Optical trapping and positioning of nanoparticles

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Optical forces are a consequence of the conservation of electromagnetic momentum in light-matter interaction. Two types of forces are at work in optical manipulation of nanoparticles: the gradient force, directed towards the beam focus, and the scattering force, directed along the beam propagation. If high numerical aperture objectives are used to focus the laser beam, the gradient force can overwhelm scattering forces and particles are optically trapped in the beam focus. However, even when the trapping is unstable, optical forces can be still used to push nanoparticles towards a surface.

In this work, recent results on the optical manipulation of h-BN, MoS_2 and WS_2 nanosheets are discussed. We use optical forces for high-resolution structural characterization and Raman spectroscopy of hBN in optical tweezers. The analysis of the thermal fluctuations allows a measurement the mean flake size directly in a liquid environment. In contrast, strongly absorbing nanosheets of MoS_2 and WS_2 are not stably trapped due to the dominance of radiation pressure over the optical trapping force. In this case, optical forces are used to pattern a substrate by selectively depositing nanosheets in short times (minutes) and without any preparation of the surface. This study will be useful for improving ink-jet printing and for a better engineering of optoelectronic devices based on two-dimensional materials.