

# Photochemical doping of Graphene and Transition metal Dichalcogenides

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Photochemistry may provide novel ways to covalently modify materials, thus tailoring its electronic and chemical properties. Due to the unique physicochemical processes taking place during the ultrashort pulsed laser-matter interaction, the surface of nanomaterials can be activated, allowing the chemical reaction with different moieties present in the surrounding medium, giving rise to novel materials production. This paper will present our recent work on the application of pulsed laser radiation for the photochemical modification of graphene oxide (GO) and transition metal dichalcogenide (TMD) nanosheets. In particular we report on a present a fast, non-destructive and roll to roll compatible photochemical method for the simultaneous partial reduction and doping of GO nanosheets through ultraviolet laser irradiation in the presence of reactive  $\text{Cl}_2$  precursor molecules (Figure 1). By tuning the laser exposure time, it is possible to control the doping and reduction levels and therefore to tailor the work function (WF) of the GO-Cl derivatives from 4.9 eV to a maximum value of 5.23 eV, a WF value that matches the HOMO level of most polymer donors employed in organic photovoltaic devices [1]. It is also found that the same photochemical approach is ideal to sufficiently control the carrier density of a single  $\text{MX}_2$  layer by incorporating chlorine atoms on the surface. Photochlorination leads to a controllable reduction of the valley polarization (VP) degree, that is directly related to the decrease of the active defect sites and consequently to the increase of the non-radiative exciton lifetime [2]. The non-linear optical properties of the pristine and photochemically-doped nanosheets are also investigated and discussed.

## References

- [1] E Stratakis et al, *Nanoscale*, **6**, 6925 (2014).  
 [2] I Demeridou et al *2D Mater.* **6**, 015003 (2019).

## Figures

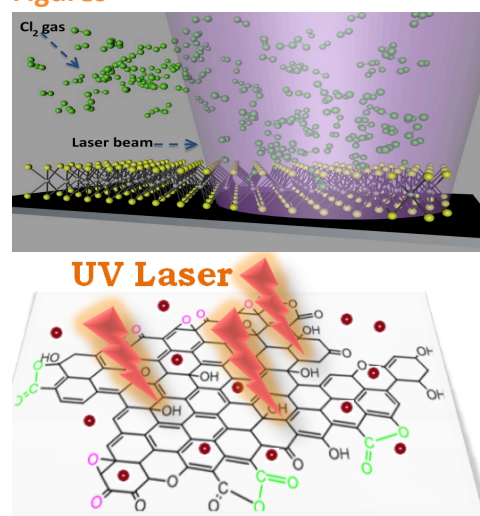


Figure 1. Schematic of the photochlorination of TMDs and GO nanosheets

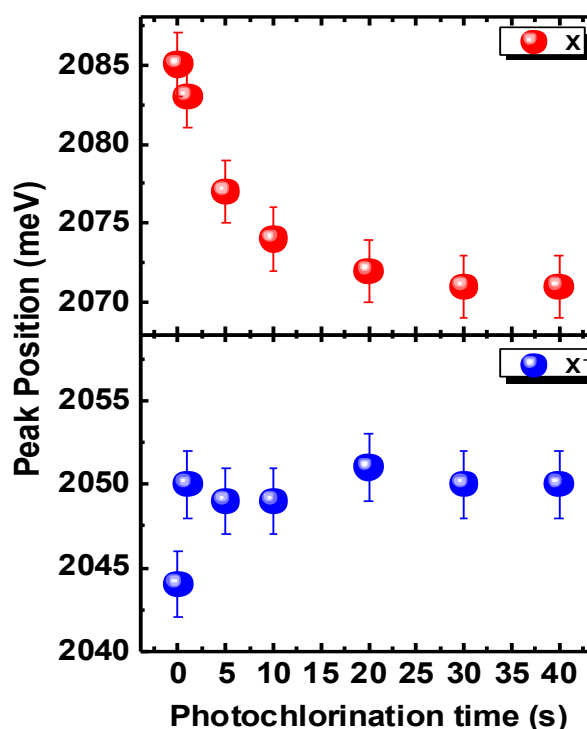


Figure 2. Evolution of the excitonic peaks of a  $\text{WS}_2$  monolayer as a function of the photochlorination time