EVC-15

Contribution ID: **157** Type: **Contributed**

In-situ electrical characterization on dipole formation on MoS2 by atomic layer deposition

Tuesday 19 June 2018 15:20 (20 minutes)

2D-TMD (transition metal dichalcogenide) materials are potential channel candidates for future semiconducting applications. There are various challenges facing the implementation 2D TMDs into high performance transistors. Key among these issues is the development of a scalable gate dielectric formation and its influence on TMD channel performance. In this presentation four deposition processes are studied using a novel, in-situ electrical characterization system.

Exfoliated MoS2 backgated devices are loaded into an ultra-high vacuum (UHV) cluster tool which integrates a thermal ALD, a plasma enhanced ALD, and a plasma enhanced chemical vapor deposition with a UHV electrical probe station. Thermal ALD of Al2O3, both alone and combined with nitrogen radical surface functionalization, hollow cathode nitrogen plasma surface functionalization, and ozone surface functionalization are studied. Samples are transferred between deposition and characterization chambers under UHV conditions, allowing "half-cycle"studies to be performed. Common to all results, as well as ex-situ studies, the ALD process results in a reduction of the on-off ratio, an increase in drive current, and a large negative shift in the threshold voltage (Vth). The shift in Vth can be seen immediately after the functionalization step or from the first ALD pulse if no functionalization is performed. In the case of functionalization, the shift in Vth is attributed to the oxidation of the MoS2 surface, a result of oxygen contamination during radical functionalization. The effect of surface dipoles, precursor adsorption and coverage, and nucleation during the ALD process will be discussed as they relate to the electrical characteristics of the device.

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Session Classification: Thin Films & Surface Engineering

Track Classification: Thin Film & Surface Engineering