High yield production of large size few layer 2D crystals dispersions by wet-jet milling

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Abstract

Efficient and scalable two-dimensional (2D) crystals production methods are urgently needed for a rapid clearing of technological hurdles towards the development of a 2D crystals-based industry, satisfying the specific needs of different application areas. Although many approaches have been demonstrated and developed [1,2], the most promising methods for large scale production of 2D crystals rely on liquid phase exfoliation (LPE) of bulk layered crystals [3,4,5]. Currently, the LPE is largely based on ultrasonication, a time consuming process [5] which is emerging as the main limitation of this method. Recently, new approaches for the full exploitation of LPE of layered crystals have been proposed, with the aim to improve the ease of production and scalability [6].
Here we propose high pressure wet-jet milling (hp-WJM, Fig. a) as a novel approach for the exfoliation of layered crystals by LPE. This technique allows us to produce bulk quantities of 2D flakes in dispersion (Fig. b). For example, by exploiting hp-WJM we scaled the production of few-layer graphene (FLG) flakes in dispersion up to over 2 L/h, with a concentration higher than 10 g/L. This dispersion is characterized by large lateral size FLG flakes (Fig. c) with low defects concentration (Raman peak intensity ratio $I_D/I_G \approx 0.5$, Fig. d). The as-produced flakes are already suitable for many industrial applications such as polymer composites. A further processing step, i.e. purification by ultracentrifugation [7], allows the selection of the highest quality flakes, maintaining a still high concentration, i.e.,~1.1 g/L ($I_D/I_G \approx 0.47$, g-force ~500 g). The same method has been successfully applied to other layered crystals (e.g., BN, MoS_2, WS_2, WSe_2, Bi_2Te_3, just to cite a few). Our latest results on the production and processing of 2D crystals as well as their applications in Li batteries, composites, flexible conductors will be presented.

References

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Figures

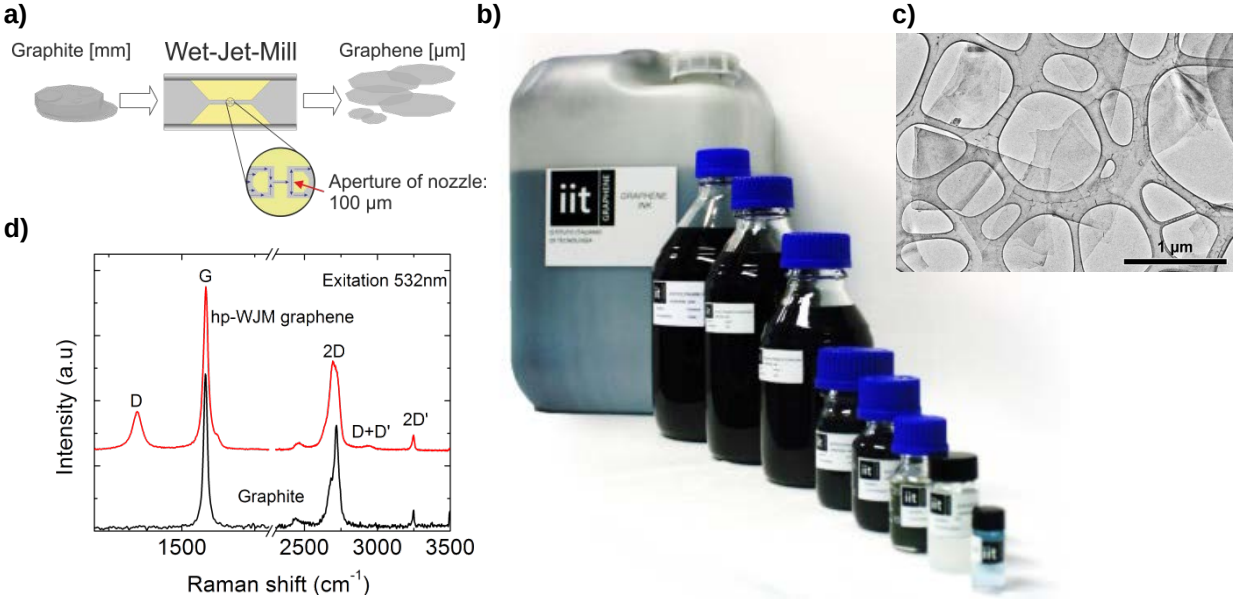

Figure: a) Scheme of the hp-WJM process, b) 2D crystal dispersions produced by hp-WJM; c) TEM image of micron size exfoliated FLG flakes; d) Raman spectra of FLG (red) and starting graphite (black).