Site-specific optical tuning and nanoscale integration of carbon nanostructures on monolayer WS_2

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Single layer WS_2 is among most researched two-dimensional (2D) materials due to its extraordinary performance in various applications like optoelectronics, sensing, catalysis and energy etc.[1] Chemical vapor deposition (CVD) is an important technique to grow large area and thickness controlled WS_2. Semiconductor 1H-WS_2 in its monolayer form possess bandgap of ~2 eV and fluorescence quantum yield of 6%.[2] Site specific tuning of optical properties and polarity is one of the fascinating challenges. E-beam is reported to have following effects on material: atom displacement, heating, sputtering, electrostatic charging, radiology, addition of contamination and removal of material.[3] Electron beam induced carbon deposition process was directly utilized to make patterns on single layer WS_2 (figure 1a and 1b). Atomic force microscopy and high-resolution transmission electron microscopy (figure 1c) proves deposition of C-based nanostructures on WS_2. The atomic level insights were extracted with Scanning transmission electron microscopy and electron energy loss spectroscopy. The shape and dimension of pattern can be manipulated by varying beam dose parameters. Spherical and 1D Patterns of size range from few microns to ~50 nm has been demonstrated. At C-WS_2 integration site ~3 times quenching in photoluminescence intensity and ~0.11 eV band-gap reduction was observed. Carbon can be used to tune polarity by inducing p-type doping in WS_2.[4] The results were found to be reproducible on MoS_2 as well. The systematic tuning of these nanoscale patterns has potential to set the trademark in the field of site-specific designing to change polarity and optical properties of 2D materials.

References

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Figures

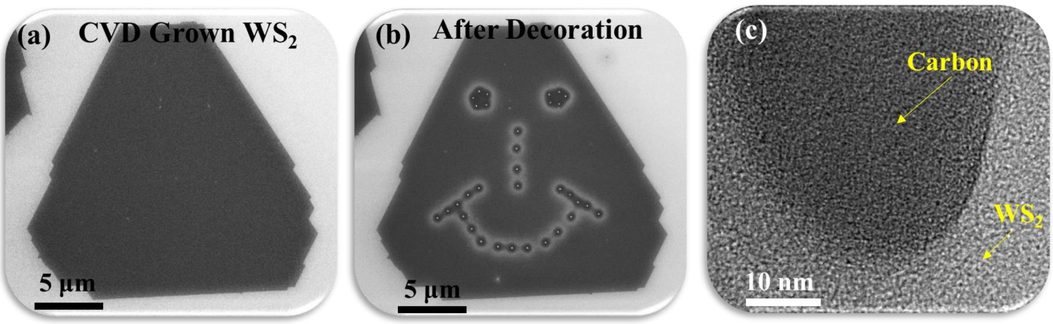

Figure1: Scanning electron microscope image of (a) CVD grown WS_2 and (b) Carbon integrated with WS_2 to design a cartoon face. (c) High-resolution transmission electron microscope image showing Carbon-WS_2 integration site.