Electrical Performance of Al_2O_3-Encapsulated Multilayer MoS_2 Thin-Film Transistor with Different Temperature Environments

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Since graphene was found, two-dimensional (2D) materials have been widely interestedin various research area. Although it has good optical, mechanical, and electricalcharacteristics, graphene was not suitable for an active channel material offield-effect transistors because of its absence of a band gap. To realize aband gap in graphene, many researchers were studying, but these efforts broughtabout the additional process complexity and reduction of mobility. 2Dtransition metal dichalcogenides (TMDs)-based thin-film transistors (TFTs) werean excellent replacement for conventional transistors. Among TMDs materials,molybdenum disulfide (MoS_2) TFTs have conspicuous advantages such ashigh mobility, a high on/off current (I_{on}/I_{off}) ratio,mechanically strengthen, good flexible property and a large band gap.

We reported that atomic-layer-deposited (ALD) aluminum oxide (Al_2O_3)for passivation layer affected the multilayer MoS_2 TFTs. Electrical performanceswere measured in different temperature from 298 K to 380 K. Al_2O_3layers for passivation were uniformly deposited onto the MoS_2 surfacewith ultraviolet-ozone (UV/O_3) treatment. This passivation layer hasthree major effects. First, decreases of the hysteresis in transfer curves. Second,enhancement of saturation current level in output curves. Third, improvement ofeffective mobility about 40.4% Through the temperature-dependent measurements,intrinsic carrier mobility was calculated by using the Y-function method. Withthis result, we suggest that the dominant mechanism of carrier transport isthermionic emission. Because Al_2O_3-encapsulated MoS_2devices had a high Schottky barrier. This barrier was indicated between thesource/drain electrodes and an active MoS_2 channel. Additionally,the proposed approach at relatively high temperatures can be employed torealize stable and reproducible electronic devices for robust and practicalapplications.