

Study of Photoluminescence of ZnO: Li Phosphor

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Abstract: Luminescence is process by which under the influence of an exciting agent, matter generates non-thermal radiation, characteristic of a particular luminescence material. Study reveals that particle size of the phosphors increases with firing temperature and reaches an average of about 30-40 m. Therefore three excitation peak observed at the wavelength 261.2 nm (4.752 eV), 273.2 nm (4.543 eV) and 284.8 nm (4.370 eV). The peak at 261.2 nm was maximum intensity it is used for study emission spectra. Similarly five emission peaks observed namely 407.68 nm (3.044 eV), 423 nm (2.934 eV), 446 nm (2.78 eV), 468 nm (2.652 eV) and 492 nm (2.62 eV). Maximum intense peak detected at wavelength 468 nm (2.62 eV). The photoluminescence in ZnO: doped Li shows donor impurity introduces some defects in the pure crystal structure.

Keywords: Photo luminescence, ZnO: Li Phosphor

1. Introduction

One of the most important problem of solid state physics is luminescence, the description of processes following the absorption of radiation by a substance. Its study reveals the dominant role the imperfections and small traces of impurities play in determining specimen's behaviour with respect to electrical and optical properties.

The importance of luminescence at present system is from its commercial applications. To mention but a few fluorescent lighting, C.R. tubes for radar and television advertising paints, commercial washing powders, scintillation counters and the recently developed solid state lasers [1, 2].

Luminescence is a process by which under the influence of an exciting agent, matter generates non-thermal radiation, characteristic of a particular luminescent material [3].

2. Method of preparation of ZnO Phosphors

ZnO Phosphors were prepared by Arnold Pfahnl [4] at a variety of firing temperature according to the reaction $2\text{ZnO} + \text{ZnS} = 3\text{Zn}(\text{excess}) + \text{SO}_2$. The absolute values of the cathode luminescent intensity I and decay time T were determined for the green emission band of these Phosphors at 5 mA/cm² and 10 KV excitation. The temperature dependence of I and T , the Form of decay, the dependence of T on exciting current density, the aging characteristics and the spectral distribution were also measured.

It was found that at liquid nitrogen temperature I and T are nearly constant for all samples regardless of the firing temperature used during the phosphor preparation. At room temperature a nearly linear relationship exists between I and T . This Behaviour is independent of sample preparation methods or commercial source of the phosphor. The influence of the firing temperature on the structure of luminescent center is also evident from the increased aging rate of those samples which were prepared at higher temperature [5].

Emphasis in this study has been placed on the relationship between emission intensity and decay time of the green

emission and no attempt was made to investigate the relationship between the green and U.V. emission. Results also were sought which may be contributed to a better understanding of the basic process involved in the green luminescence of ZnO.

3. Experimental

For the preparation of the phosphor 5 or 10gm of ZnO (R.P) + X weight % ZnS (X = 0, 1, 5, 10, 15) were fired at various temperature for one hours in covered quartz crucibles and in an atmosphere of nitrogen. All the samples used in the present experiments were prepared from the same batches of ZnO and ZnS as same variation in the emission intensity were found among batches from different procedure. It was necessary that the luminescent pure (l.p.) grade of ZnS be used, since the use of reagent pure (r.p) grade resulted in a considerable reduction of the emission intensity.

The particle size of the phosphors increases with the firing temperature and reaches on average of about 30-40 μ for the samples fired at the highest temperatures. This is well within the limits of the particle size of the commercial samples. On the other hand, it was found that it is possible to change the particle size distribution considerable without reducing the maximum intensity if careful mechanism treatment (grinding) is applied. A demountable cathode ray tube was used to measure the emission intensity and decay time.

A comparison between the commercial samples and those prepared in the present experiment shows that most of the former have higher intensities than the latter. The method used for the preparation has certainly a strong influence on the maximum intensity. The highest intensity in this case was obtained by the oxidation of luminescent pure ZnS but this is still 20% below the maximum found for commercial samples. There are different methods to prepared ZnO phosphor. The method which is adopted is the ZnO Phosphor as ZnO : Li.

The preparation of ZnO phosphor is carried out with starting compound $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$. The phosphor samples have been prepared by adding calculated amounts of activator and co-activator. So for 10 gm of $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ of LiCl with some NH_4OH in excess is mixed. The solution so obtained should

be so uniform that no particles can be seen with Naked eyes. With the above concentration, 20 gm of ZnO phosphor was made. The above solution is put electric furnace and heat treatment of phosphors have been carried out for 2 hours at 1050 °C in purified Nitrogen.

This firing process gives powder form of the sample which is to be studies for photoluminescence property of the material. This formed ZnO phosphor is then exposed with the help of the fluorescence spectrophotometer F- 4000 model.

4. Result and Conclusions

The present work includes 1) Excitation spectra 2) Emission Spectra 3) Study of energy level diagram of ZnO phosphor –Li doped.

The relative luminescent intensity I in emission and excitation spectra was determined for the green emission of ZnO- Li phosphor.

