Plasma treatments of CVD-MoS_2: Functionalization, Reactivity, and Doping

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As processes to controllably synthesise atomic sheets of 2D materials have become more understood and their fundamental properties studied, attention has shifted towards applications and the manipulation of these materials towards that end. To achieve this, reliable methods to tune their properties through chemical functionalization must be developed. However, the saturated bond surface of many of these materials, including pristine MoS_2, gives them remarkable stability and can inhibit the formation of strong chemical bonds [1]. We demonstrate that plasma treatments can be a reliable, large-scale compatible method to alter the properties of MoS_2 [2][3]. In particular, remote NH_3 plasma creates a highly reducing atmosphere reacting with the surface of CVD-grown monolayer MoS_2 and substitutionally replacing sulfur in the lattice with nitrogen atoms. The reaction products were characterized by a variety of advanced spectroscopies and microscopies (XPS, Raman, PL, AFM). This gradual substitution of sulfur atoms with nitrogen, and the formation of covalent bonds between the Mo and N by facile and controllable plasma treatments is a viable technique that potentially can be utilized for band-gap engineering exemplified by significant shifts in the photoluminescence energy, controlled functionalization, and synthesis of hybrid materials.

References

[1] C. Wirtz, T. Hallam, C. P. Cullen et al, Chemm Comm, 51 (2015) 16553-16556
[2] J. Jadwiszczak, C. O'Callaghan, Y. Zhou, D. S. Fox, E. Weitz, D. Keane, C. P. Cullen, et al, Sci. Adv, 4 (2018)
[3] J. Jadwiszczak, L. Gen, C. P. Cullen, et al, Appl Phys Lett, 114 (2019)

Figures

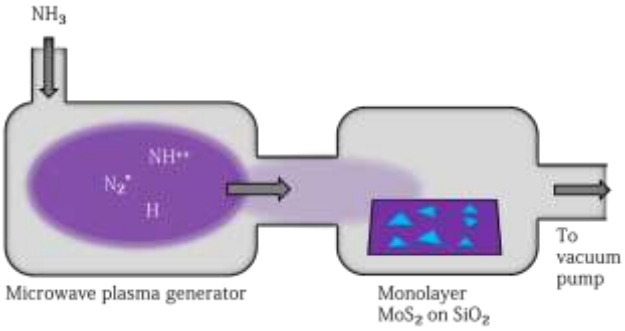

Figure 1: Schematic of NH_3 remote plasma treatment of MoS_2

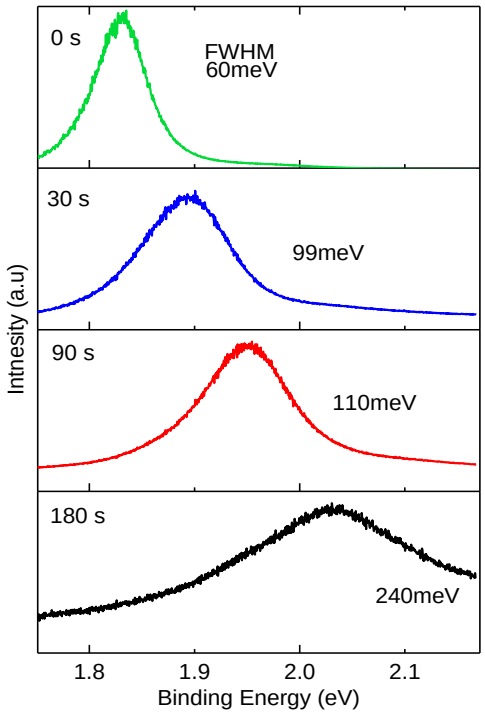

Figure 2: Graph showing changing photoluminescence from MoS_2 with NH_3 plasma duration.