Generation of graphene nano-sieves by ultrashort laser pulses

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Femtosecond lasers have become an advanced tool in the field of micromachining due to their extensive use for the processing of advanced materials [1]. Their ultrashort light pulses combined with high peak powers offer unique advantages such as sub-micrometer spatial resolution, repeatability, non-contact processing and non-thermal heating of the affected area [2]. In this context, femtosecond laser illumination for patterning or engineering defects on graphene can be utilized for the fabrication of graphene nano-sieves.

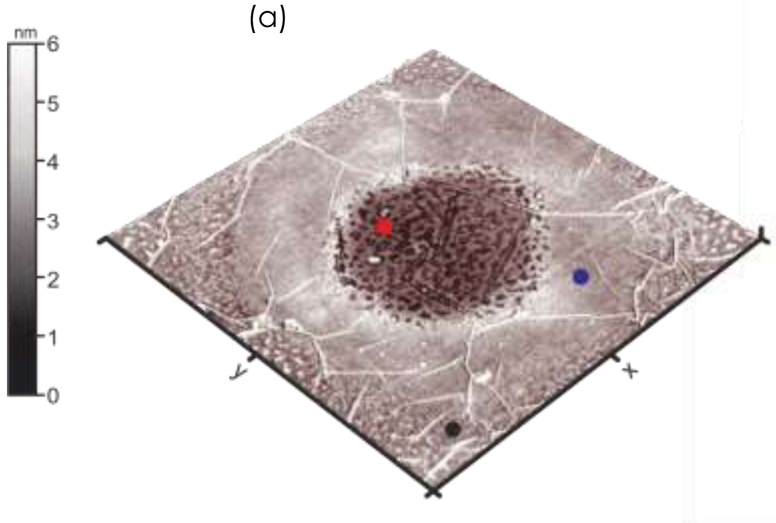
In our experiments we irradiated monolayer CVD graphene on SiO_2 substrates, with low energy femtosecond laser pulses by varying: a) the laser fluence from 1.6 to 50.9 mJ/cm^2 at a constant exposure time of 20s and b) the irradiation time from 1 up to 500s at laser power of 4.8 mJ/cm^2. At each spot, three topographically distinct regions are clearly visible. The outer region is a non-irradiated area, the ring flatter area where only wrinkles are discriminated and the inner circular area (fig.1a) where the black spots correspond to the nanopores of a circular sieve with diameter of 1.3 μm.

Figure 1b illustrates three indicative Raman spectra in the range 1200 - 3000 cm^{-1} recorded at the locations denoted with the coloured circles in fig. 1a. G and 2D band characteristics and peaks associated with defected areas (D, D') are used to identify and distinguish the nanopore area. Therefore, we show how Raman microscopy in combination with AFM imaging can be utilized to quickly identify the graphene nano-sieve formed by ultrashort pulse irradiation.

References

[1] Gattass, R.R. and E. Mazur, Nature Photonics, 2 (2008) 219.
[2] Feng, N. and J. Yong, Frontiers in Chemistry, 8 (2020) 884.

Figures



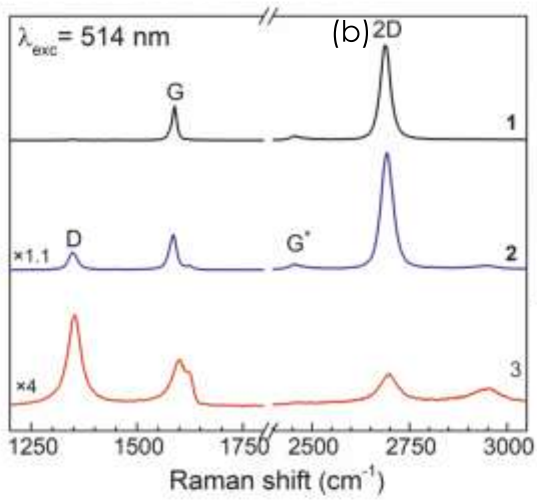


Figure 1: (a) A 3D topography AFM image (3x3 μm^2) of graphene at an irradiated spot. The black spots in the central area with diameter of 1.3 μm correspond to the created nanopores. (b) Raman spectra recorded at the locations denoted with the coloured circles in (a).