Stability of High-Performance MultilayerMoS_2 Field-Effect Transistor improved by O_2 Plasma Pretreatment and Al_2O_3Encapsulation

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In this study, wedemonstrated a method for improving the stability of multi-layered MoS_2field-effect transistors (FETs) by O_2 plasma treatment and Al_2O_3 encapsulation.The MoS_2 FETs were exposed to O_2 plasma for 30 s prior to Al_2O_3 passivation tocarry out high electrical performance and relatively small hysteresis. BetweenMoS_2 and the Al_2O_3 passivation layer, there is a MoO_x layer formed during theplasma treatment. This MoO_x interlayer prevents the generation of excesselectron carriers in the channel due to Al_2O_3 encapsulation which minimizes theshift of threshold voltage (V_{th}). However, plasma treatment for a long time (90and 120 s) was found to introduce excess oxygen traps into the MoO_x interlayer,resulting in a persisted hysteresis and a high off-current leakage. The stableMoS_2 FETs were also suffered from the tests of the gate bias stress underdifferent conditions. The MoS_2 FETs showed negligible degradation ofperformance under a positive gate bias stress, positive gate bias illuminationstress, and negative gate bias stress, but a large negative shift of V_{th} wasobserved under a negative gate bias illumination stress, which is suggestedbecause of the presence of sulfur vacancy. This easy approach can be applied toother transition metal dichalcogenides and the high performing and hysteresis-freeMoS_2 FETs could open up new opportunities for future electronics.

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