Observation of defect-bound excitons in V-doped WS_2 monolayers

Bhumit Luhar[1]
Rahul Dhankhar[2]
Rajesh V. Nair[2]
Viswanath Balakrishnan[3, †]
[1] *School of Physical Sciences, Indian Institute of Technology Mandi, Kamand, Mandi H.P., India 175005*
[2] *Department of Physics, Indian Institute of Technology Ropar, Rupnagar, Punjab India 140001*
[3] *School of Mechanical and Materials Engineering, Indian Institute of Technology Mandi, Kamand, Mandi H.P., India 175005*
[†] *Corresponding author*
viswa@iitmandi.ac.in

Abstract

Localized and defect-bound excitons in monolayer transition metal dichalcogenides are the subject of enormous interest and intense research due to their wide range of applications in sensors, quantum light emitting diodes and other quantum technologies. Impurity induced in-gap states provide a platform to achieve the desired optical response from the two-dimensional TMDs. Previous reports emphasize the doped and disordered structures induce defect-bound excitonic emission. However, a distinct and prominent feature in photoluminescence had only been observed at cryogenic temperatures and realizing it at room temperature remains a challenge. Here, we observe a prominent defect-bound excitonic feature at room temperature ~150 meV below the characteristic emission line in V-doped WS_2 monolayer. V-doping introduces gap states causing the trapping of carriers and results in bound distinct emission line. While optimising the dopant concentration, defect feature starts dominating the luminescence in spectral weight, which appears the same in amplitude. Further systematic investigations of PL unveil the rise and dynamics of defect-bound excitons with increasing dopant concentration. The investigation opens a path to realize a distinct and stable defect-bound excitonic lines at room temperatures and demonstrates the use of chemically doped 2D materials for applications.

References

[1] Loh L, *et al. Nano Lett.* (2021) **21** 5293−5300

[2] He Y M, *et al. Nat. Nanotechnol.* (2015) **10** 497–502

[3] Johnson A D, *et al. Nano Lett.*(2017) **17** 4317–22

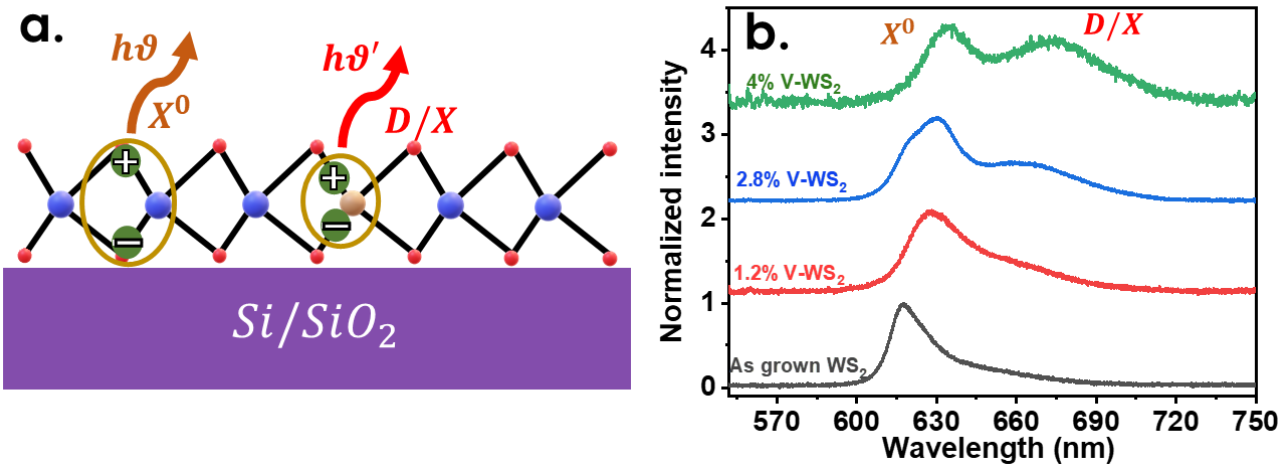

Figure 1: Presented figure show the photoluminescence emission form the dopant site, where a. schematically represents the emission from regular and defect site and b. present the photoluminescence spectra from V-WS_2 flakes with different V-concentrations.