自己形成ヘテロ構造原子膜半導体の伝導特性

Self-assembled hetero-semiconducting structure

based on two-dimensional transition metal dichalcogenides

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Growth of a uniform oxide film with a tunable thickness on two-dimensional transition metal dichalcogenides is of great importance for electronic and optoelectronic applications in next generation atomically-controlled hetero semiconducting structure. Here we demonstrate homogeneous surface oxidation of atomically thin WSe_2 with a self-limiting thickness from single- to trilayers.

Exposure to ozone (O_3) below 100 °C leads to the lateral growth of tungsten oxide selectively along selenium zigzag-edge orientations on WSe_2. With further O_3 exposure, the oxide regions coalesce and oxidation terminates leaving a uniform thickness oxide film on top of unoxidized WSe_2. At higher temperatures, oxidation evolves in the layer-by-layer regime up to trilayers. The oxide films formed on WSe_2 are nearly atomically flat. Using photoluminescence and Raman spectroscopy, we find that the underlying single-layer WSe2 is decoupled from the top oxide but hole-doped.

The hole-doping by the under-stoichiometric tungsten oxides (WO_x with $x < 3$) grown on WSe_2 can be used as both controlled charge transfer dopants and low-barrier contacts for p-type WSe2 transistors. WO_x-covered WSe_2 is highly hole-doped due to surface electron transfer from the underlying WSe_2 to the high electron affinity WO_x. The dopant concentration can be reduced by suppressing the electron affinity of WO_x by air exposure, but exposure to O_3 at room temperature leads to the recovery of the electron affinity. Hence, surface transfer doping with WO_x is virtually controllable. Transistors based on WSe_2 covered with WO_x show only p-type conductions with orders of magnitude better on-current, on-off current ratio, and carrier mobility than without WO_x, suggesting that the surface WO_x serves as a p-type contact with a low hole Schottky barrier.

Our findings point to a simple and effective strategy for creating p-type devices based on two-dimensional transition metal dichalcogenides with controlled dopant concentrations.

References：

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