

Controlling photoluminescence of Molybdenum disulfide (MoS₂) by molecular doping

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Atomically thin Molybdenum disulfide has been studied extensively because when the thickness of MoS₂ 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.¹ Chemical vapour deposition (CVD) has been the most effective method to obtain large domains of single layer MoS₂.² However, during the growth process sulfur vacancies are formed and influence the electronic properties.³ In this work we studied the photoluminescence (PL) of single layer MoS₂ upon functionalization with thiol-terminated molecules. We demonstrate that the PL intensity increases when p-type doping chemisorb on single layer MoS₂, 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 MoS₂.⁴ We confirmed the chemical environment of MoS₂ before and after functionalization using X-ray photoemission spectroscopy (XPS), while Raman spectroscopy was employed to monitor the functionalization via the vibrational modes of MoS₂. 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 MoS₂ system, which is essential for optoelectronic applications.

References

- [1] K. F. Mak, C. Lee, J. Hone, J. Shan and T. F. Heinz, *Phys. Rev. Lett.*, 2010, **105**, 136805.
- [2] Y. Zhan, Z. Liu, S. Najmaei, P. M. Ajayan and J. Lou, *Small*, 2012, **8**, 966–971.
- [3] W. Zhou, X. Zou, S. Najmaei, Z. Liu, Y. Shi, J. Kong, J. Lou, P. M. Ajayan, B. I. Yakobson and J. C. Idrobo, *Nano Lett.*, 2013, **13**, 2615–2622.
- [4] S. Mouri, Y. Miyauchi and K. Matsuda, *Nano Lett.*, 2013, **13**, 5944–5948.

Figures

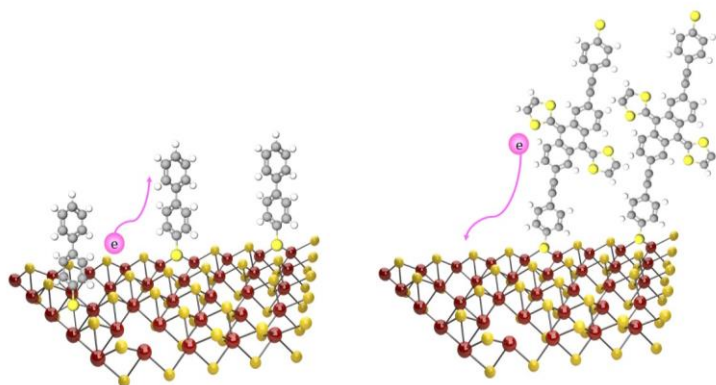


Figure 1: Schematic illustration of surface charge transfer between MoS₂ and dopant molecules