DARK– CURRENT RELAXATION IN $YbGa_2S_4$

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ABSTRACT
It is shown that dark-current relaxation in $YbGa_2S_4$ single crystal is connected by the charge accumulation at deep levels at the expense of contact injection. Agreement of experimental data of relay mechanism theory allows contact capacitance, charge accumulation region, to be determined mobility of charge carrier in localized states and deep level concentrations.

Keywords: dark-current relaxation, crystal, accumulation, concentrations.

I. INTRODUCTION

Ternary chalkogenide rare-earth semiconductors with total formula $AB_2^{III}C_4^{VI}$ (A-Eu, Yb, Sm, Ca; B-Ga, In; C-S, Se) are crystallized in rhombic singony. They are high-resistance ($10^7 \div 10^{11}$Om.sm), wide-band ($E_g \approx 4.0$eV) semiconductors [1-5].

In papers [1, 2, 5] crystal structures of $YbGa_2S_4$, $EuGa_2S_4$, $YbGa_2Se_4$ and $EuGa_2Se_4$ have been investigated. Crystal structures of these compounds are close to each other. $YbGa_2S_4$ single crystal has the following parameters of crystal lattice: a=20.14, b=20.12 and c=12.15 $\overset{0}{A}$ [5]. As it is shown in papers [3, 4], Yb and Eu in structure are in special positions 16(e), 8(a) and 8(b), in space group D_{2h}^{24} = Fddd having 8 nearest neighbours of S atoms. Ga atoms are located in tetrahedron centre formed by 4 S atoms. Coordinated polyhedron around Yb atoms represents tetragonal antiprism.

In papers [7-9] there have been given investigation results of injection and thermo activated currents of $YbGa_2S_4$- typed single crystals. It is established that in electric fields $10^2 \div 10^3$V/sm circuit diagram is due to the hole injection from In contacts, in fields $10^3 \div 10^5$V/sm sharp growth of current relates to the thermal field ionization of trap levels at the expense of Frenkel- Pool effect.

To obtain more complete information about the charge accumulation mechanism in $YbGa_2S_4$ single crystals we investigate dark – current relaxation at different electric fields and temperatures.

II. EXPERIMENTAL RESULTS AND THEIR DISCUSSION

To grow $YbGa_2S_4$ single crystals one use gas-diffusion method [10] where crystalline I threefold purified by sublimation has been used as a carrier. Temperature difference at $YbGa_2S_4$ single crystal production is 30^0S. Obtained single crystals are plane-parallel plates. Investigations have been carried out on samples in thickness 150-200mkm, contacts are created by in melting as a type of sandwich, i.e. In- $YbGa_2S_4$-In.

Current relaxation observed at electric field voltage 10^3V/sm are accompanied by charge accumulation which remains in In- $YbGa_2S_4$-In system for a long time.

In fig.1, 2 there have been given experimental charge dependencies accumulated in In- $YbGa_2S_4$-In structure on voltage, square root of current and time.

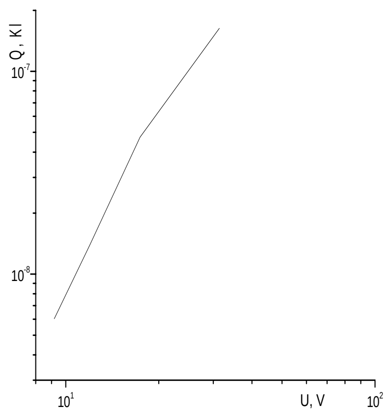

Fig.1(a). Dependence of the accumulated charge on the appended stress.

Dependence of accumulated charge value on delay time of polarized field, shows that first the charge rises to reach the saturation gradually (fig.2).

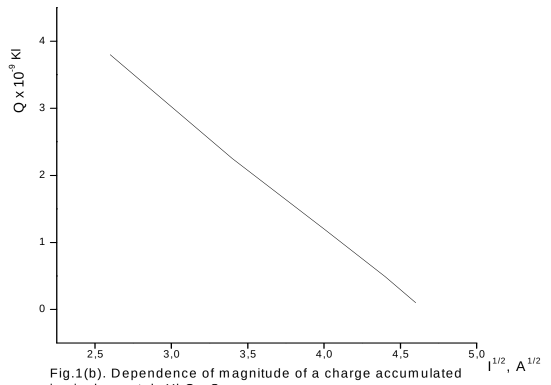

Fig.1(b). Dependence of magnitude of a charge accumulated in single crystals $YbGa_2S_4$ from the radical square from values of a current.

