Oxidative/reduction effect in ultrafast laser´s patterning of graphene and graphene oxide

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The optical methods of graphene processing can be classified as photochemical processing, typically based on far and mid-UV light oxidation using ozone and active oxygen generation and photo-physical processing based on ultrafast (or/and high power) laser light absorption with phonon heating and thermo-elastic ablation. The threshold energy for graphene ablation (the minimum energy per one pulse required for graphene destruction) by ultrafast lasers strongly depends on pulse duration and photon energy.

Despite a number of results in laser processing of graphene, to our knowledge, the role of topological defects and imperfections like bilayer flakes and wrinkles as well as impact of trapped water on ultrafast laser pulsed irradiation of large-scale CVD single-layer graphene have been never reported before. In this work we investigate the effect of ps- and fs-laser pulses on the photo-induced oxidation (functionalization) of graphene as well as on reduction of graphene oxide in normal condition. The role of photochemical and photo-thermal effects, as well as the influence of trapped water, are discussed here in comparative study of transferred single-layer CVD graphene containing a certain amount of bilayer islands and wrinkles onto Si/SiO2 substrate and graphene oxide film on PEN substrate.

We investigated the difference and similarities in the processes of graphene oxidation and GO film reduction by the same laser. We found the threshold energy is equal for both processes as well as for carbon nanotube film patterning.

The AFM. XPS, Raman, SEM investigations were performed to reveal the mechanism of laser-carbon bond interactions.

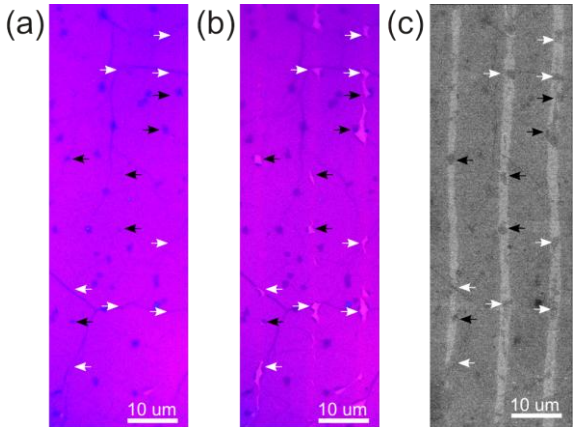

Fig. 1. Laser induced effects at near threshold energy fluence: (a) before and (b and c) after laser processing. Scale bar 10 µm.

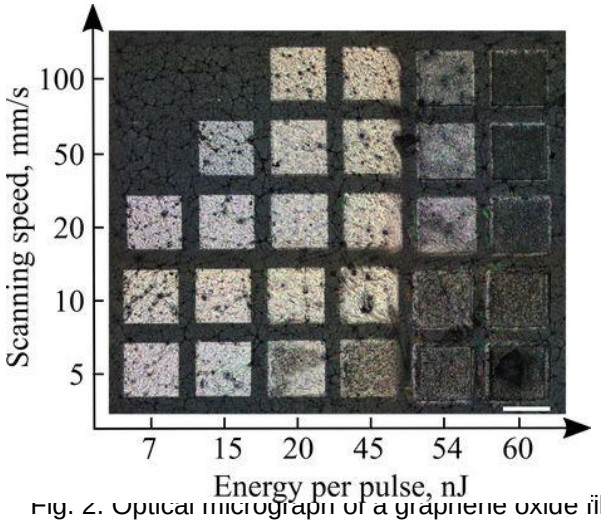

Fig. 2. Optical micrograph of a graphene oxide film exposed to a fs-laser with different pulse energy and scanning speed. Scale bar, 250 µm.