The results are discussed on the basis of a model for ZnO phosphors.

4.1 Excitation Spectra

The excitation spectra of a phosphor as the plot of the luminescence intensity as a function of wavelength of the exciting radiation (fig.1 (a)). It was found that the excitation peaks in the region 260 nm to 290 nm. These peaks are seen in the fig.1 (a).

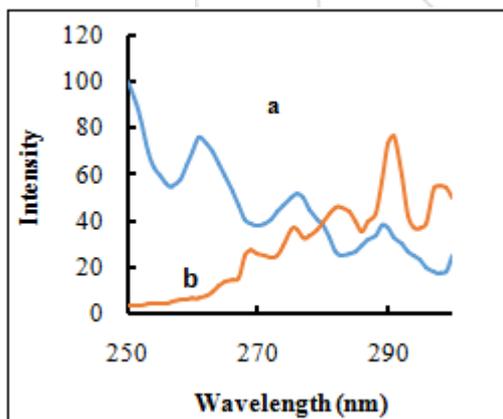


Figure 1: (a) Excitation spectra b) Emission Spectra of ZnO : Li phosphor

Peak positions of emission were found to vary as the wavelength of exciting light was varied. 1st peak, 2nd peak and 3rd peak at the wavelength 261.2 nm (4.752 eV), 273.2 nm (4.543 eV) and 284.8 nm (4.370 eV) respectively. The peak at 261.2nm was maximum intensity so it was used for studying emission spectra.

4.2 Emission Spectra

It gives the luminescence intensity as a function of wavelength of emitted radiations keeping the wavelength of exciting radiation same. For ZnO: Li phosphor, 400-500 nm regions is plotted on enlarged scale as show in fig 1 (b). The

emission spectra taken by exciting the sample using excitation wavelength 261 nm (4.752 eV). Five different peaks obtained at the wavelength 407.68 nm (3.044 eV), 423 nm (2.934 eV), 446 nm (2.783 eV), 468 nm (2.652 eV) & 492 nm (2.52 eV). The intensity of the maximum peak is obtained at the wavelength of 468 nm (2.62 eV).

The fluorescence intensity depends on a large extent on the preparative parameters such as grain size homogeneous mixing of ingredient and heat treatment. From the peaks inter-band level are calculated as the first peak at 407.68 nm when converted in to eV, it gives 3.044 eV. Now the forbidden gap of ZnO is coated as 3.2 eV in the literature. As ZnO is n - type the level have to be donors. So subtracting 3.044 eV from 3.2 eV gives the position of first level below the conduction bands. In the similar manner other peaks are treated. Thus we found that there are five different levels situated within 0.16 to 0.88 eV below the conduction bands. The structure of these levels may be due to interstitials of Li atom.

4.3 Energy level diagram and conclusions

Arnold Pfahnl [4] has shown that ZnO is on n-type semiconductor with donor levels at 0.04-0.05eV below the conduction band. Several energy level of an atom or a more complicated system are represented by horizontal lines inside the band gap. The vertical distance between two lines is proportional to the corresponding difference in energy. Energy level diagram for ZnO doped Li is shown in Fig.2. As ZnO is an n-Type semiconductor with interstitials Zn acting as a donor. In the present method, the donor impurity takes its place near the conduction band, since there always is a great number of electron present in the conduction bands it is assumed that the green emission, takes place, whenever a hole has been captured by the luminescent center. In the present study, Li is incorporated interstitially into the ZnO lattice. Different trap levels are shown below the conduction band. The firing temperature in the present case is quite high at 80 eV can assume these bands in energy level diagram to be due to excess of oxygen in different ionized states. A Pfahnl [4] has concluded that Li is a donor with activation energy of 0.05eV. Doping with Li should therefore simply increase the electron concentration in the conduction band but should have no influence on intensity.

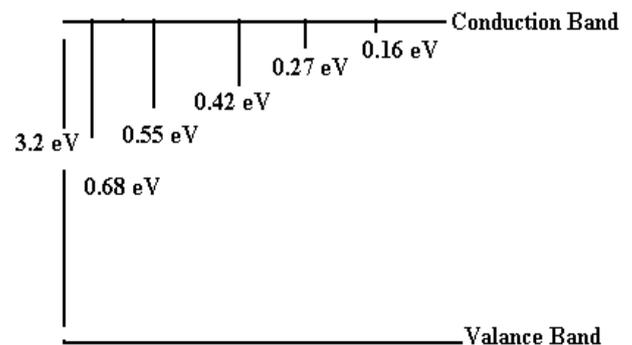


Figure 2: Energy level: (with different trapps) ZnO: Li Phosphor

The studies in hand are expected to result into some fruitful and interstitial data which may throw some light on the

mechanism of photoluminescence phenomena in ZnO: Li phosphor. The study of photoluminescence of ZnO phosphor is sufficient to know that the donor impurity introduces defects in the pure crystal structure of the original sample and makes it possible to show the luminescence property.

5. Acknowledgements

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Author Profile



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