Label-free optical nanoscopy of graphene

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The application of ultrafast pulsed laser sources and spectroscopic techniques in microscopy allows the development of novel label-free, deep-tissue optical methods. However, the circumvention of the diffraction limit in this framework is still a challenge. Non-linear optical microscopy goes together with the exploitation of the near-infrared (near-IR) part of the spectrum. It was mainly introduced to overcome the scattering problem in fluorescence imaging of thick samples, resulting in an increase in imaging depth, in a greater molecular specificity, and in an enhancement of contrast and resolution [1]. Among such approaches, pump-probe microscopy is of increasing interest thanks to its highly specific non-fluorescent-based contrast mechanisms for the imaging of material and life science samples. It opens the possibility to explore saturation and differential techniques for the circumvention of the diffraction limit also in non-fluorescence-based methods [2,3,4]. We present a custom femtosecond-pulsed near-infrared pump-probe microscope, which exploits transient absorption and stimulated Raman scattering interactions. In our pump-probe microscope, two femtosecond pulsed laser beams are coupled with a commercial confocal Nikon microscope. They are generated by an OPO (Optical Parametric Oscillator), which is pumped by a mode-locked Ti:sapphire laser. We explore the ultrafast (sub-picosecond) dynamic properties of the sample with high spatial and temporal resolution, and high sensitivity. The pump is absorbed by the sample, inducing a measurable change in its carrier population, which is then monitored by a delayed probe pulse. The probe intensity variations are filtered from the background with shot-noise-limited sensitivity using a fast intensity modulation and a lock-in amplifier. The superimposition of a third doughnut shaped beam allows to investigate super-resolution capabilities, taking advantage of spatially controlled absorption saturation effects [5]. By optimizing the acquisition parameters, such as power and temporal overlap of the saturation beam, we can image single layer graphene deposited on a glass surface at the nanoscale. These results suggest that saturation pump-probe nanoscopy is a promising tool for label-free high-resolution imaging.
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