Emergent Properties from WS2 Empowered by Laser Sculpting and Au Nanoparticles Landscaping

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Transition metal dichalcogenides (TMDs) show great potential as sensors and optoelectronic devices. To enhance their potential, methods to functionalize TMDs' fluorescence properties are of interest. WS2, a type of TMDs, is selected in this work as it exhibits strong optical properties that depend sensitively on structural and chemical heterogeneity. Putting gold nanoparticles (Au NPs) onto TMDs is common. One anticipates Au NPs to decorate on the edge and randomly within WS2. Surprisingly, Au NPs exhibit preferential, site-selective decoration that maps out interesting fluorescence pattern within the WS2 monolayers! In this process, Au NPs are nanoexplorers which reveal the heterogeneities in WS2. Photoluminescence (PL) emission from pristine WS2 monolayer exhibits a multitude of emissions from various excitons. Due to plasmonic effect, Au NPs decoration increases the fluorescence intensity of monolayers. But most remarkably, Au NPs sharpen the PL spectra by enhancing the density of neutral excitons. Au NPs help to clean up the system and improve the quality of emitted fluorescence. Bulk layer WS2 are deemed less important due to its lack of PL emission. Techniques are developed to transform bulk layers into useful systems. By combining laser sculpting and AuNPs decoration, hybrid AuNP-WS2 bulk layer with strong fluorescence is engineered. Laser sculpting creates high density AuNPs deposition, as it creates nucleation sites for Au NPs deposition. The application of the hybrid system as a detector of aromatic compounds has also been demonstrated. The improved functionalities of WS2 using Au NPs is anticipated in other TMDs. This work is a positive step towards practical sensing and optoelectronic applications in future.

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