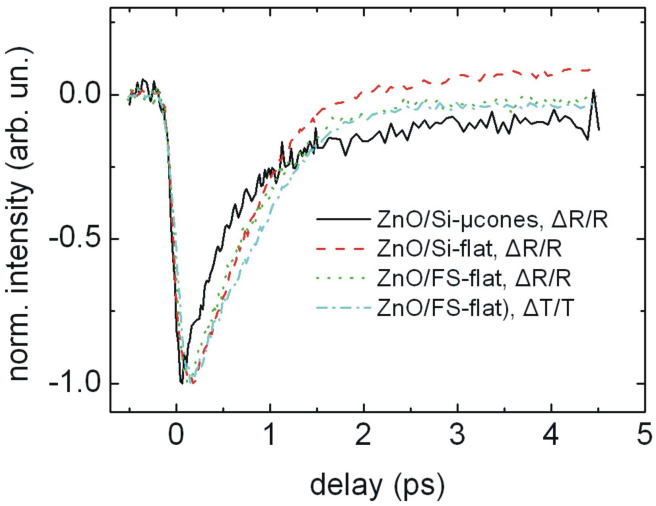

Fig. 2 Ultrafast pump-probe measurements of ZnO thin films on flat and on micro-conical Si substrates. The dynamics in the micro-conical structures is faster due to the introduction of defects by the conical shape and the decorative protrusions [1].

References

[1] E. Magoulakis, E. L. Papadopoulou, E. Stratakis, C. Fotakis, and P. A. Loukakos, Appl. Phys. A **98** 701 (2010).