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Unveiling nanoscale optical and structural properties of TMD monolayers using combined electron spectroscopies techniques

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In this contribution, we will present new results on optical and structural properties of WS2 (from the TMD semiconductor family) encapsulated monolayer, at the tens of nanometer scale. The strength of this work is the correlation of optical spectra at the nanoscale with structural and chemical maps, connecting what is usually available in optical diffraction limited techniques, such as photoluminescence (PL), and high spatial resolution techniques, such as electron microscopy or scanning tunneling microscopy.

To achieve this, high spatial and spectral resolution techniques were used in an aberration-corrected scanning transmission electron microscope (STEM). Electron energy loss spectroscopy (EELS) was used to obtain optical absorption (low loss range) and chemical analysis (core loss range).
Cathodoluminescence (CL), a nanoscale counterpart of PL, used was to measure light-emission at tens of nanometers scale. Both spectral information can be measured from the same regions in samples, at the tens of nanometer scale. With these combined information, one has access, for example, to the local Stokes shift, which is the difference between absorption and emission energies.

Using these optical absorption and emission techniques, we found very localized, down to ten nanometers, emission from the WS2 encapsulated monolayer, measured at 150K in a STEM microscope. To understand the origin of such localization, high resolution structural measurements were done, including atomically-resolved imaging and nanoscale diffraction, both giving access to local strain.

Language

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Field

Nanophysics, nano-optics, electron microscopy, electron spectroscopy, optical spectroscopy

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