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Metal-Incorporated CdS Nanostructures for Improved UV Photodetection: A Study for Solar Energy Applications

In this work, we have studied the used of a thin film-based metal-semiconductor junction to improve the optical absorption, scattering and field intensities of the electromagnetic spectrum in the ultra-violate (UV) region. Nanoparticles (Nps) of copper (Cu), silver (Ag) and gold (Au) with size 14nm are individually incorporated on 5nm thick CdS thin film. The finite difference time domain (FDTD) method was applied to simulate the optical cross-sections and field intensities of these metal-incorporated CdS nanostructures. Out of the three metals, Cu-incorporated CdS (Cu/CdS) and Au-incorporated CdS (Au/CdS) show enhanced optical absorption from 250nm to 400nm under the UV region compared to that of isolated Cu and Au Nps. In the ultraviolet spectrum, the combined Au/CdS nanostructure exhibits the highest absorption in comparison to the individual contributions of isolated CdS and Au Nps. Similarly, the individual absorption of isolated CdS and isolated Cu Nps contribute the highest absorption in the combined Cu/CdS nanostructure in the UV range. The scattering cross-sections of Cu/CdS and Au/CdS are also found to be enhanced in the UV region. In the case of Ag/CdS, no significant enhancement of absorption and scattering cross-section is found in the UV region. A study of electric field intensity shows that at the lowest wavelength (˜ 200nm) Cu/CdS shows the highest field intensity at around 38 (V/m)2. At 300nm Au/CdS shows the highest field intensity around 47.6 (V/m)2. However, in 400nm Ag/CdS shows the strongest field intensity value 9.3×103 (V/m)2 arises due to surface plasmon resonance excitation.

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