Chemical p- and n-doping for MoS_2 transistor and its application

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Abstract

The discovery of isolation of the monolayer graphene using mechanically exfoliation has triggered the intense studies on the other two-dimensional (2D) materials, e.g., semiconducting molybdenum disulphide (MoS_2) and insulating hexagonal boron nitride (h-BN) [1]-[3]. MoS_2, one of the transition metal dichalcogenides (TMDCs), has a great potential for replacing the Si-based electronics due to its comparable band gap as large as 1.8 eV for monolayer and 1.2 eV for multilayers. For more versatile transistor applications, however, the doping process is inevitably necessary since various practical devices such as tunneling, transistors, logic circuits, and memory devices are composed of p-n junctions. Although there have been some reports about surface charge transfer doping effects of MoS_2 using potassium [4], MoO_3 [5], and molecules [6] recently, it is still quite ambiguous to apply for practical junction devices since they just demonstrated slight changes of electrical properties or improvement of contact resistance.

In this study, we demonstrate the chemical p- and n-doping for MoS_2 using AuCl3 and benzyl viologen (BV), respectively. **Figure 1** shows the electrical properties (I_D-V_G) of MoS_2 transistors after (a) BV and (b) $AuCl_3$ doping. Before these doping, the MoS_2 transistor shows n-type semiconducting property as previously reported (see **Figure 1**(a)) [2]. However, it becomes to degenerate n-type and p-type semiconductor after BV and $AuCl_3$ chemical doping, respectively. Using potassium, which is a strong electron donor, there has been similar behavior compared with BV doping [4]. While the clear p-type semiconducting property using $AuCl_3$ has not been reported from our literature survey so far. Furthermore, it seems feasible to apply for the p-n diodes toward various optoelectronics. For achieving this, we stacked h-BN on a partial area of MoS_2 and dope the other area using $AuCl_3$ as shown in **Figure 2**(a). When we measured the photo-response of this prototype diode, it showed the unique properties of the conventional diode such as open circuit voltage and short circuit current as shown in **Figure 2**(b). Consequently, we demonstrated the proper chemical doping method for MoS_2 toward various optoelectronics.

References

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Figures

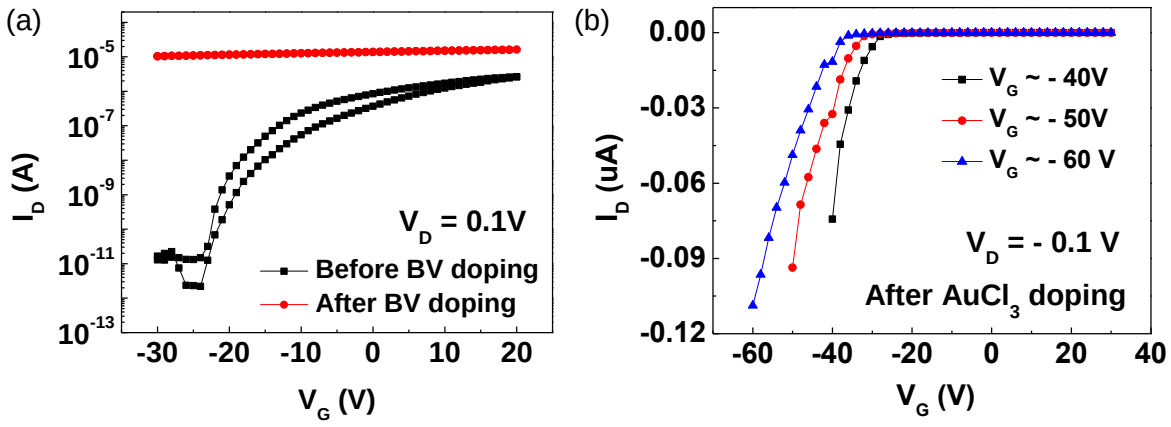

Figure 1: The electrical properties (I_D-V_G) of MoS_2 transistors (a) before and after BV doping, and (b) after $AuCl_3$ doping.

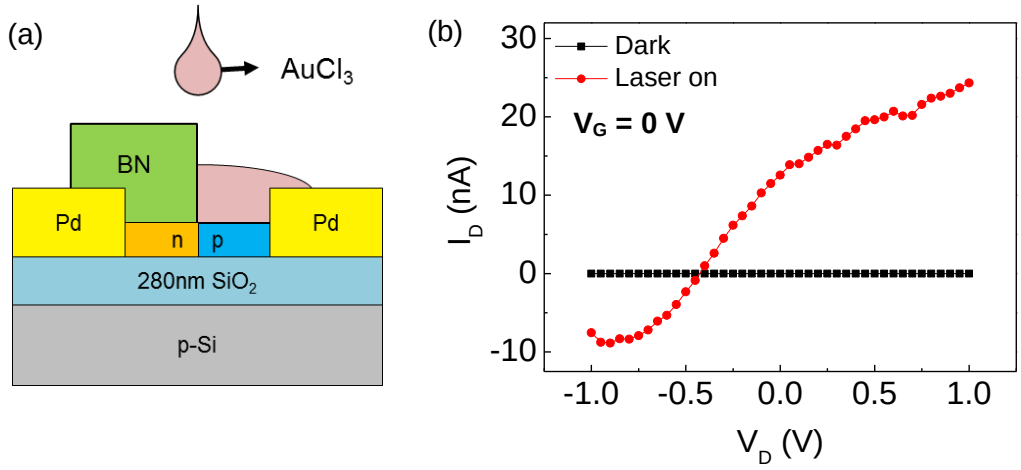

Figure 2: (a) Cross-sectional diagram of MoS_2 p-n diode. (b) The photo-response of a fabricated diode.