First the accumulated charge value is characteristic of quadratic dependence ($Q \sim V^2$), further it changes linearly with the growth of polarized field (fig 1a).

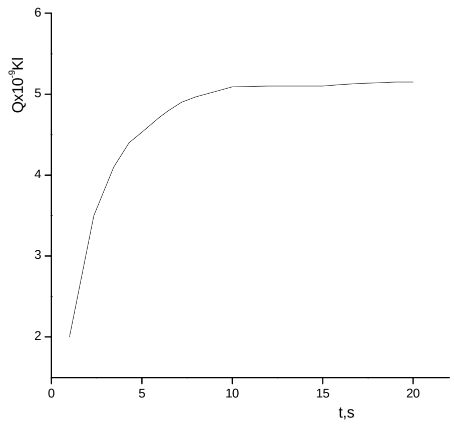

Fig.2. Dependence of magnitude of the accumulated charge.

In papers [11-14] it is shown that temporary current changes and charge accumulation are connected by so-called relay mechanism of charge transfer. Given mechanism suggest that there have been centres of deep capture levels in the single crystal where it is possible jumping conductivity. The presence of barrier between anode and local centres tends to the accumulation of space charge in the neighbourhood of anode, that causes the redistribution of applied voltage. In this case voltage drop in contact must increase gradually, but current intensity through the sample decreases.

According to the relay mechanism of charge transfer [11, 12], current value passes through metal-dielectric-metal system and the value of accumulated charge at each instant are related:

$$Q = VC_k - \sqrt{\frac{C_k LJ}{\mu d_k}}$$

This dependence has taken place in the structure under investigation (fig.1b). By straight line extrapolation Q ~f($\sqrt{1}$) the value of “cut-off current” $I_0=2,5\cdot10^{-9}\,\overset{0}{A}$ and “cut-off charge” $Q_0=8\cdot10^9$Kl. By I_0 and Q_0 value and using formulas given in paper [11] there have been determined values of contact capacitance $C_k=1,6\cdot10^{10}$F, charge concentration region $d_k=1,65\cdot10^4$sm, charge mobility in localizated states $\mu=3,5\cdot10^{-4}sm^2/Vsm$, charge constant $\tau = 3,2s$, trap concentration $N_t=6,4\cdot10^{15}sm^{-3}$.

According to [15] the level position due to the decreasing current relaxation at given temperature one can determine from the equation:

$$E_t = kT \ln \nu t_m$$

Where ν-phonon frequency, t_m-time, corresponding to the dependence maximum I·t~(lgt). Thus from the current measurement results of isothermal relaxation during the sample transition from non-stationary state into stationary one we can immediately (fig.3) determine energy distribution of levels in band gap.
For activation energy the value 0,57eV has been found.

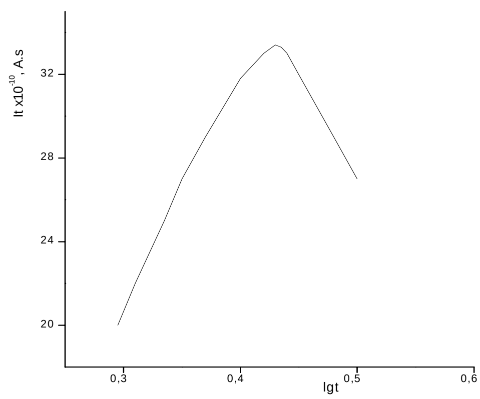

Fig3. Dependense of the accumulated charge in a sistem In-$YbCa_2S_4$-In

III. CONCLUSION

Obtained data indicate to the processes of charge accumulation under the effect of voltage in near-electrode regions of $YbGa_2S_4$ samples. These processes reveal long-term dark-current relaxation.

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