SYNTHESIS AND CHARACTERIZATION OF NANOCOMPOSITE POLYMER FILMS

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ABSTRACT

"Synthesis and Characterization of Nanocomposite Polymer Films"

Introduction

Inexpensive inorganic substances are traditional ingredients in polymer industry. They are widely used as fillers to improve mechanical and thermal properties of polymers and polymer composites, to decrease shrinkage and internal stresses during conductivity, thermal stability, flame resistance, and, not of least importance, to improve cost effectiveness. The last motivation often became the most important one despite some deterioration of properties with immoderate filling of polymer or polymer composite.

The work existing in this field shows the possibility to include magnetic ions impurity (Ni, Co, Mn) at low concentration in GaAs, ZnSe, ZnS etc., offers good prospects of combining magnetic phenomena with high speed electronics. If these materials embedded with the polymer matrixes then their stability is expected to improve and agglomeration of nanocrystals will be negligible.

SHI irradiation effect of embedded nanocrystals in a polymer matrix is also important to know whether SHI fluence alter the size as well as distribution of nanocrystals uniformly. In the interaction of ionizing radiation through a polymer, the incident energy is transferred to the medium as a result of primary ionization and excitation of the target molecules. Charged particles lose their energy to the stopping materials, mainly via two independent processes i.e. elastic collisions (ion atom interaction) and inelastic collisions (ion electron interaction). The former is the dominant mechanism at low energies region (~KeV/nucleon), whereas the inelastic collisions dominant at high energies (>1MeV/nucleon).Thus, for heavy ions the electronic energy loss leads to the deposition of incident energy on the target material, which creates defects and atomic displacement due to the formation of tracks in material.

Objective of Research:

For this proposed work transition metal ions (Ni, Cu, Co, Mn…) doped nanocrystalline semiconductors (ZnS, CdS, ZnSe, CdSe,...) are embedded in a polymer matrix like polystyrene (PS), polyvinyl alcohol (PVA), PMMA etc. The motivation behind this work is to understand the distribution of these semiconductor nanocrystals of different-different particle size in the polymer matrix. It is expected that greater particle size semiconductor nanocrystals will be distributed up to higher depth while smaller particle size nanocrystals will be distributed on the surface of the polymer matrix. So distribution of defects will be different for both sizes of nanocrystals. Apart from this it is also expected that the modifications after irradiation of swift heavy ions (SHIs) will be also different at surface of the semiconductor nanocrystals embedded polymer matrix comparatively to higher depth distributed nanocrystals in the same matrix. Ion-matter interaction is an important issue because of nature of electronic and nuclear energy losses. Due to this grain evaporation and grain fragmentation is expected, so ion impact on embedded nanoparticles system is interesting due to suppression of weak link boundaries which is inherent in case of nanostructure films.

Polymers will provide the stability and protect against the agglomeration of the semiconductor nanocrystals. A typical embedded nanoparticles system is different from nanostructure films in view of the presence of isolated nanoparticles where the grain boundary problem is no obvious, which is otherwise observable in nanostructured materials. Therefore, the embedded structure provides a suitable system where ion matter interaction at the nano scale level can be studied in great detail.

It has been reported in the literature that band gap is engineered by control of the crystal size that leads to tunable band-edge emission. By doping the nanocrystals with luminescent activators, the excitation can be tuned by quantum size effects, even though the activator-related emission energy is largely unchanged.

Doped semiconductor nanocrystals are extensively investigated to obtain basic information on impurity states in quantum dots and to examine their potential applications in novel light-emitting devices. It was reported that doped semiconductor nanocrystals can yield high luminescence efficiencies. The doping of Mn^{2+} into II–VI semiconducting nanoparticles potentially gives rise to a new class of luminescent materials with a wide range of applications in displays, sensors and lasers. An appreciable enhancement in the PL property of ZnS-coated CdS nanoparticles in a polymer polycetyl-*p*vinylbenzyldimethylammonium chloride (PCVDAC) has also been reported.

Some studies show the effectiveness of various inorganic capping agents having different band gaps on the surface passivation of cadmium sulphide (CdS) nanoparticles. They have reported that it is possible to block the non-radiative channels on the surface of these nanoparticles by capping them with wider band gap inorganic materials like Cd $(OH)_2$ and zinc sulphide (ZnS).

The purpose of this work is synthesis of nanoparticles by chemical route, and these nanocrystals embedded in the polymer matrix for the stabilization to protect them from the agglomeration. The embedding of these nanocrystals was done by using the solution cast method. The nanocomposite polymer matrix irradiated by swift heavy ions (SHIs) with in different doses range and different ions. Their alignment after irradiation is characterized.

In summary, the following work has been carried out:

1. Synthesis the nano particles of CdS/ZnS with varying concentration
2. Doping of CdS/ZnS with transition metals
3. Characterization of formed Nano particles
4. To embed these nano particle in a polymer matrix (PS)
5. To characterize optical, chemical and structural properties of nano composite membranes before and after irradiation

The present work is organized into following five chapters:

Chapter-1 Deals with the basics of polymers and nanocomposites. Importance of irradiation in the field of materials science is explained. An idea about energy loss mechanism of ionizing radiation and swift heavy ions irradiation in polymers are discussed. The significance of swift heavy ion beam, in the field of materials science is explained in detail. A review of literature on present experimental work on the swift heavy ion beam on the properties of polymeric materials is carried out. The objectives and future scope of the present work have been given at the ending of this chapter.

Chapter-2 Gives the information about the material used and experimental technique used in present work. The synthesis of ZnS and CdS nanoparticles is shown in this chapter. This chapter gives the information about the formation of nanocomposites film. The facility of Pelletron accelerator is discussed. 60 MeV Ni ions beam of the fluence from 10^8 to 10^{11} ions/cm^2 used for irradiation of nanocomposites film. Different characterization techniques like UV-Visible, XRD, FTIR and SEM are discussed before and after irradiation.

Chapter-3 This chapter includes the comprehensive studies of optical, chemical and structural properties of the pristine and 60 MeV Ni ion beam irradiated with CdS doped polystyrene (PS) and metal (Ni, Cu) doped polystyrene (PS) films at different fluences. The effect of doping of metals and ion irradiation was studied for modification in optical, chemical and structural properties of PS/CdS nanocomposites. The optical band gap energy and carbon atom through UV-visible spectroscopy for such nanocomposites films is explained. The diffraction peaks of metal doped polystyrene (PS) at various fluence discussed in this chapter. Further, FTIR spectral analysis was used to investigate the bonding and structural changes induced in the nanocomposites polymer due to Ni^{5+} ions beam irradiations.

Chapter-4 In this chapter the optical, chemical and structural properties of the pristine and 60 MeV Ni ion beam irradiated with ZnS doped polystyrene (PS/ZnS) and metal (Ni, Cu) doped polystyrene (PS) films at different fluences. Conformation of ZnS nanoparticles is done by SEM image. The films of Ni doped PS/ ZnS and Cu doped PS/ ZnS were irradiated with Ni^{5+} ions of energy 60 MeV to different fluences of 10^{10} and 10^{11} ions/cm^2.Modification due to heavy ions in optical, chemical and structural modifications were studied by UV-Visible Spectroscopy (UV- Vis), Fourier Transform Infrared spectroscopy (FTIR) and X-Ray Diffraction Spectroscopy (XRD).

Chapter-5 This chapter concludes the outcomes of this research work and presents a discussion of their implications in the context of present and future effects of nanocomposite materials. The future scope of the present work has also been presented.