Characterizations of MoS_2 nanosphere fabricated using vacuum thermal evaporation at steady and rapid heating

Nurrsyazwani Abdullah [a], Saifful Kamaluddin Muzakir [a], Nur Farha Shaafi [b], Muhammad Zamzuri Abdul Kadir [c], Ruziana Mohamed [d]

[a] Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Kuantan, Pahang, Malaysia

[b] Faculty of Psychology and Education, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, Malaysia

[c] Kulliyyah of Science, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia

[d] Faculty of Applied Science, Universiti Teknologi MARA, Lintasan Semarak, Bandar Jengka, 26400 Bandar Tun Razak, Pahang, Malaysia

ABSTRACT

Two-dimensional MoS_2 has been speculated to be the best material to replace graphene due to its peculiar structural-electronic properties. The MoS_2 with size smaller than its exciton Bohr radius (ca. 1.61 nm) would favor multi exciton generation upon absorption of photon with sufficient energy, $E_{photon} \gg E_{gap}$ (1.89 eV); which would increase the efficiency of an excitonic solar cell greater than 60%. Despite promising properties of the MoS_2, however an excitonic solar cell with high efficiency is yet to be exhibited. In this work, the MoS_2 thin films were fabricated using vacuum thermal evaporation technique and characterized. Four objectives have been outlined i.e., to study the effect of heating rate (steady, and rapid) on the (i) morphology, (ii) size, (iii) optoelectronic and (iv) crystal properties of the fabricated thin films. The MoS_2 precursor was heated at the rate 2.027 A/s (steady), and 18.75 A/s (rapid), 1.5×10^{-3} Torr, 1.48 A, and 4.58 V. The deposited films later were characterized using Field Emission Scanning Electron Microscope with Energy Dispersive X-ray attachment, photoluminescence spectrometer, UV–vis-NIR spectrometer, and X-ray Diffractometer. The fabricated thin films exhibited nanosphere morphology with different size distributions i.e., wide (steady heating), and narrow (rapid heating). Two hypotheses were made based on the optoelectronic properties i.e., the basic building block of the MoS_2 thin film fabricated under steady heating is (i) experiencing stronger quantum confinement effect, and (ii) dominated by nanocrystals which are smaller than that of the rapid heating. Similar energy loss could be expected in both MoS_2 thin films i.e., ca. 0.15 to 0.17 eV, indicating the existence of shallow trap states. The MoS_2 thin films were dominated by (0 0 2), (0 0 4), and (1 0 6) crystal planes. Therefore, the vacuum thermal evaporation technique would offer materials with unique size, crystal arrangement, and optoelectronic properties upon change of heating rate.

KEYWORDS

Molybdenum disulfide; Nanosphere; Vacuum thermal evaporation

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