

# Tungsten disulphide (ws2) thin films from “green” liquid exfoliation for wide applications

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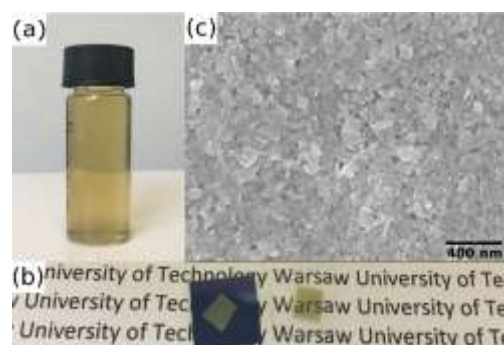
2D materials attracts huge attention due to their unique properties and opportunity for wide applications. One of the well-known representatives beside graphene, molybdenum disulfide and black phosphorus is tungsten disulphide (WS<sub>2</sub>).

Here, we present a novel method of producing a stable thin film of such flake's material. Firstly, a stable suspension was fabricated with “green” liquid exfoliation (LPE). “Green” LPE include a sonication process which run between mixture of DI water and isopropyl alcohol and bulk powder of exfoliated material. After completing the process, suspension is subjected to centrifugation and supernatant is then collected. Such made suspension is sequent filtered on cellulose membrane in vacuum filtration setup. The result of this step is formation a thin film which is next transferred of demand substrate (Si/SiO<sub>2</sub>, glass, gold, quartz) in acetone vapor. The transfer method is optimized specially for flake's materials.

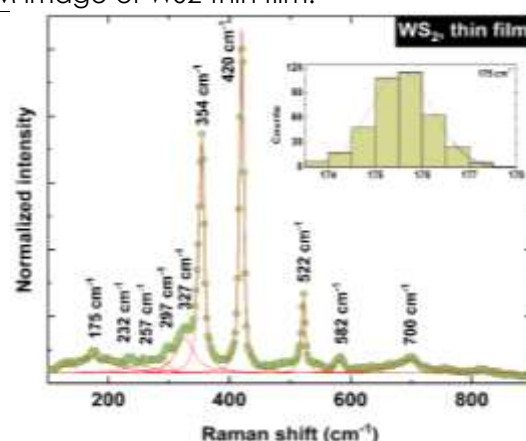
The samples transferred on Si/SiO<sub>2</sub> and glass were characterized using SEM, AFM, Raman spectroscopy. Additionally, optical and electrical measurements were performed. Also, the statistical analysis of flakes distribution and Raman modes were made.

Findings presented here are important in view of scalable production of defect-free 2D materials and further applications. The thin films presented here could be used for example as a simple electronic and optoelectronic devices.

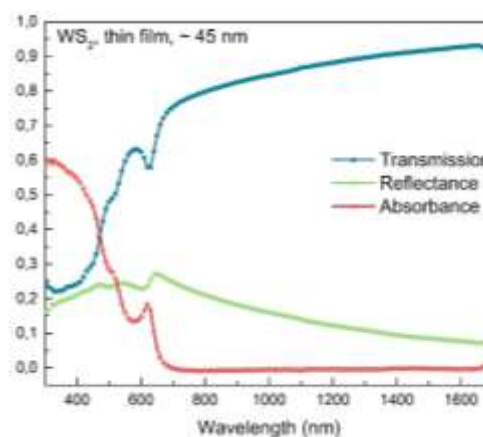
Figures



**Figure 1:** (a) WS<sub>2</sub> thin flakes suspension, (b) WS<sub>2</sub> thin films transferred on Si/SiO<sub>2</sub> and glass, (c) SEM image of WS<sub>2</sub> thin film.



**Figure 2:** A typical Raman spectrum obtained for WS<sub>2</sub>, laser wavelength:  $\lambda=514$  nm, RT, inset picture: statistical evolution of Raman position of 175 cm<sup>-2</sup> mode.



**Figure 3:** Optical characteristic of WS<sub>2</sub> thin film: absorbance, reflectance, transmittance.