Charge trap memory based on MoS_2 with He^+-irradiated h-BN as a trapping layer

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Charge trap memory has attracted much attention for applications in memory-based computing. Two-dimensional (2D) materials such as graphene and transition metal dichalcogenides have great potential as building blocks of charge trap memory, owing to the absence of surface dangling bonds and the stacking degree of freedom. However, wide range control of trap density is challenging with an intrinsic 2D material, although is crucial for novel analog computing applications. Here, we fabricated MoS_2-based charge trap memory using He^+-irradiated h-BN as a charge trapping layer, where the trap density can be tuned widely with the He^+ dose amount. BN flakes were exfoliated from bulk crystals onto Si/SiO_2(285 nm) and irradiated with He^+ by using a helium ion microscope. After the irradiation, MoS_2 flakes were transferred onto He^+-irradiated h-BN and Ti/Au electrodes were defined by the electron-beam lithography method (Fig. 1a). The trapping properties of BN-supported MoS_2 were investigated at room temperature in vacuum using the field effect geometry, where Si and SiO_2 serve as a gate and a gate dielectric. Figures 1b-c show transfer characteristics of FETs based on MoS_2 on He^+-irradiated BN with different dose amounts (D). The FETs show hysteresis in the forward and backward gate sweeps, hence working as charge trap memory. With increasing the dose amount, the hysteresis window monotonically widens, indicating that traps are present at defective sites in h-BN. However, at D ~ 10^{16} cm^{-2}, the off state was suppressed, possibly due to the significant increase in the trap capacitance, which may be unfavorable for applications in charge trap memory. Our results could be a guidance to create a charge trapping layer with the controlled trap density for memory applications. ***Acknowledgement*:** This work was partly supported by the JST SICORP program (grant No. JPMJKB2103) and ARIM of MEXT (JPMXP1224NM5118). We extend our gratitude to Mr. Tomohiko Iijima (AIST) for operating the AIST SCR HIM during the helium ion irradiation process.

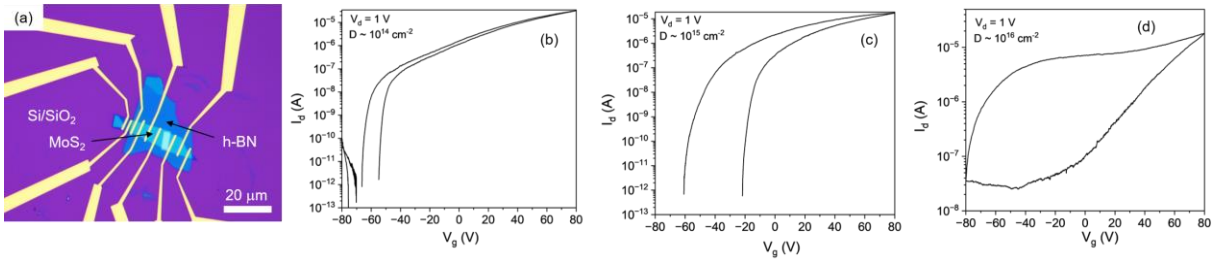

Figure 1. (a) Optical image of MoS_2 on He^+-irradiated h-BN on a Si/SiO_2 substrate. (b)-(d) Drain-current (I_d)-gate voltage (V_g) characteristics of MoS_2 on He^+-irradiated h-BN with dose amounts (D) of 10^{14}, 10^{15}, and 10^{16} cm^{-2}. The drain voltages (V_d) are 1 V.