Controlling photoluminescence of Molybdenum disulfide (MoS\textsubscript{2}) by molecular doping

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Atomically thin Molybdenum disulfide has been studied extensively because when the thickness of MoS\textsubscript{2} is reduced to a single layer, the latter no longer exhibits the indirect band gap typical of the bulk, but a 1.8 eV direct band gap and gives rise to strong photoluminescence even at room temperature.\textsuperscript{1} Chemical vapour deposition (CVD) has been the most effective method to obtain large domains of single layer MoS\textsubscript{2}.\textsuperscript{2} However, during the growth process sulfur vacancies are formed and influence the electronic properties.\textsuperscript{3} In this work we studied the photoluminescence (PL) of single layer MoS\textsubscript{2} upon functionalization with thiol-terminated molecules. We demonstrate that the PL intensity increases when p-type doping chemisorbed on single layer MoS\textsubscript{2}, while the PL intensity is reduced upon functionalization with an n-type dopant. This PL intensity variation is due to the switching between exciton and trion recombination PL, which depends on the carrier density in the single layer MoS\textsubscript{2}.\textsuperscript{4} We confirmed the chemical environment of MoS\textsubscript{2} before and after functionalization using X-ray photoemission spectroscopy (XPS), while Raman spectroscopy was employed to monitor the functionalization via the vibrational modes of MoS\textsubscript{2}. Since the dopant molecules are covalently bonded, the PL intensity is not affected by solvent exposure. This straightforward and effective approach of controlling the PL by molecular doping enables a robust MoS\textsubscript{2} system, which is essential for optoelectronic applications.

References


Figures

Figure 1: Schematic illustration of surface charge transfer between MoS\textsubscript{2} and dopant molecules