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Graphene and tungsten disulfide nanosheets prepared using liquid phase exfoliation

○F.R. Bagsican[1], M. Ohshiro[1], K. Takayama[1], I. Kawayama[1], H. Murakami[1],
A. Winchester[2], S. Kittu[2], S. Talapatra[2], M. Tonouchi[1]
Osaka University[1], SIU – Carbondale[2]
E-mail: bagsican-f@ile.osaka-u.ac.jp

Atomically thin materials such as graphene and tungsten disulfide (WS_2) have many possible applications like in flexible electronics and solar cell technologies. But production by micromechanical cleavage or physical vapor deposition is impractical for industrial applications because of low yield. This can be overcome by using methods that exploit the fact that graphene (graphite) and WS_2 have structures with strong intraplanar forces but relatively weak interplanar interactions. In this study, we used liquid phase exfoliation to produce large quantities of graphene and WS_2 nanosheets from bulk powder samples.

The starting powder materials were annealed in argon atmosphere to remove any impurities present. Suspensions in isopropyl alcohol (IPA) of each of the powder materials were prepared and exfoliation was done using a sonic dismembrator at ~30W for 4 hours. The suspensions were centrifuged at 1500 rpm for 45 min to sediment any non-exfoliated particles. Supernatants were collected and subsequently used for drop casting on substrates with temperatures raised to ~80ºC to evaporate IPA. For sample characterization, AFM and Raman mapping (using 532nm excitation laser) measurements were taken.

AFM measurements of the films show features with sizes in the nanometer range (for graphene - RMS roughness is ~70nm and height measurements are 50nm-300nm; for WS_2 - RMS roughness is ~14nm and height measurements are 3nm-20nm). Fig.1 are the Raman measurements at different spots in the films as indicated in the optical images (inset photos). Fig. 1A shows the characteristic peaks for graphene at ~1580 cm^{-1} (G band), ~2700 cm^{-1} (G' band), and the defect-induced D band at ~1350 cm^{-1}. In Fig. 1B, the prominent peaks of WS_2 are blue-shifted with respect to the observed peaks for bulk sample (E_{2g} at 347 cm^{-1} and A_{1g} at 410 cm^{-1}) which might be stress-induced (because of substrate) or due to phonon confinement caused by the reduced crystal dimensions. THz-TDS data and estimated optical conductivities of samples will be also discussed.

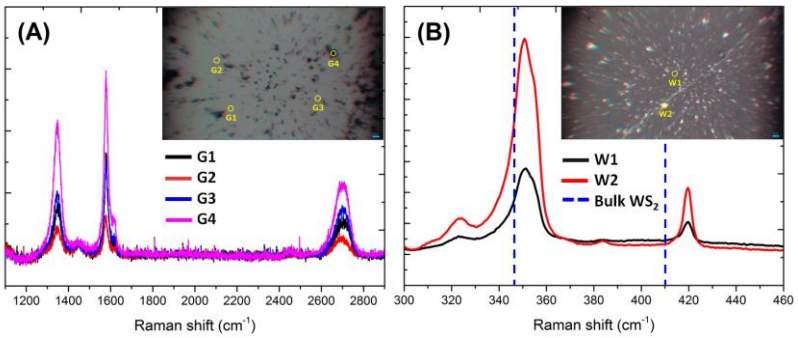

Fig. 1: Raman spectra of drop-casted (A) graphene and (B) WS_2 nanosheets taken at different spots in the films.

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