Structural and Optical Studies of Hydrothermally Synthesised WS_2-WO_3 Nanorods

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Abstract. Transition metal dichalcogenides (TMDC) are among the most studied layered compounds due to their excellent electronic, optical, mechanical and thermal properties. Monolayer WS_2 is a direct band gap semiconductor showing high photoluminescence intensity in the visible spectral range. Here we synthesized tungsten disulfide-tungsten oxide (WS_2-WO_3) nanocomposites by hydrothermal method for different duration of growth and temperatures. Structural, optical and morphological properties of the as-prepared nanocomposites were characterized by X-ray diffraction (XRD), photoluminescence and SEM analysis. XRD pattern confirms the formation of hexagonal phase WS_2 and monoclinic phase WO_3 nanocomposites. Morphological studies showed the formation of WS_2-WO_3 nanorod like structures with a diameter in the range of (21-34) nm. The presence of A and B excitonic peaks of WS_2 in the photoluminescence emission spectra corresponds to the indirect to direct band gap transition and is found to be independent of the excitation wavelength.

INTRODUCTION

Low dimensional materials are promising candidates for device applications where size can be reduced to nano scale without compromising its functional properties. The advent of graphene and its extraordinary properties led researchers to seek out for other layered materials having unique electronic and optical attributes. Besides other layered materials like graphene oxide, phosphorene and boron nitride, transition metal dichalcogenides (TMDC) are gaining interest since they possess excellent properties for nanoelectronic and optoelectronic devices. TMDCs have chemical formula MX_2, where M is a transition metal belonging to group IV, V or VI and X is a chalcogen. These materials posses layered structure of the form X-M-X, where hexagonal plane of transition metal atoms is sandwitched between two hexagonal planes of chalcogen atoms. Each layer is strongly attracted by in-plane covalent bonding whereas adjacent layers are held together by weak van der waals interactions facilitating isolation of single layers via mechanical or chemical exfoliation. Among the various TMDCs, molebdenum and tungsten based chalcogenides are found to be semiconducting[1]. Properties of TMDCs changes with layer number and have attracted a great deal of attention. For example, in several semiconducting TMDCs the transition from an indirect band gap at the Γ-point to a direct band gap at the K-point of the Brillouin zone occurs when thickness is reduced to a single layer. In particular, bulk WS_2 has an indirect band gap of 1.3 eV, whereas single layer WS_2 has a direct band gap of 2.1 eV[2] that results in enhanced photoluminescence by up to 4 orders of magnitude. The absence of dangling bonds on TMDC basal planes enable them to combine with materials such as oxides, polymers, and small organic molecules, finding potential applications in ultrathin memory devices[3] and transistors[4].

In this work, we report simple hydrothermal synthesis of WS_2-WO_3 nanorods and the effect of temperature and duration of growth on their formation and properties of as synthesised samples were studied in detail.

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