Investigation of Photodiodes from Vapor Phase Grown MoS_2

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In recent years, molybdenum disulfide (MoS_2), a semiconducting layered transition metal dichalcogenide (TMD), has been identified as one of the most promising two-dimensional (2D) materials for nanoelectronic applications because of its properties which can be tuned by controlling the number of layers.[1-3] Monolayer MoS_2 has a direct band gap of ~1.8 eV and bulk MoS_2 has an indirect band gap of ~1.3 eV,[1] and electronic devices based on mono- or multilayered MoS_2 films have shown good photodetection capability.[3, 4] While mechanical exfoliation is a widely used method to prepare layered MoS_2 thin films, the difficulty of controlling layer thickness and the lateral size limitation have led to the development of alternative synthesis routes. Recently, large-area growth techniques based on vapor phase sulfurization of thin Mo films have been adopted for the synthesis of MoS_2 thin films.[5, 6]

In this study, we introduce a vertically-stacked hybrid photodiode with n-type MoS_2 grown by vapor phase sulfurization of pre-deposited Mo films.[7] N-type MoS_2 thin films with various thickness are transferred onto p-type silicon (p-Si), producing p-n heterojunction diodes. The effect of varying the incident light intensity, wavelength and MoS_2 film thickness is investigated. Current-voltage measurements reveal that the n-type MoS_2/p-Si diodes have good rectifying behavior as well as clear photoconductive characteristics. In addition, it is found that the photocurrent of the device has a strong dependence on the MoS_2 film thickness. The spectral response of the device shows that there are contributions from direct and indirect band transitions in the multilayer MoS_2 film. Further, we observe a blue-shift of the spectral response into the visible range. The results are a significant improvement in the fabrication of devices from 2D TMDs and opens up a wide range of device applications for future nanoelectronics.

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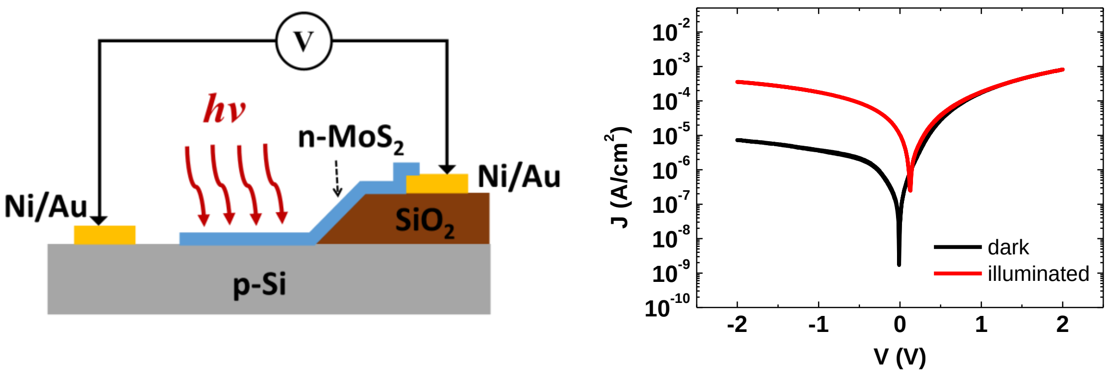

Figure 1. Schematic diagram of the n-type MoS_2/p-Si diode (left) and semi-logarithmic plot of its current-voltage measurement data in dark and illuminated condition (right).