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Effect of deposition duration on the structural, optical, and electrical properties of chemically deposited Cd_{1-x}Mn_xS thin films

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Cd_{1-x}Mn_xS thin films were successfully deposited onto soda-lime glass substrates via the cost-effective chemical bath deposition (CBD) technique at varying deposition durations. Structural characterization using XRD confirmed the formation of a polycrystalline cubic zinc blende structure. The enhanced intensity of the prominent (111) diffraction peak indicates improved crystallinity. Furthermore, an increase in crystallite size accompanied by a reduction in microstrain and dislocation density suggests the formation of high-quality films with reduced structural disorder as the deposition duration increases. SAED patterns obtained from HRTEM further verified the polycrystalline nature of the films, and the interplanar spacings were calculated from the high-resolution images. FESEM analysis revealed a decrease in grain size from 154.04 nm to 118.72 nm with increasing deposition duration, while cross-sectional FESEM images confirmed an increase in film thickness. EDX and XPS analyses validated the presence of the constituent elements Cd, Mn, and S, along with their respective oxidation states. UV-Vis spectroscopic analysis revealed an optical transmittance of 80–90%, confirming the high transparency of the Cd_{1-x}Mn_xS thin films. The optical band gap was found to decrease from 2.875 eV to 2.737 eV with increasing deposition duration, indicating a tunable direct band gap. I–V measurements further verified that the films exhibit semiconducting behaviour. The combination of high optical transmittance, tunable band gap, and semiconducting conductivity demonstrates that Cd_{1-x}Mn_xS thin films are promising candidates for optoelectronic device applications, particularly in photovoltaics, photodetectors, and other light-harvesting technologies.

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