Pulsed Laser Engineering and Diagnostics of Graphene and Two-Dimensional Materials

Emmanuel Stratakis

Institute of Electronic Structure and Laser, Foundation for Research & Technology Hellas, (IESL-FORTH), P.O. Box 1527, Heraklion 711 10, Greece.
stratak@iesl.forth.gr

We focus on the application of advanced laser based techniques for the synthesis and diagnostics of 2D materials used in photovoltaics and nanoelectronics. In particular, the pulsed laser assisted fabrication of transparent graphene electrodes and interlayers for flexible photovoltaic devices, is demonstrated [1]. Furthermore, we present a fast and non-destructive photochemical method for tunable doping of transition metal dichalcogenide (TMD) crystals [2]. The reversible electron density control in chlorine-doped TMD monolayers by pulsed laser irradiation in chlorine gas atmosphere is particularly demonstrated. A systematic red-shift in the PL energy of the neutral exciton indicates a reduction of the crystal's electron density (Fig. 1). In the second part, we present an all-optical, non-invasive ultrafast laser-scanning microscopy method to resolve the crystallographic imperfections of atomically thin TMD nanocrystals, via experimentally probing and theoretically interpreting their nonlinear optical properties [4]. In particular, we show that polarization resolved second harmonic generation (PSHG) imaging reveals with high-precision a pixel-by-pixel mapping of the armchair orientations on a CVD-grown TMD samples (Fig. 2). This allows us to measure the mean orientational average of armchair angle distributions from specific regions of interest and consequently to define the standard deviation of these distributions as a crystal quality factor. Furthermore the same method can be used to optically identify the twist angle in stacked layers of different armchair orientation [5]. We envisage our methodology as a new tool for the discovery of new phenomena in twisted 2D layers.

References

[1] Konios et al., Adv. Func. Materials, 25, 2213 (2015)
[2] Stratakis et al., Nanoscale, 6, 6925(2014)
[3] Demeridou et al., 2D Materials 6, 015003 (2018)
[4] Psilodimitrakopoulos et al., Light: Science & Applications 7, 18005 (2018)
[5] Psilodimitrakopoulos et al., arXiv:1903.02431

Figures

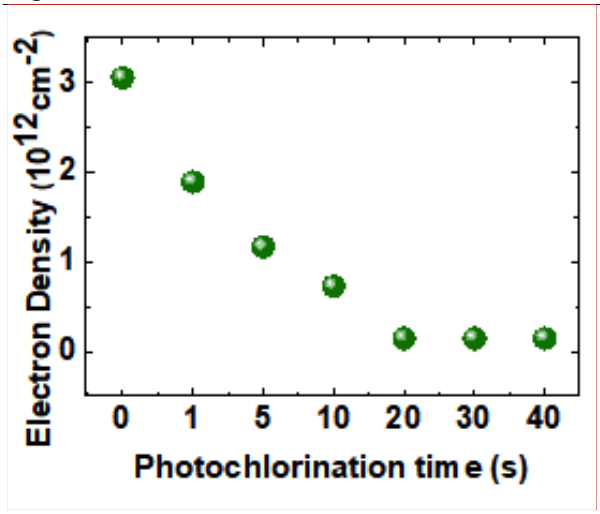

Figure 1: Evolution of the electron density with the photochlorination time.

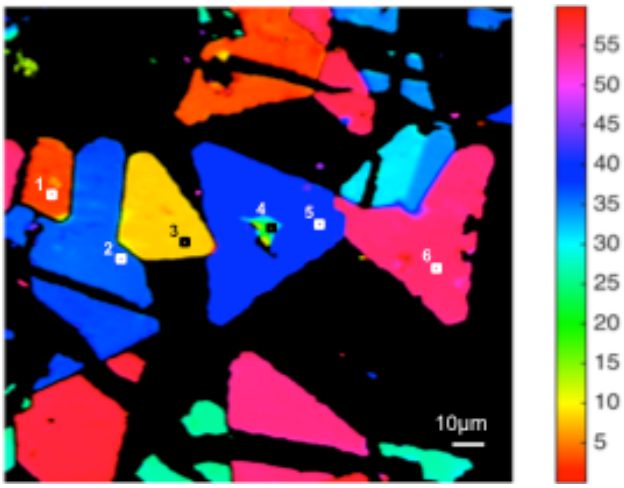

Figure 2: Mapping of the armchair orientations via PSHG on CVD grown WS_2 monolayers.