Controlled growth of vertical MoS_2 flakes to in-plane MoS_2 and their utilizations in photodetectors

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Abstract (Arial 11)
Here, we proposed controlled growth of vertical MoS_2 flakes from in-plane MoS_2 by our modified chemical vapor deposition (CVD) technique. We synthesized in-plane MoS_2, vertical MoS_2 and pyramid MoS_2 flakes from CVD. Detailed structural, optical and morphological characterizations were performed. The initial in-plane MoS2 flakes worked as the seeding platform for the growth of vertical MoS_2. We systematically played with the gas flow rate to grow these unique structures.
Further, we utilized the unique vertical MoS_2 structures in fabricating broadband photodetectors. We formed the heterojunction of p-type earth abundant 3D Cu_2ZnSnS_4(CZTS) and n-type 2D-layered MoS_2 to develop photodetector. Detailed photoelectron spectroscopy performed, not just to inspect the chemical bonding at the interface, but also to uncover the electronic interaction at the interface in terms of band alignment. Taking a step further, photoluminescence (PL) measurements were carried out as a curiosity to investigate any significant change in the PL signal while going from MoS2 side towards the CZTS/MoS_2 interface.
As a proof of concept, a self-driven CZTS/MoS_2 heterojunction broadband photodetector was constructed exhibiting pronounced photovoltaic features with high responsivity 141 mA/W, outstanding photo switching capability (I_{On}/I_{Off} = 112) and fast response (τ_r/τ_d= 81/79 ms). The responsivity was further enhanced to 79 A/W at moderate bias (@ 6V). Additionally, the device showed exceptional stability after 1500 hours of operation. This work intends to trigger the research on 3D/2D for high performing optoelectronic devices based on CZTS/MoS_2 heterojunctions.

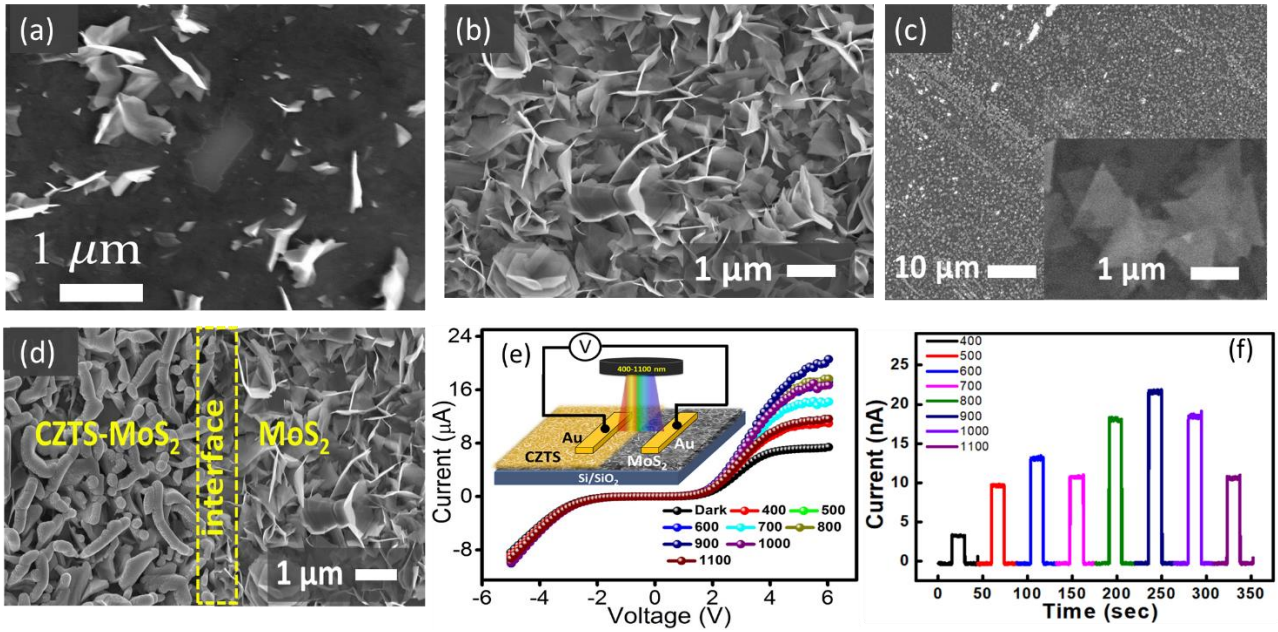

Figure: FESEM image of (a) mixed MoS_2 flakes (b) Vertical MoS_2 (c) Pyramid MoS_2 flakes (d) FESEM image of area showing the interface between CZTS and MoS_2. (e) CZTS/MoS_2 p-n junction PD, in dark and under illumination with different wavelengths, (wavelengths in nm scale). (f)Transient photoresponse measurements of CZTS/MoS2 PD at different wavelengths ranging from 400 to 1100 nm in self-powered mode (0Vbias).

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