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Tunable Band Gap Energy from WS_xSe_y Monolayer

The transition metal dichalcogenides (TMDs) have attracted much attention because its unique characteristics and potential application in the low-power and optoelectronic devices. Recent reports have successfully demonstrated the growth of 2-dimensional MoS_xSe_y, $Mo_xW_yS_2$ and $Mo_xW_ySe_2$ alloys, where these materials exhibit tunable band gap energies. However, WS_xSe_y alloys are not available via CVD process until now. In the study, we report that WS_xSe_y monolayer alloys were synthysized using tungsten oxides, selenium and sulfur powders as the sources in the CVD process, where different heating temperatures of selenium and sulfur powders are applied respectively to control the ratio of S to Se. The optical band gap of the as-grown WS_xSe_y monolayer alloys is precisely tunable from 2.0 eV to 1.64 eV via modulating the ratio of S to Se. With the increase of selenium in WS_xSe_y monolayers, apparent electronic state transformation from p-type to n-type were recorded through energy band diagrams, beneficial for the future optical design.

References

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Figures

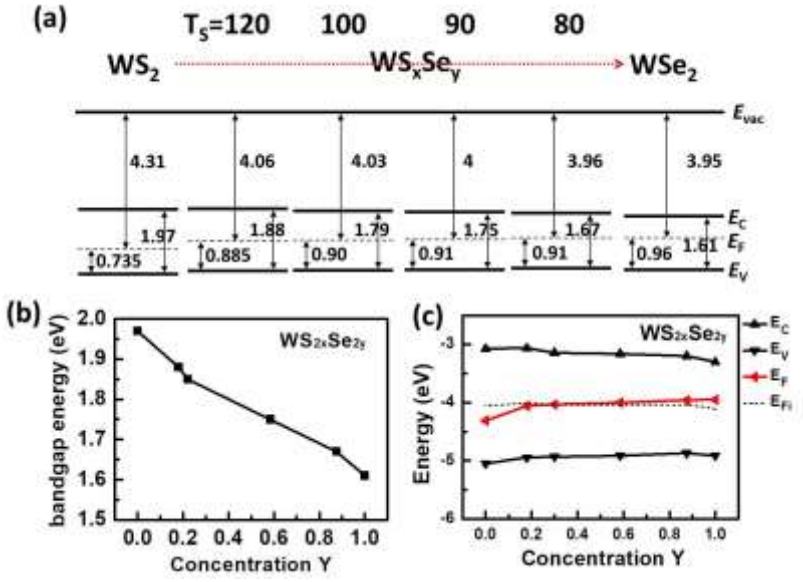

Figure 1: (a) The energy band diagram of pristine WS_2, WSe_2 and as-grown WS_xSe_y monolayers acquiring form UPS examination. (b) The band-gap energy of WS_xSe_y monolayers as a function of Se concentration, showing a well linear relationship. (c) The conduction band minimum (CBM), valence band maximum (VBM) and Fermi level positions of WS_xSe_y monolayers as a function of Se concentration. The vacuum energy is taken as zero for reference.