Synthesis of $NbSe_2$/Bilayer Nb-doped WSe_2 Heterostructure from Exfoliated WSe_2 Flakes

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Abstract

Forming heterostructures of 2-dimensional (2D) metals/semiconductors (m/s) using chemical vapor deposition (CVD) has significant potential to effectively reduce contact resistance in electronic devices.[1] However, semiconducting transition-metal dichalcogenides (TMD) layer in m/s heterostructures are currently restricted to monolayer despite the superior mobility and density of states in bilayer TMDs.[2] Herein, we first synthesized $NbSe_2$/bilayer Nb-doped WSe_2 m/s heterostructure from exfoliated WSe_2 flakes. The exfoliated WSe_2 bulk crystals on Nb-coated substrate are heated to 950 °C under a flow of selenium vapor, and then the $NbSe_2$/bilayer Nb-doped WSe_2 heterostructures were formed. X-ray photoelectron spectroscopy, atomic force microscopy and transmission electron microscopy clearly clarified the number of Nb-doped WSe_2 layers and heterostructure of $NbSe_2$/bilayer Nb-doped WSe_2. Electrical measurements reveal significantly improved mobility and on/off ratio compared to monolayer Nb-doped WSe_2. Moreover, the performance is further enhanced in $NbSe_2$/bilayer Nb-doped WSe_2 contacts due to a clean vertical staked interface. Additionally, we demonstrate high photovoltaic effect and fast response time in a photovoltaic device. These findings emphasize our growth method opens new avenues for synthesizing a wide range of metal-doped TMD heterostructures, fostering innovation in the field of 2D material-based electronic and optoelectronic devices.

References

[1] Yuanyue Liu et al., Sci Adv, 2 (2016), e1600069
[2] Liu, L., Li, T., Ma, L. et al., Nature, 605 (2022), 69-75

Figures

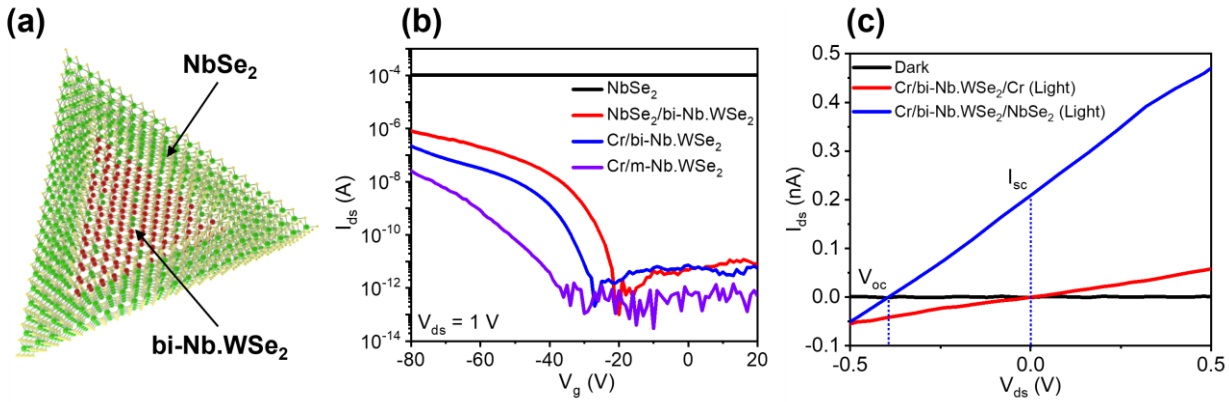

Figure 1: (a) Schematic illustrating the CVD growth of $NbSe_2$/bi-Nb.WSe_2 heterostructure. (b) Transfer characteristics of Cr/m-Nb.WSe_2 (purple line), Cr/bi-Nb.WSe_2 (blue line), $NbSe_2$/bi-Nb.WSe_2 (red line) and Cr/$NbSe_2$ (black line) contact FETs. (c) Output characteristics under dark and light conditions for Cr/bi-Nb.WSe_2/Cr and Cr/bi-Nb.WSe_2/$NbSe_2$ devices.