Eu impurity in mixed crystal KBr_xCl_{1-x} and measurement of its thermoluminescence

Haji-Ali E.

Department of Physics, Imam Hossein Comprehensive University, Tehran, Iran

Email: ebhajiali@gmail.com

Abstract

In this article, we single crystal were grown KBr_xCl_{1-x} and KBr_xCl_{1-x}:Eu in the laboratory by Czochralski method (CZ). Then cut pieces were exposed under γ - ^{60}Co radiation and their glow curve was investigated. Optical properties of KBr_xCl_{1-x}:Eu mixed crystal as a result of Eu heavy element effect determine in UV confine with decreasing F absorption band and formation of Eu^{+2} stable ones. Also existence of electron trap centers (F) belong to pure host crystal and Eu activation element role is recognized as luminescence center which is effective in sensitivity enhancement of measuring radiation dose by thermoluminescence method.

Keywords: glow curve, Thermo-luminescence, alkali halide,

Introduction

According to increasing usage of nuclear energy knowledge, the importance of monitoring different ionized radiations is tangible. Because of the differences between radioactive source, it is necessary to do survey about the different type of radiations with different energy and dose. Thermo-luminescence (TL) is a significant method for dosimetry applications. Alkali halide crystals are suitable environments as scintillator and ionized radiation dosimeter.

Recently, most of researches were concentrated on luminescence, TL and dosimeter alkali halide crystals properties.Entering Eu^{+2} as an impurity to the alkali halide uses for detecting α, β and γ radiations [1]. In addition they have got a significant application for detecting UV radiation [2-3]. KBr_xCl_{1-x}:Eu mixed crystal favours because of improvement of TL yield with respect to the status that each of main elements use alone [3-4].

Experimental

Preparation of the materials

Pure KBr_xCl_{1-x} and KBr_xCl_{1-x}:Eu were grown by Czochralski method. At first in preparation stage pure KBr and KCl salt powder (Merck) and Eu impurity (Merck) with specific weight proportion was measured and was mixed for uniformity the composition. Then mixed salt was poured into the crucible and was placed in the middle of the furnace and salt's powder was heated to 100 °C upper than melting point. After contacting seed to the melt's surface, growth condition is controlled with regard to correct necking process to minimize crystal defects. After necking process, increasing the crystal diameter to the ideal size does with slow cooling process. Figure 1 shows growing pure and doped KBr_xCl_{1-x} crystal with Eu impurity.

$KBr_{89.90}Cl_{10}:Eu_{0.1}$

$KBr_{90}Cl_{10}$

Figure 1. Schematic of grown crystals

Results and discussion

Grown crystals were cut in crystallographic planes direction in size $3 \times 3 \times 1mm^3$ and their glow curve were measured by TLD (Harsha Model). Figures 2 and 3 are related to KBr-KCl and KBr-KCl:Eu, respectively.

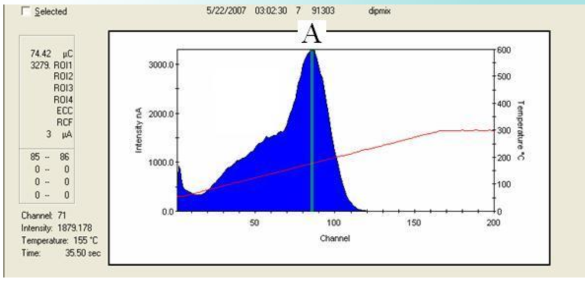

Figure 2. glow curve of $KBr_{90}Cl_{10}$ crystal

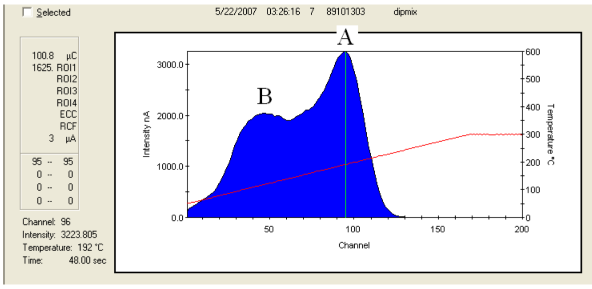

Figure 3. glow curve of $KBr_{89.90}Cl_{10}$:$Eu_{0.1}$crystal

Under the graph area tell this subject that TLD system is counted 74.42 $\mu C$and the largest peak (A peak namely) appears with 3μA intensity.
Under the graph area is 100.8μC and A's peak shifts to the higher temperature. The highest peak (A peak namely) is read with 3μA intensity.
Eu^{+2} is responsible of electron trapcenter in lattice so the enhancement of its concentration is effective to increasing TL's under the graph area and its peak intensity. In figures 2 and 3, the displacement of glow peak temperature (GPT) to the higher temperature determines the enhancement of trap depth. Which it can be attributed to the formation of Eu^{2+} interstitial clusters in lattice.
Hence presence of Eu^{2+} impurity in place of K^{+} with formation of (I-Vc) dipole as F center reduces the effect of shallow traps and increases measurement sensitivity.
Indeed if we want to have a good interpretation of KBr-KCl:Eu glow curve, we should compare as-grown crystal (before annealing) and annealed crystal. Because (Figure3. B peak) complicated dipole cluster (Eu^{2+}-Vc) creates before annealing so peaks appearance site specify in high temperature, with high intensity and also weak peaks in low temperature. But in annealed status high temperature peaks lose or appear with very low intensity because of breaking complexes to free dipoles. At opposite low temperature peaks appear with more intensity. Recent situation is compatible by increasing free dipoles concentration. So it displays the effect of available complexes for creating shallow defects and stability of creates defects in lattice under irradiation [5].
As observed, with adding Eu^{2+} impurities to KBr-KCl according to these diagrams the importance of thermo luminescence of this crystal evaluates following.

The role of natural defects in crystal lattice proposes as main trap center. Eu^{2+} impurity operates as recombination center and it's effective for enhancement of TL sensitivity response.

Conclusions

As regards we know the place of formation of TL peaks in approximation temperature (120-230 °C) is suitable for individual dosimetry so, by comparing curves can be concluded the enhancement of its radiation sensitivity to the γ ionizing radiation which is suitable in dosimetry properties. Also dislocation's density of as-grown crystals is at times of 10^5 cm^{-2}.Whereas density for crystals with optical usage determined less than $10^7 cm^{-2}$, so the quality of grown crystals are appropriate for optical fragments.

References

[1] H. Nanto, K.Murayama, T.Usuda, F.Endo, Y.Hirai S.Taniguchi and N.Takeuchi, *J. Appl. Phys.***74**, 1445 (1993).
[2] I. Aguirre de Carcer, F.Cusso and F.Jaque, *Phys. Rev. B***38**, 10812 (1998).
[3] B. Castaneda, R.Aceves, T.M.Piters, M.Barboza-Flores, *Appl. Phys. Lett.***69**, 1388 (1996).
[4] M. Barboza-Flores, R. Melendrez, B. Castaneda, T. M. Piters, R. Perez-Salas, R. Aceves, J. A. Munoz and I. Aguirre de Carcer, *Radiat. Meas.* **29**, 487 (1998).
[5] S.W.S. McKeever, "Thermoluminescence of Solids" (1988).
[6] K.Sangwal,"Etching of Crystals", *North Holland* (1987).