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TL-OSL Study in Doped Nacl

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ABSTRACT

Optically Stimulated Luminescence based phosphors are recently becoming popular in the field of radiation measurements due to its advantages over traditionally used Thermoluminescence based phosphors. With this view NaCl doped samples of various impurity concentrations were synthesized and studied for their TL-OSL properties. NaCl: Ca,Cu,P and NaCl:Mg,Cu,P samples show good OSL and TL properties. Intense OSL is observed in these samples and the observed OSL is 14 times more than that of commercial Al_2O_3:C(Landuer Inc.). These phosphors will be useful as reference phosphors for the retrospective dosimeters with varied origin.

I. INTRODUCTION

Alkali halide base phosphors find widespread application in field of radiation detection. In the past, sodium chloride-based materials have been claimed as suitable candidates for TL dosimetry[1-4]. Recently there is renewed interest in this material for the possible applications as an accidental dosimeter in the retrospective dosimetry. NaCl is widely available material both in the residential areas as well as in surroundings. It has a strong radiation-induced OSL sensitivity. In recent years several publications are seen on this subject with OSL as technique to measure radiation doses. [5]

Use of NaCl has also been proposed for the to date palaeohydrological events [6].NaCl is highly soluble in water and natural halite deposits are found when the water in the region evaporates. This property suggests a possible geological application in which dissolution is the resetting event and the date obtained represents the date of crystallization.

Some recent OSL studies on alkali halides including those of Nanto et al. [7-8] Bandyopadhyay et al. [9]Bailey et al. [10]have discussed the OSL property of NaCl relevant to dating and dosimetry. The above discussion suggests that NaCl is a potential material for retrospective dosimetery and can act a good dosimeter in case of accident. However to get the exact estimation of the dose there should some calibration with respect to NaCl based standard phosphor of known properties. To our knowledge such phosphor is not available. In the presented work an attempt is made to develop NaCl based OSL material which can be a reference material for the retrospective dosimeters with varied origin.

II. EXPERIMENTAL

Desired quantity of Analytical grade Sodium chloride was taken and dissolve in minimum amount of double distilled water to which impurities(Ca,Cu,P) in desired amount were added. The water was evaporated slowly at 80°C to yield dry powder of doped NaCl. The dried powder was melted in a porcelain crucible in preheated furnace maintained at its melting point. and cool naturally to room temperature, the solidified mass was crushed to fine powder. Samples with NaCl:Ca(0.2)Cu (0.002)P(1.92): NaCl:Mg(0.2)Cu(0.002)P(1.92) concentration of impurities show good dosimetric properties and hence are discussed here.

Photoluminescence studies were carried on Hitachi F-4000 Spectrofluorometer with the excitation slit 1.5 nm and the emission slit 5 nm. For studying the TL and OSL response, all the samples were irradiated using $^{90}Sr/^{90}Y$ beta source with the dose rate of 20mGy per min. The samples were given a test dose of 100 mGy. The CW-

OSL response and thermoluminescence of the samples is recorded on the assembly described elsewhere. [11]

During the OSL measurements the LED power was kept at 11mW/cm^2 and signal was recorded for 100 s with the acquisition time 0.1s. All the thermoluminescence measurements were taken at the heating rate 4°C/s.

III. RESULTS AND DISCUSSION

A.Photoluminescence in doped NaCl Samples:

Figure 1 shows photoluminescence spectra of NaCl samples. In samples the emission band is observed at 358 nm with excitation at 259nm (fig 1 d) . This emission from Copper is attributed to $3d^9 4s^1 \rightarrow 3d^{10}$ transition. [12] The emission intensity is less compared to only Cu doped sample(fig 1 c). This is due to addition of divalent impurity which increases the de-excitation probability of Cu^+ ions. Incorporation of P doesn't affect the Cu luminescence intensity and is nearly same to what is observed in case of only Cu doped sample.

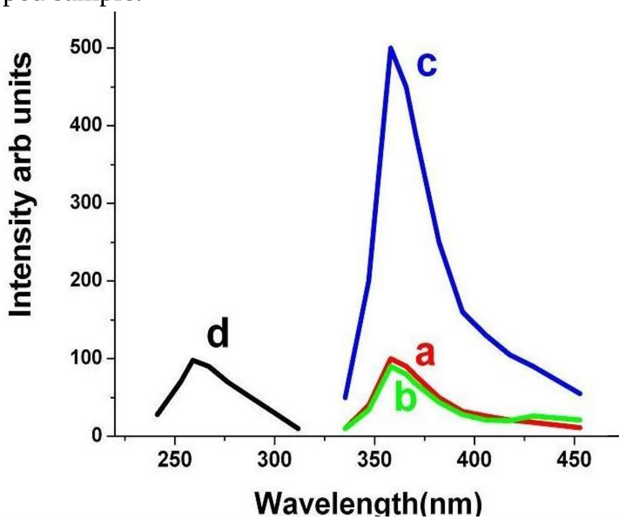

Figure 1. Photo-Luminescence in NaCl: Emission (a) NaCl:Ca,Cu,P (b) NaCl:Mg,Cu,P (c) NaCl:Cu Excitation: (d)For all samples of NaCl.

