Time Decay of Stable Absorption of Gamma Irradiated LNO:Cu and YAP:Ce crystals

Piotr Potera[1,*], I Stefaniuk[1]

Abstract. *The present work is devoted to investigation of stability of stable color centers that are induced by gamma radiation in Cu-doped LiNbO3 and YAP:Ce single crystals*

I. Introduction

Lithium niobate $LiNbO_3$ (LNO) is a ferroelectric crystal having important applications in laser, electrooptic, acoustooptic and optical storage devices. Yttrium aluminium perovskite is perspective materials for laser engineering .

Unfortunately, the lifetime of color centers were studied in literature only for transient color centers. In this work the lifetime of stable additional absorption induced by gamma irradiation of LNO:Cu and YAP:Ce crystal will be determined from data obtained during 10 years.

II. Experiment

The LNO:Cu (0.03 mol%) and YAP:Ce (0,3%) crystals were grown from congruent melt in Institute of Electronic Materials Technology (ITME) by the Czochralski technique. Samples for the SCC investigations were irradiated with gamma quanta (1.25 MeV) from ^{60}Co with absorbed doses $7*10^5$ Gy.

The additional absorption (AA) was measured three times: immediately after irradiation (04.06.2002 for LNO, 8.07.2002 for YAP), two years after irradiation and ten years after irradiation.

III. Results and Discussions

The AA spectrum of LNO:Cu crystal after gamma irradiation represents an intensive wide band with maximum near 25 000 cm^{-1} . Besides, some weak clearing near 10000 cm^{-1} is observed. It was early shown, that such character of AA spectrum indicates that after the annealing of LNO:Cu crystals an increasing of the absorption band caused by Cu^+ ions (at 25 000 cm^{-1}) and decreasing of absorption of Cu^{2+} ions (absorbing at 10 000 cm^{-1}) take place [1]. According literature the contribution in AA with maximum near 25000 cm^{-1} can be due to O^- polarons [2], F^+ [3] or F [4] centers. For YAP:Ce the growth absorption of Ce^{3+} ions was observed after gamma irradiation at 34000 cm^{-1}.

Decay kinetic for the AA LNO:Cu crystals were measured at 25000 cm^{-1} and for YAP:Ce at 34000 cm^{-1}

[1] Rzeszow University, Rzeszow, Poland
[*] ppotera@univ.rzeszow.pl

Analysis of decay kinetic for LNO:Cu shows that approximation with sum of two exponents is satisfactory. Thus, centers of two types with substantially different lifetimes contribute to the absorption band and can be described as:

$$\Delta K(t)_1 = \Delta K_{0,1} + \Delta K_{1,1}\exp\left(\frac{t}{\tau_{1,1}}\right) + \Delta K_{2,1}\exp\left(\frac{t}{\tau_{2,1}}\right) \quad (1)$$

where $\Delta K(t)_1$ is the AA value at time t, $\Delta K_{0,1}$ – AA at the time $t \gg \tau_{1,1}$, $\Delta K_{1,1}$ and $\Delta K_{2,1}$ – maximal AA value for the first and second types centers at the beginning of measuring, $\tau_{1,1}$, $\tau_{2,1}$ – lifetimes of the first end second types centers respectively. Numerical values of the equation parameters are listed in Table 1.

Analysis of decay kinetic for YAP:Ce shows that approximation with one exponent is satisfactory:

$$\Delta K(t)_2 = \Delta K_{0,2} + \Delta K_{1,2}\exp\left(\frac{t}{\tau_{1,2}}\right) \quad (2)$$

Numerical values of the equation parameters are listed in Table 1.

Table 1. Decay parameters for AA of LNO:Cu crystal

Parameters	Value
$\Delta K_{0,1}$	1,808 см$^{-1}$
$\Delta K_{1,1}$	0,245 см$^{-1}$
$\Delta K_{2,1}$	0,104 см$^{-1}$
$\tau_{1,1}$	3,81 year
$\tau_{2,1}$	11,76 year
$\Delta K_{0,2}$	26,47 см$^{-1}$
$\Delta K_{1,2}$	11,29 см$^{-1}$
$\tau_{1,2}$	3,92 year

IV. Conclusions

The stable additional absorption decay in LNO:Cu crystal is mainly due to release electron by Cu^+ ion. The long half-life time of AA is about 12 years. For YAP:Ce crystals one exponential decay with 3,9 year was observed.

References

[1] A.Matkovskii, P.Potera, D.Sugak, Ya.Zhydachevskii, V.Pankratov, D.Millers, L.Grigorjeva, I.Pracka, T.Lukasiewicz, , *Cryst. Res. Technol*. vol. 38 no. 3-5, pp. 388-393.

[2] T.R.Volk, N.M.Rubinina, *Phys. Stat. Sol. (a)* vol. 108, pp. 437-442, 1988.

[3] E.R.Hodgson, F.Agullo-Lopez, *Solid State Comm.* vol. 64 no. 6, pp. 965-968, 1987.

[4] S.M.Kaczmarek, Biuletyn WAT L(6), pp. 21-34, 2001.