Improving the efficiency of MoS_2 based FETs through Potassium Iodide doping

Hemanjaneyulu Kuruva
Jeevesh Kumar and Mayank Shrivastava

Department of ESE, Indian Institute of Science, Bengaluru, India -560012

hemanjaneyul@iisc.ac.in

Abstract

In this work, a new, easy and cost-efficient technique for doping of MoS_2 thin flakes by Potassium Iodide (KI) solution (2%) is proposed. The doping is investigated using high resolution XPS. The XPS results show a red shift in Molybdenum (Mo) 3d and Sulphur (S) 2p peaks, confirming the doping inside the sample [1]. The result is further investigated through DFT calculations, which confirm the shift in Fermi-level (E_F) of MoS_2 with KI doping (Fig. 1(b)). DFT calculations also confirm the shift in E_F for potassium (K) doping as reported by Ratogi et. al [2] (Fig. 1(b)). KI solution-based doping has shown non-degeneracy (low shift in E_F) which enables high ON to OFF current ratio (I_{ON}/I_{OFF}) compared to K doping reported by Fang *et.al* [3].

Fig. 2 presents the electrical characteristics of the back gated FET (fabricated using electron beam lithography) before and after the KI doping. Negative shift in threshold voltage (V_{TH}) (Fig. 2(a)) confirms n-type doping in the FET. In addition to V_{TH} shift, device also shows increased ON current (I_{ON}) while maintaining the I_{ON}/I_{OFF} greater than 10^6. I_{ON} is observed to increase by 2X times, whereas transconductance (g_m) and mobility (μ_{FE}) are observed to increase by 1.3X times and 2.12X times respectively, enabling the device to reach very high current densities of around 500μA/μm (Fig. 2(a) inset).

References

[1] Yang, Lingming, et al. "Chloride molecular doping technique on 2D materials: WS2 and MoS2." Nano letters 14.11 (2014): 6275-6280.

[2] Rastogi, Priyank, et al. "Doping strategies for monolayer MoS2 via surface adsorption: a systematic study." The Journal of Physical Chemistry C 118.51 (2014): 30309-30314.

[3] Fang, Hui, et al. "Degenerate n-doping of few-layer transition metal dichalcogenides by potassium." Nano letters 13.5 (2013): 1991-1995.

Figures

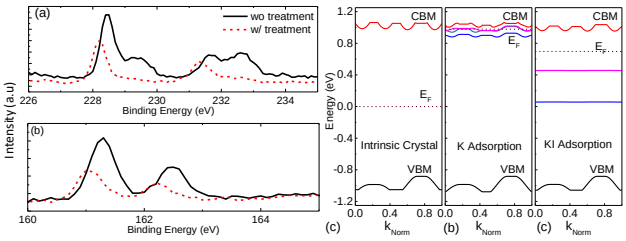

Figure 1: Variation of XPS spectra of Mo 3d peak and S 2p peak across the doping. Both the peaks show a red shift after the doping. (c) Comparison of band structure across the different adsorptions with intrinsic crystal.

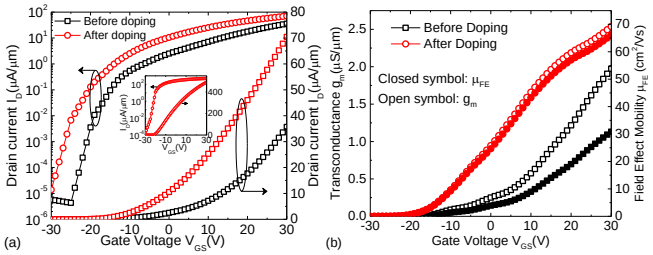

Figure 2: (a). Input characteristics of a device with L_G=300nm, V_{DS} = 0.5V before and after the doping by KI solution. (b) Transconductance and mobility. Inset of (a) shows the highest current density of 500 μA/μm achieved for a device with V_{DS} = 3V, L_G = 500nm.