Evaluation of doping concentration of MoS_2 via Schottky diode for the Terman method

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【Introduction】Layered Molybdenum disulfide (MoS_2) is being studied intensively as a candidate for use in future scaled transistors because of its semiconducting properties with a sizable bandgap and relatively high carrier mobility[1]. However, it is essential to understand a property of MoS_2 metal-oxide-semiconductor (MOS) interface in particular for MOS transistors. In our previous study, the Terman method has been adopted to evaluate the density of interface traps (D_{it}) by fabricating thick-body MoS_2 MOS capacitors [2]. However, the unknown doping concentration (N_d) of MoS_2 made the D_{it} analysis inaccurate. Therefore, in this study, in order to figure out the doping concentration of natural MoS_2 crystal, we propose to use a thick-body MoS_2 Schottky diode. Owing to the thick-body MoS_2, we can use the regular C-V measurement to extract the doping concentration. Using the extracted doping concentration, the Terman method is applied to extract the energy distribution of D_{it} of MoS_2 MOS interface.

【Device structure】 A schematic of thick-body MoS_2 Schottky diode is shown in an inset of Fig. 1. After pre-cleaning of highly doped n-type Si, flakes of MoS_2 were transferred onto the surface of the wafer by exfoliation. Then, Au or Al was deposited on the MoS_2 flakes through shadow mask, which confines circle areas with a diameter of 200 μm. Finally, Al was evaporated onto the back side of Si wafer to offer a better conduction. First, we made an Au/MoS_2/n^+-Si/Al diode to find out the ohmic contact between MoS_2/n^+-Si. Then, we substituted Au with Al to achieve a Schottky contact between Al and MoS_2.

【Result and discussion】 Fig. 1 shows the I-V characteristic of the fabricated Schottky diode. It exhibits typical n-type semiconducting property of MoS_2. From the $1/C^2$-V curve, N_d of MoS_2 is extracted to be 4×10^{16} cm^{-3}. With this experimental N_d value, we can estimate the D_{it} of MoS_2 using the Terman method. Fig. 2 shows the comparison of measured and ideal C-V curves of a MoS_2/Al_2O_3 MOS capacitor. Due to the existence of interface traps on the MoS_2/Al_2O_3 interface, the measured C-V curve stretches out with gate voltage. By comparing the measured and ideal C-V curve, we successfully extract more accurate D_{it} distribution.

【References】

[1] B. Radisavljevic et al. *Nat. Nanotechnol.*, vol. 6, no. 3, pp. 147–50, Mar. 2011.

[2] M. Takenaka et al., “Quantitative evaluation of energy distribution of interface trap density at MoS_2 MOS interfaces by the Terman method,” *International Electron Devices Meeting (IEDM’16)*, 5.8, San Francisco, 5 December 2016.

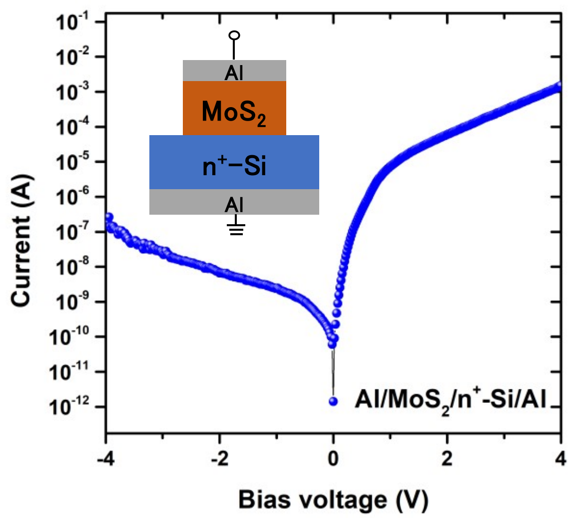

Fig.1 I-V characteristic of the MoS_2/Al Schottky diode.

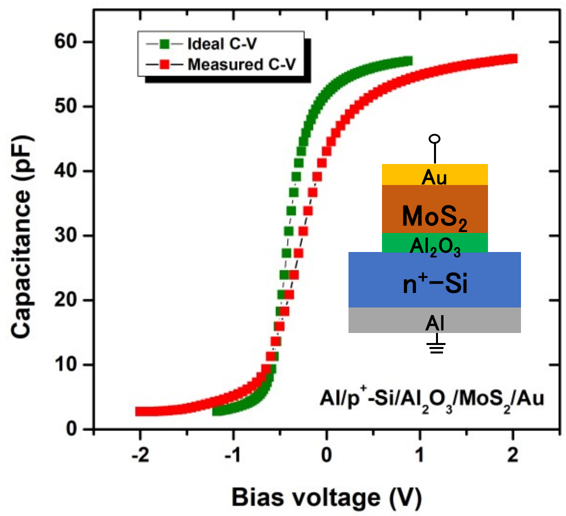

Fig. 2 Ideal and measured C-V characteristics of a MoS_2 MOS capacitor.