Investigation of Gas Sensing Efficiency and Mechanism Based on P-type MoS2

Chueh-Cheng Yang (楊爵丞)[1], Chia-Hsin Wang (王嘉興)[2] , and Yuan-Chieh Tseng (曾院介)[1]

[1]Department of Materials Science and Engineering, National Chiao Tung University, Hsinchu, Taiwan
[2]National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu Science Park, Hsinchu, Taiwan
yctseng21@mail.nctu.edu.tw

Abstract

Transition metal dichalcogenides have attracted significant attentions due to their unique chemical and physical properties. These materials are widely applied to various applications, and one of them is gas sensing technology, due to their large surface-to-volume ratio and relative low operation temperature. In this work, we fabricated gas sensors based on P-type MoS_2 doped with niobium(Nb), and we explored the sensing efficiency and sensing mechanism of CO_2 and CO. With a relatively high Nb dopant concentration, the sensor response showed a decrease in sensitivity, which was likely attributed to a high metallic NbS_2 ratio in the semiconducting MoS_2 film[1].

The resistance of P-type MoS_2 appeared to increase while sensing both Co and CO_2, and we found that such mechanism was associated with electron transfer from gas molecules to the sensor[2]. Furthermore, we used in-situ x-ray absorption spectroscopy (XAS) and ambient-pressure x-ray photoelectron spectroscopy (APXPS) techniques at national synchrotron radiation research center (NSRRC) to probe the interactions between gas and MoS_2 during the gas absorbing process. The results (Fig.1) not only confirmed the electron donation from gas molecules but also showed that the interactions mainly arose from surface sulfur reacting with gas molecules.

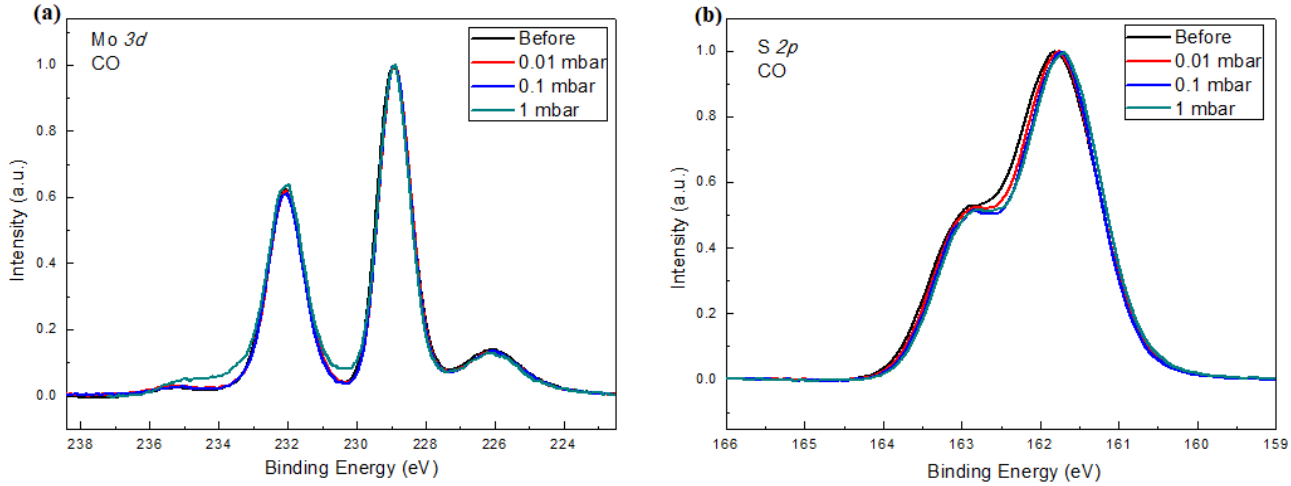

Figure 1: (a) Mo 3d spectrum remains unchanged under different CO pressures, while (b) S 2p spectrum shifts toward lower binding energy as a result of the shielding effect by electron donation.

References

[1] Sun Young Choi et al., ACS Appl. Mater. Interfaces, 9 (2017) 3817
[2] Byungjin Cho et al., Sci. Rep., 5 (2015) 8052

Keywords – MoS_2, APXPS, Gas sensor