Tunable Optical and Electronic Interactions in 2D WS_2/Cu_2O Heterostructures

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2D transition metal dichalcogenides (2D TMDCs), such as WS_2, exhibit remarkable optical properties, making them highly promising for electronic and optoelectronic applications in various heterostructures [1]. Among these, WS_2/Cu_2O has gained significant interest for use in solar cells and sensors [2]. However, a comprehensive understanding of its electrical and optical interactions remains elusive. This work investigates WS_2/Cu_2O heterostructures, where WS_2 is synthesized via chemical vapor deposition (CVD) and Cu_2O is deposited using spatial atomic layer deposition (SALD), a scalable and efficient method for fabricating high-quality Cu_2O thin films. The interplay between band alignment, interfacial defects, and the formation of a CuO surface layer leads to complex recombination dynamics, which we analyze using steady-state, low-temperature, and power-dependent photoluminescence (PL) spectroscopy. Additionally, Raman spectroscopy and Kelvin probe force microscopy (KPFM) provide further insights into the structural integrity and electronic behavior of the heterostructure. The presence of interlayer excitons at the WS_2/Cu_2O interface seen in figure 1, along with spectral overlap in their PL emissions, reveals diverse optoelectronic processes governing charge carrier transitions. Furthermore, we demonstrate that the PL emission energy can be tuned through SALD deposition parameters, offering a pathway for engineering the optical properties of the heterostructure. We believe that these insights provide a foundation for future research and optimization, facilitating the integration of WS_2/Cu_2O heterostructures into next-generation optoelectronic devices.

References

[1] Wang et al, Nature Nanotech, 7 (2012) 699–712
[2] Singh et al, Environ Sci Pollut Res, 30 (2023) 98718–98731

Figures

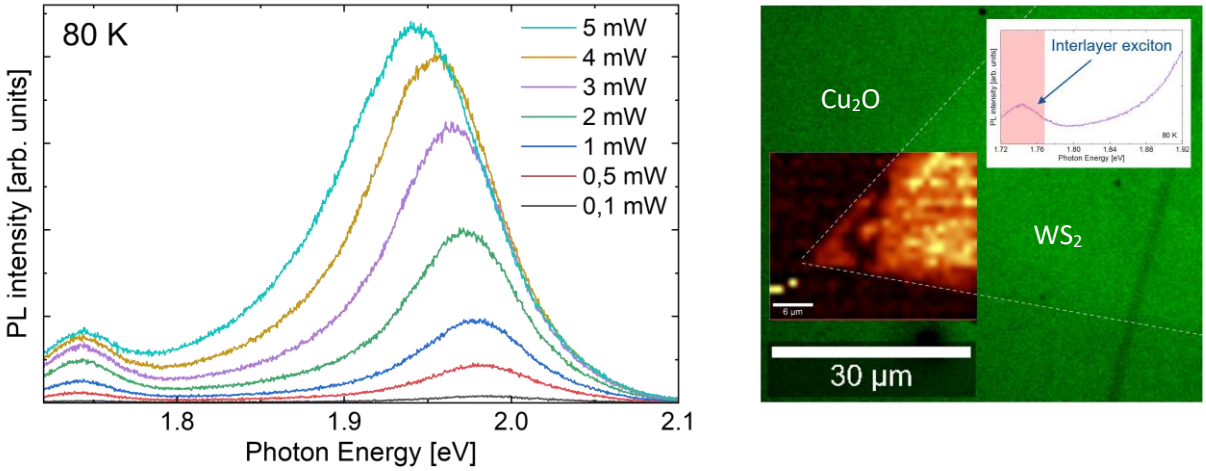

Figure 1: (Left) Power-dependant PL of WS_2 on Cu_2O. (right) PL map overlapped on a microscope image of WS2 with the energy region of the interlayer exciton showing the outline of the WS_2 flake.