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Thermoluminescence and Microhardness Studies in Ternary Mixed crystals with different dopants

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Abstract.

In the present work we have grown (KCl) (KI)(KBr) ternary alkali halide crystals with LiCl and $MgCl_2$ as dopants for different compostions of KCl, KBr and KI by the melt method and physically characterized. We have studied the Microhardness for unirradiated crystals and thermoluminescence(TL) spectra of γ-irradiated KCl-KBr-KI ternary mixed crystals containing LICl and $MgCl_2$ as the dopants. It is observed that the formation of a mixed crystal is accompanied by an increase in hardness for $MgCl_2$ added sample where as decreased for the LiCl impurity and Microhardness varies non-linearly with composition. Thermoluminescence glow curves were analysed as function of composition x and irradiation strength. A thermoluminescence enhancement, relative to the pure end components is found and mixed crystal presents a significant increase in thermoluminescence efficiency.

Keywords: Mixed alkali halide crystals,Microhardness, Thermoluminescence, γ-irradiation

1.0 INTRODUCTION

Alkali halide crystals have several practical applications viz. as radiation detectors, as X-ray and neutron mono-chromators, as infrared optical components and also as laser host materials [1]. A physical property that limits the utility of alkali halides as device materials is their low hardness. The mixed and doped crystals of alkali halides are found to be harder than the end members and so they become more useful in these applications. for these reasons, it becomes necessary and useful to prepare mixed crystals regardless of miscibility problem and characterize them by measuring their physical properties.

The phenomenon of thermoluminescence finds successful applications in many disciplines today, namely in Archaeology, Biology, Geology, Biochemistry etc. Apart from the practical applications of TL, TL in correlation with other techniques has been successfully employed for several years to study the defects in crystals, their formation, distribution and interaction among themselves and with the lattices.

An extensive amount of work on thermoluminescence studies of pure alkali halides has been done and the defect parameters concerning process have been evaluated. The TL studies on alkali halide ternary mixed crystals is very limited. Therefore in the present investigation, Microhardness and Thermoluminescence Studies on (KCl) (KI) (KBr) ternary mixed alkali halide crystals with Lithium Chloride and Megnisium Chloride dopants have been considered.

1.1 EXPERIMENTAL

(KCl)(KI)(KBr) mixed crystals of different composition with and without LiCl & $MgCl_2$ dopants were grown from the melt using AR grade chemicals of KCl, KBr, KI. LiCl and $MgCl_2$ as the starting materials.

Microhardness measurements were carried out using Zwick 3212 hardness tester fitted with a Vicker's diamond pyramidal indenter at a load of 50P on non radiated crystals.

Pellets of the samples were irradiated at T=300K from a ^{60}Co Gamma irradiation source having beam energy 1.17 Mev and 1.27 Mev to strength of 10, 15 and 20Mrads. The TL spectra were recorded with a standard method at a linear heating rate of 5°C/s & 2°C/s in the 300-650 K range and the luminescent intensity emitted by the sample is recorded using PC based TL reader. The necessary calculations were performed on a computer with use of a numerical method.

1.2 Results and Discussion

Figure.1 shows the variation of Microharness in undoped and $MgCl_2$ doped mixed system. Microhardness measurement shows that the formation of a mixed crystal is accompanied by an increase in hardness for $MgCl_2$ added sample where as decreased for the LiCl impurity and Microhardness varies non-linearly with composition. It implies that the divalent impurity ions(Mg^{++} ions) are favoring hardness whereas monovalent impurity ions (Li^+ ions) are not favoring the hardness, which is in agreement with the earlier reports. Also the increased hardness is attributed to the size misfit Anions in KCl-KBr-KI solutions[2].

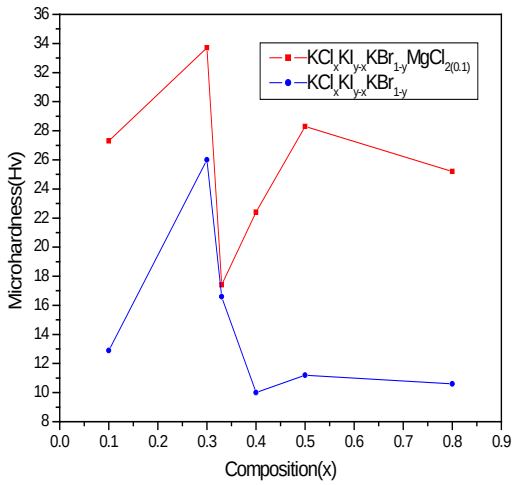

Figure.1 Variation of Microhardness with composition in $MgCl_2$ doped system

Figures 2 & 3 shows the TL glow curves of LiCl doped (KCl)(KI)(KBr) mixed samples and Figures 4 & 5 shows the TL curves of $MgCl_2$ doped (KCl)(KI)(KBr) mixed samples irradiated to a strength of 10Mrads for the heating rate of $2^oC/s$ and $5^oC/s$.

TL glow peaks observed for $MgCl_2$ doped mixed samples which appeared at the higher temperature for the heating rate of $2^oC/s$ merges as the heating rate is increased to $5^oC/s$. The glow peak intensity is observed to be more in the samples with higher concentration of KCl and is low for the samples with higher concentration of KI. Shift in the glow peak is observed with the change in the concentration of either of three.

With increase in the concentration of KBr, intensity of the glow peak decreases. Glow peak position shifts towards the low temperature with the increase in concentration of KBr and towards the high temperature side with the increase in the concentration of KCl. Intensity of glow curves are found to be more for the $MgCl_2$ added samples than with the LiCl impurity.

