Few-Layer MoS_2 on AlN and AlTiO/p^+-Si for Energy Device Applications

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Transition-metal dichalcogenides (TMDCs) van der Waals (VdW) layered materials and their alloys are significant potential in the area of transistors, light-emitting diodes, photodetectors, and energy devices. Especially, MoS_2 and WSe_2 are naturally *n*- and *p*-type TMDCs, respectively with bandgap E_g in the range of 2.1–1.2 eV and absorption coefficient a of ~10^5 cm^{-2} exhibiting huge potential for advanced nanoscale optoelectronic and photovoltaic devices. However, the choice of the substrate plays a crucial role in the growth of uniform large-area film as well as scalable, defect-free, high-performance devices fabrication. Aluminum nitride (AlN) has a high E_g of approximately 6.24 eV, the thermal conductivity of 300 W/m-K, and a dielectric constant ε of 4.7 with the least lattice mismatch of ~1.6% (with MoS_2), whereas mist CVD AlTiO has high E_g of 5.12 eV and dielectric constant ε of 13.8 with the strong hydrophilic surface is found as promising substrates for the growth of large scale TMDCs [1,2]. Here, we report the growth of the few-layer large-scale MoS_2 and $WS_{2-x}Se_x$ films on the AlN and AlTiO wafers by chemical vapor deposition (CVD) and mist-CVD. Further, we demonstrate the applications of MoS_2/AlN and $WS_{2-x}Se_x$/AlTiO/p^+-Si structures as energy Devices. The photocurrent current of I_{ph} of 7×10^{-8} A with a responsivity of ~1×10^5 AW^{-1} was obtained in visible light at blue and red wavelengths in a $WS_{0.3}Se_{1.7}$ photodetector (Figure 1). Further, the *PCE* of 3.1×10-3 with I_{ph} of 3×10^{-6} A/cm^2 with V_{OC} of 0.84 V and FF of 0.57 was achieved in $WS_{0.3}Se_{1.7}$-based in-plane p^+-*n* solar cells fabricated on a high-κ mist CVD-AlTiO/p^+-Si [4]. We will demonstrate the improved performance of few-layer mm-scale MoS_2/AlN, and $WS_{2-x}Se_x$/AlTiO/p^+-Si structures photodetector and solar cell devices.

References

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Figures

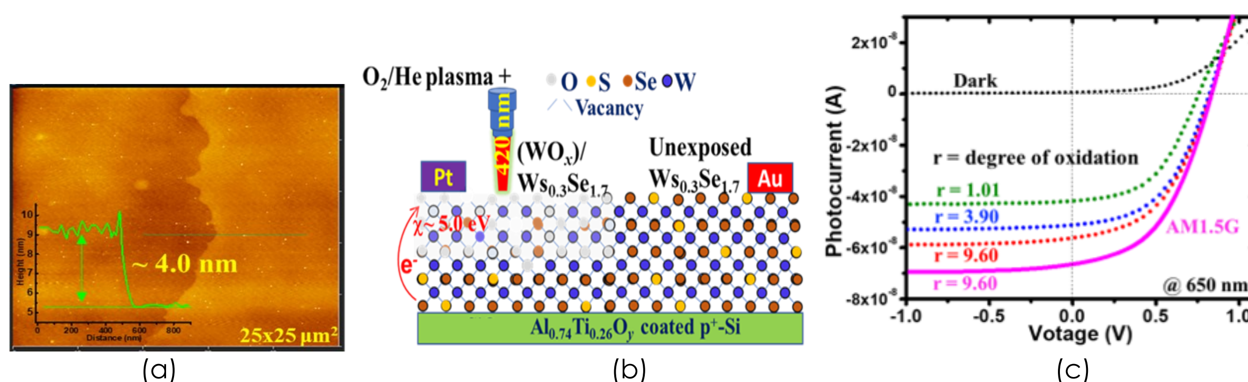

Figure 1: (a) AFM of few-layer $WS_{2-x}Se_x$ film; (b)schematic of $WS_{2-x}Se_x$ /AlTiO in-plane p^+-*n* junction formed by plasma layer exposure; (c) *I-V* characteristics of devices at different degrees of oxidation.