Photoluminescence Measurements from Liquid-Phase Exfoliated Dispersions of Inorganic Layered Materials

Keith R. Paton[1*], Claudia Backes[1], Damien Hanlon[1], and Jonathan N. Coleman[1]

[1*] AMBER, Trinity College Dublin, Dublin, Ireland
[2] School of Physics, Trinity College Dublin, Dublin, Ireland

The range of layered materials beyond graphene are have recently begun to attract the level of attention that had previously been attributed to graphene[1]. These materials offer a range of properties that, when combined in novel combinations, offer the possibility of fully integrated devices formed from 2D materials. Liquid-phase exfoliation (LPE) of these materials is now well established as a viable route for the production of these materials. In particular, LPE provides a route to obtain high-quality and defect free flakes of these materials in easily processable form[2,3]. The liquid dispersion produced by this approach can be easily incorporated into established deposition and printing techniques, such as ink-jet printing, screen printing and spray coating[4,5].

Although a large range of these materials have been successfully exfoliated in liquids, there are notable gaps in the in the characterization of these materials. This paper will describe recent work in the rapid characterization of exfoliated flakes of 2D materials in liquids. UV-vis absorption spectroscopy can be used to measure the lateral size and thickness of the flakes of transition metal dichalcogenide (TMD) materials[6]. This approach is also shown to be able to be extended to provide information of the thickness of graphene flakes in dispersion.

Many TMD materials show a transition in their band-structure to produce a direct band-gap, and a resulting enhancement in the photoluminescence (PL) signal. It will be shown that this photoluminescence can be measured directly from the dispersions of these materials for a wide range of inorganic layered materials (figure 1). For dispersions of black phosphorous, differences were seen in the position and width of the PL peak with variation in layer number. Furthermore, by using a raman spectrometer, the photoluminescence and raman signals can be recorded simultaneously. As a result, the single-layer content can be quantified in a dispersion. This accelerates the optimization of production routes to enhance the monolayer content.

References

[1] R. Lv *et al.*, M. Terrones, Acc. Chem. Res. (2014).
[2] V. Nicolosi *et al.*, Science, 340 (2013) 1226419.
[3] K.R. Paton *et al*, Nat. Mater. 13 (2014) 624.
[4] D.J. Finn *et al.*, J. Mater. Chem. C 2 (2014) 925.
[5] F. Torrisi, J.N. Coleman, Nat. Nanotechnol. 9 (2014) 738.
[6] C. Backes *et al.*, Nat. Commun. 5 (2014) 4576.
[7] This research was supported by Graphene Flagship, Science Foundation Ireland, Intel and European Research Council.

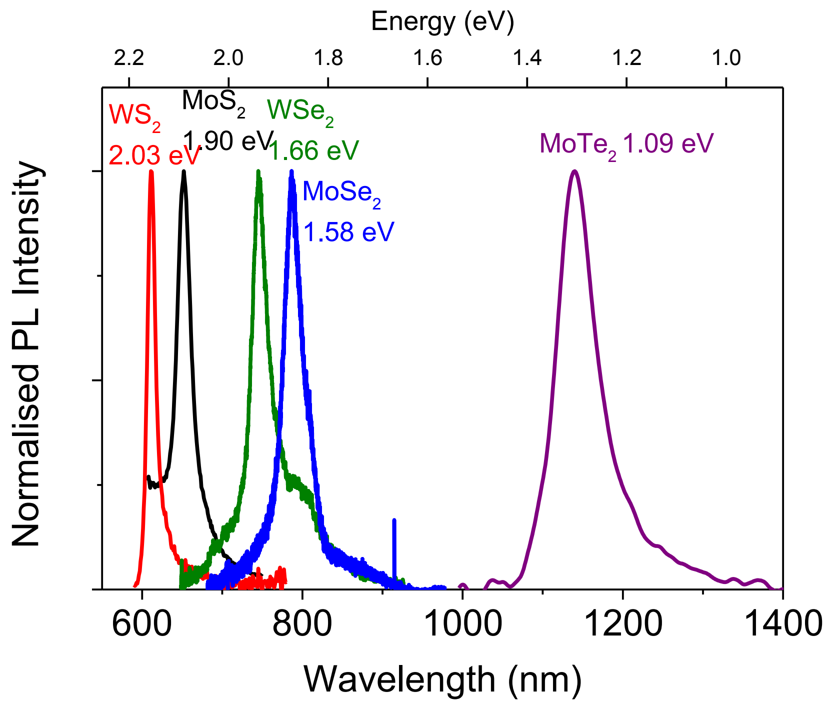

Figure 1: Photoluminescence measured from liquid dispersions of various TMD materials.