Nanoparticle assemblies – advanced diagnostics and applications

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Nanotechnology and nanoscience need new approaches in diagnostics, enabling a deeper insight into the structure and processes at nanoscale. In particular, extensive research of 2D and 3D macroscopic nanoparticle assemblies with potential applications in plasmonics, nanooptics and smart sensors is conducted. New routes to directed or stimulated self-assembly are investigated in order to achieve a tight control of the process and tailoring specific properties.

The SAXS and GISAXS are the only techniques that provide statistically relevant and non-destructive quantitative information on the nanoparticle arrangement in terms of the crystallographic space group, lattice parameters, type of the lattice disorder or vertical correlation between the nanoparticle layers. In our contribution, we present a complex SAXS/GISAXS analysis of the formation of 2D and 3D nanoparticle assemblies formed from a colloidal solution by Langmuir-Schaeffer deposition or solvent evaporation.

A compact table-top GISAXS setup with low-energy consumption and experimental resolution approaching a synchrotron beamline that is applicable to both solid/air and liquid/air interfaces was developed at the Institute of Physics SAS. Details of the nanoparticle self-assembly process at the liquid/air interface was monitored by in-situ fast tracking time-resolved GISAXS. An unknown transient phase far from equilibrium was revealed at 2D-3D transition. A new paracrystal diffraction model for evaluation of the real structure of the supported 3D nanoparticle assemblies from experimental GISAXS patterns was introduced and applied to a study of spontaneous formation of a photonic crystal composed of plasmonic nanoparticles.

The application of transition oxide nanoparticle arrays in gas sensors for explosives detection and air pollution monitoring as well as employment of plasmonic nanoparticles for enhanced light harvesting in organic photovoltaic devices will be exemplified. Silica nanoparticle-based superhydrophobic coatings suitable for application on the multifunctional photovoltaic panels with increased photo-conversion efficiency will be presented.

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