The thermoluinescence behavior in mixed ternary crystals is associated with trapped electrons in the form of F and Fz centers[3].

It is well known that thermoluminescence is produced while trapped carriers are thermally released and recombined with carriers of the opposite sign; the intensity of the TL glow peaks is proportional to the number of trapped carriers[4]. Therefore, an increase of trapped carriers and in the TL efficiency should be expected for the mixed crystals.

The glow curves obtained for all the combinations of mixed crystals were analyzed by numerical curve fitting and the trap depth (activation energy) has been calculated. The trap depth decreased with increase in KBr concentration and attained minimum at the intermediate compostion and increased again. The non linear variation of trap depth with compostion were thougth of as due to high disorder present in the mixed crystals[5].

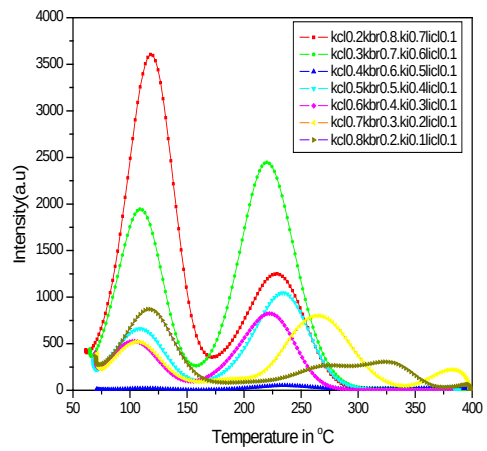

Figure.2.Thermoluminescence glow curves of (KCl)(KI) (KBr) ternary mixed Crystals doped with LiCl for the heating rate of $2^oC/s$

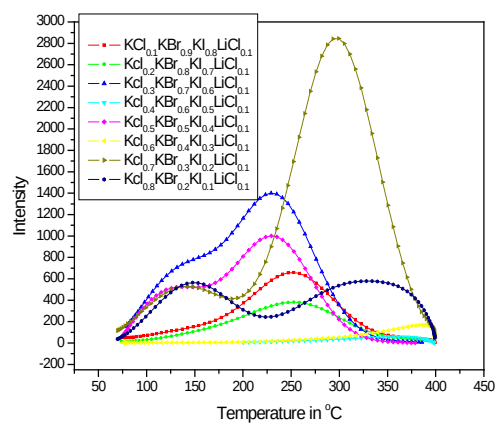

Figure.3.Thermoluminescence glow curves of (KCl)(KI) (KBr) ternary mixed Crystals doped with LiCl for the heating rate of 5°C/s

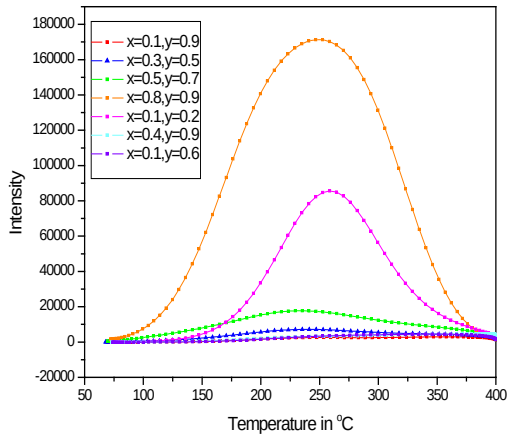

Figure.4.Thermoluminescence glow curves of (KCl)(KI)(KBr) ternary mixed Crystals doped with $MgCl_2$ for the heating rate of 2°C/s

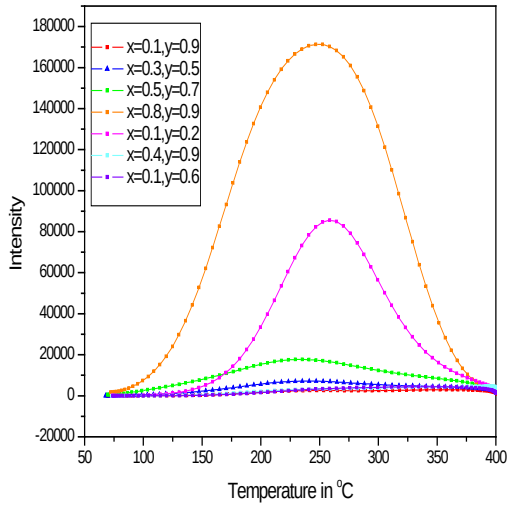

Figure.5.Thermoluminescence glow curves of (KCl)(KI)(KBr) ternary mixed Crystals doped with $MgCl_2$ for the heating rate of 5°C/s

2.0 CONCLUSION

Good optically transparent ternary alkali halide mixed crystals of (KCl) (KI)(KBr) of different composition with LiCl and $MgCl_2$ dopants were grown from the melt. The composition dependence of micorhardness is exhibited and increased hardness of mixed crystals is attributed to the size misfit in solid solutions. Addition of divalent impurity Mg++ ions are favoring hardness whereas monovalent impurity ions (Li^+ ions) are not favoring the hardness. Intensity of glow curves are found to be more for the $MgCl_2$ added samples than with the LiCl impurity. The non linear variation of trap depth with compostion is due to the high disorder present in mixed crystals.

Systematic investigation of other systems is essential in order to get more information and also to confirm the ideas that have been proposed. Since mixed crystal systems have more concentration of defects, their role on macroscopic physical properties would be worth investigating.

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