B. TL & CW-OSL Response in doped NaCl Samples

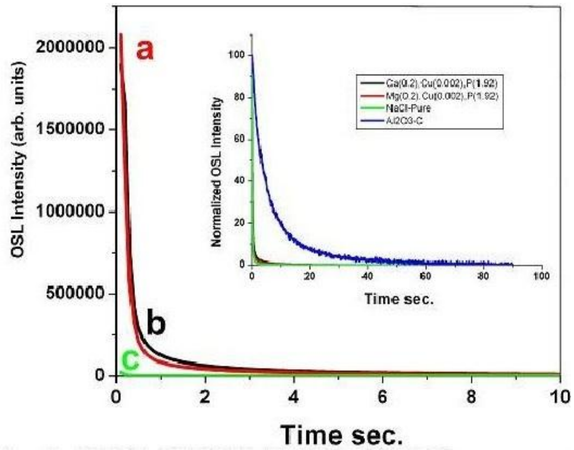

Figure 2.CW- OSL Response in NaCl (a) NaCl:Ca,Cu,P (b) NaCl:Mg,Cu,P (c) NaCl:Cu

Figure 2 shows the CW–OSL response for blue stimulated for various NaCl samples. For pure NaCl the intensity is very low and the whole signal decays within 0.5s. For pure NaCl TL peak is observed around 175^O C along with the high temperature peak around 350^O C (Figure 3 e). The intensity of these peaks are less compared to doped samples. After OSL the peak around 175^O C completely vanish and a non-structured TL glow curve is observed (Figure 3 f). This indicates that the carriers released from the deep traps gets re-trapped in the TL traps present in the 50^O C to 400^O C temperature range. In case of doped samples the OSL sensitivity increases many fold and intense Blue stimulated luminescence (BSL) with fast decay (~3s) is observed.

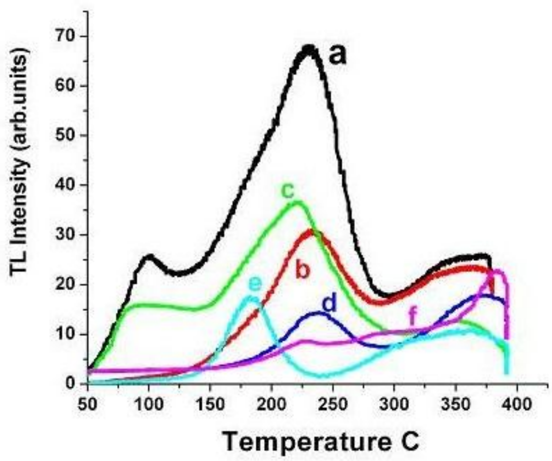

Figure 3. TL Response in NaCl (a) NaCl: Ca,Cu,P (b) NaCl: Mg,Cu,P (c) NaCl:Cu

Thus incorporation of impurities also influences the decay and makes the decay slower. Maximum OSL sensitivity is obtained for Ca=0.2m%,Cu=0.002m% and P=1.92m% and Mg=0.2m%,Cu=0.002m% and P=1.92m%. If the Mg doped and Ca doped samples are compared then the BSL for Ca doped sample (Figure 2 a) is slower compared to Mg doped sample (Figure 2 b) for same concentration of Cu and P impurity. The glow curve for TL after OSL is shown in figure 3 In case of Ca doped sample substantial decrease in TL is observed. The TL after OSL is half of the TL before OSL. After OSL all the peaks vanish with substantial decrease in the peak around 210 C (Figure 3 b). In case of Mg doped sample similar thing is observed. All the samples show intense BSL comparable to the commercial Al_2O_3:C(Landuer Inc.). The inset shows the OSL decay of Al_2O_3:C (Landuer Inc.). Since the decays are different the OSL cannot be compared directly. Hence method of averaging counts over initial few seconds suggested by Yukihara [13] was employed to compare the samples. It was found that the sample with Ca (0.2m%) ,Cu (0.002m%), P(1.92m%) is 14 times sensitive to that of Al_2O_3-C, Similar sensitivity is observed incase of Mg (0.2m%) Cu (0.002m%) P(1.92m%) doped sample and sensitivity is 13 times more than that of Al_2O_3-C. In case of Mg doped sample the TL(fig 3c) is less compared to Ca doped sample (fig 3 d) and the TL peak is broad and spans the 50 C to 350 C range, therefore the contribution from the TL/OSL traps to the total OSL in case of Mg doped samples will be less compared to Ca doped sample. The TL and OSL data is summarized in table I. Since it has been observed that low temperature peaks fades quickly with time it is expected that Mg doped sample should fade less compared to Ca doped sample.

Table 1. TL-OSL Data

Sample	**Avg counts For 3 Sec.**	**Comparison with Al_2O_3**	**Integrated TL**	**TL after OSL**
NaCl:Ca(0.2)Cu (0.002) P(1.92)	234046.	13.7 times	10110	4759
NaCl:Mg(0.2)Cu(0.002)P(1.92)	192347	12.77 times	5837	2803
NaCl-Pure	1565	.091 times	2006	2670
Al_2O_3	17057	--	-	-

IV. CONCLUSION

NaCl:Ca,Cu,P NaCl:Mg,Cu,P OSL phosphors are synthesized. All the samples shows Cu^+ emission around 360 nm, Of the various doped samples the sample with concentration Ca(0.2m%), Cu(0.002m%), P(1.92m%) shows intense TL with main peak appearing around 225 C. In case of Mg, Cu, P doped sample also intense OSL is observed for the same concentration however observed TL is less than Ca , Cu , P doped sample. Intense OSL is observed in these sample and is almost 14 times more than Al_2O_3:C.With further study of fading and linearity of dose ,NaCl can be recommended as reference material for dosimeters with varied origin. And can be used in accidental and retrospective dosimeters

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