Scalable methodology for the direct synthesis of atomically thin WS_2 films

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Abstract

Tungsten disulfide (WS_2) in the monolayer form is a promising 2D material for the next generation of optoelectronic devices due to its direct bandgap in the visible [1]. However, the development of such technologies needs scalable synthesis processes able to provide WS_2 deposition with full control in terms of structural quality, thickness and, hence, optical properties.
In this contribution, we show the flexibility of a pure chemical methodology for depositing mono and few layer WS_2 films with defined layer structures on different substrates including SiO_2, Si, Al_2O_3, CVD- and epitaxial-graphene (van der Waals heterostructures). This CVD technique uses tungsten hexacarbonyl ($W(CO)_6$) and sulfur (S) as precursors and is based on a single step chemical mechanism ($W(CO)_6 + S_2$ ➔ $WS_2 + 6CO$) which allows a good control in the material growth (especially on the large area) compared with more traditional two step processes based on the metal oxide physical deposition and subsequent sulfurization [2]. A full chemical (Raman, EDS), structural (SEM, AFM) and optical characterization (photoluminescence and spectroscopic ellipsometry) of deposited WS_2 films is provided to give further insight to the optical response of WS_2 exciton system and its dependence on WS_2 films structural quality and interface nature, e.g. presence of an epitaxial relationship with the substrate or occurrence of charge transfer processes.

References

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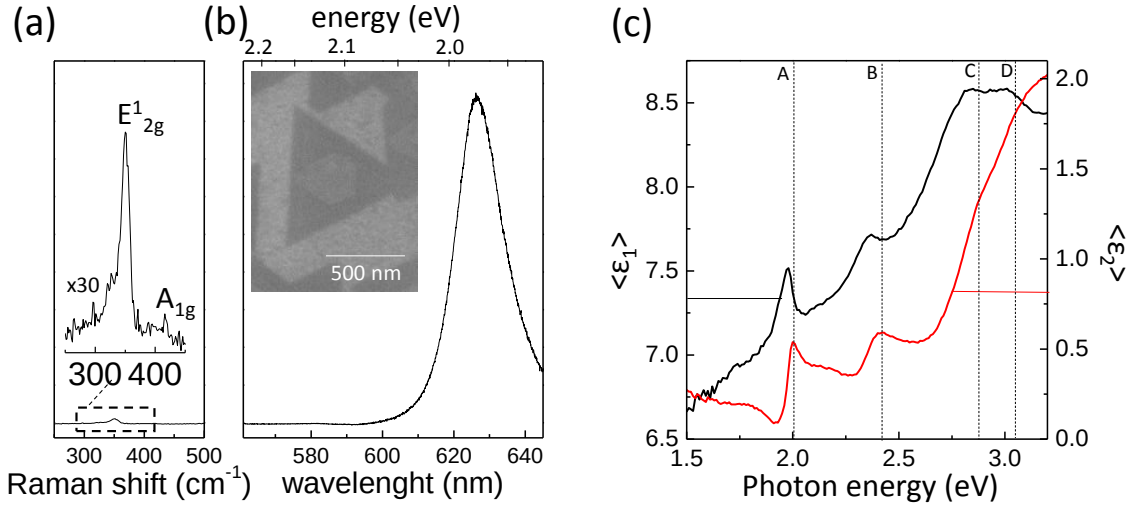

Figure. (a) Raman and (b) photoluminescence spectra (in the same intensity scale) of WS_2 film deposited on SiO_2 substrate (SEM image in the inset). (c) Ellipsometric spectra of the imaginary ($<\varepsilon_1>$) and real part ($<\varepsilon_2>$) of the pseudodielectric function ($\varepsilon = <\varepsilon_1> + <i\varepsilon_2>$) of WS_2 film on epitaxial graphene