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Topic: Study on the properties of pure and doped wide -band gap semiconductor films

Abstract:

Wide bandgap semiconductors have appeared as promising materials suitable for high-temperature, high-frequency and high power operations in electronic as well as optoelectronic devices because of their exceptional material characteristics. More specifically, these semiconductors possess an outstanding ability to materialize short wavelength light emitting devices due to their large band gap energy. Considered a useful class of materials with high stability and numerous useful properties, II–VI wide bandgap semiconducting oxide nanocrystals are widely used for optoelectronic applications. In this thesis, the studies of properties of wide bandgap semiconductors are presented. Their structural, optical and electrical properties have been studied. Screen printing technique, which is the focus of this research, has been used as a multifaceted method for the fabrication of semiconductor layers in photovoltaic devices, especially II–IV compound semiconductors.

In first two chapters 1 and 2, we have presented an overview on the II-VI semiconducting oxide nanocrystals especially ZnO and CdO and have described screen printing technique , as a novel synthetic method for the directed synthesis of wide bandgap semiconductor nanocrystals ZnO and CdO with tunable morphology and composition.

In chapter 3 we have discussed the synthesis and characterization of pure ZnO and CdO films. In case of pure ZnO films, the structural, optical and electrical studies have indicated that such types of films are suitable for photovoltaic devices and other electronic applications. The XRD, SEM studies show that ZnO films have polycrystalline nature with hexagonal structure. From UV-study direct energy band gap transition has been confirmed and it comes out to be 3.12 eV. FT-IR spectrum reveal the presence of ZnO stretching vibration. The dark DC conductivity has revealed the semiconducting nature of films and gives activation energy value 0.27 eV, hence, this exhibit that the conduction process of charge carriers is thermally activated. For pure CdO the characterization investigations exhibit the successful utilization of a simple and economical screen printing method for preparing wide band gap semiconductor thick films. The structural, morphological, optical and electrical studies prove the suitability of these films for photovoltaic devices and other electronic applications. The XRD, SEM and AFM studies show that CdO films have polycrystalline nature with cubic structure, spherical grains and porous morphology. The direct energy band gap transition has been found to be 2.53 eV. FTIR spectrum reveal the formation of CdO with no trace of any type of impurity. DC conductivity measurement reveals the semiconducting nature of film and gives activation energy value 0.29 eV. Such types of films are suitable for solar cells and other optoelectronics devices.

Similarly, in chapter 4 we have discussed the synthesis and characterization of doped ZnO and CdO films. In this chapter, we characterize three different films materials; Cd doped ZnO, Yt doped ZnO and Cu doped ZnO. Cd doped ZnO films are successfully synthesized by screen printing method. The effects of Cd doping on the various physical properties of ZnO thick films are investigated. XRD patterns exhibit the degradation in crystalline and grain size is found to increase with the increase in Cd^{2+} ions concentration and pure material. The peaks due to impurities or secondary phase are not observed in the XRD patterns. The surface morphology of the films change with an increase in both the grain size and reducing the porocity. IR and Raman spectra show the vibrational peaks pertaining to hexagonal wurtzite structure of the films with a shift in peak positions and intensities on substitution of Cd^{2+} ions at Zn sites. These variations are attributed to the change in crystalline field effect on substitution of bigger sized Cd^{2+} ions at Zn^{2+} site. PL spectra exhibit the peaks pertaining to recombination of free excitons arising from near-band-edge emission and neutral bound excitons present in these films. The optical and electrical conductivity studies reveal the decrease in band gap energy with a red shift in reflection edge and activation energy on increasing Cd^{2+} ions concentration in film matrix. For Yt doped ZnO, $Zn_{1-x}Y_xO$ samples are synthesized using screen printing technique as confirmed from XRD and Raman spectroscopy. By analyzing the XRD pattern, it is observed that there is improvement in crystallinity and increase in grain size with the increase in Y^{3+} ions concentration as compared to pure ZnO thick film. The peaks due to impurities or secondary phase are not observed in the XRD patterns. The surface morphology of the films change with increase in the grain size and increase in agglomeration of particles. Raman spectra show vibrational peaks pertaining to hexagonal wurtzite structure of the films with a shift in peak positions and intensities on substitution of Y^{3+} ions at Zn^{2+} sites. These variations are attributed to the change in crystalline field effect on substitution of bigger sized Y^{3+} ions at Zn^{2+}sites. PL spectra shows the free and neutral bound excitons peaks arising from their near-band-edge emission present in these films and lowering of band gap is observed. The optical studies reveal the decrease in band gap energy with a red shift in reflection edge on increasing Y^{3+} ions concentration in film matrix.

Similarly, For Cu doped ZnO, $Zn_{0.94}Cu_{0.06}O$ polycrystalline powder is synthesized by screen printing route**.** The incorporation of Cu^{2+} ion into ZnO lattice rather than the interstitial is observed from XRD analysis.SEM micrograph show porosity and agglomeration of particles occured.Pl study show direct transition with a direct band gap of 3.1 eV and resistivity vs temperature show semiconductor behavior with activation energy of 0.63 eV.

Finally, in Chapter 5, the effect of sintering temperature on the structural and optical properties of Zn doped CdO screen printed thick films have been studied. The structural, morphological and optical properties of the CdZnO composite coated films at the most preferred sintering temperatures of 450^0C and 550^0C have been studied in order to reveal the modifications that occur in the properties of the film with change in temperature.