Using the thermal-field measurements for evaluating the parameters of the MC based on AS

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Abstract - **In this paper the thermal-field measurements for evaluating the parameters of the memory cells (MC) based on amorphous semiconductors (AS) are used for the analysis of the temperature dependence of differential electrical conductivity of memory cells.**

Keywords - **Memory cell, amorphous semi-conductors, electrical conductivity.**

I. INTRODUCTION

MC based on phase transitions are known to be characterized by nonlinearity of current-voltage characteristic (CVC), thus the temperature dependence of counter-balanced and unbalanced conductivity are different. Consequently, the study of nature of the unbalanced conductivity is essential for the development of MC based on phase transitions; and researching the temperature dependence of conductivity, when applied to a sample of an external electric field, allows estimating parameters of MC, which influence its operation.

II. BASIC FORMULAS

The temperature dependence of electrical conductivity of chalcogenide glassy semiconductors (CGS), which are used to construct MC on the phase transitions, can be described by equation [1]:

$$s = m_p q N_n \exp\left(-\frac{F - E_n}{kT}\right), \qquad (1)$$

μ_p - mobility of holes; E_v - energy of the upper level of the valence band; F - energy of the Fermi level; N_v - concentration of charge carriers in the valence band; k - Boltzmann constant; T - the absolute temperature.

Considering the dependence of the bandgap E_g on temperature and the fact that the Fermi level in AS is fixed in the middle of the conduction band, the equation (1) can be rewritten as:

$$\sigma = \mu_p q N_v \exp\left(-\frac{E_{q_0} - \alpha T}{2kT}\right), \qquad (2)$$

α - coefficient of temperature dependence of the AS bandgap.

Optical measurements, performed by a number of authors show that the bandgap of AS E_q is 0,7eV [2], coefficient $\alpha \approx 3{,}7 \cdot 10^{-4}$ eB/°K .Temperature dependence of electrical conductivity is defined as the change in charge carrier mobility, which can be defined by the equation:

$$\mu_p(T) = \mu_0 \frac{N_v E}{N_l kT} \exp^{-\frac{E}{K}}, \qquad (3)$$

N_l - concentration of traps near the Fermi level; E - electric field intensity.

In paper [3] it is proposed to split the current from CVC of MC based on CGS into two components - ohmic and emission currents. Since the temperature dependences of these currents differ, we can accurately determine the voltage U_0 under which these currents are equal. U_0 ratio to the threshold voltage can be used to determine the parameters of emission models of MC based on AS. Emission model assumes that the strong electric fields lead to unstable charges emission.

Under low electric fields the current through the MC is proportional to the electric field:

$$I = G_0 E, \qquad (4)$$

$G_0 = K_\phi q \mu_p p$ - electrical conductivity of the MC, which is defined by the balanced concentration of charge carriers; K_ϕ - shape factor; p - balanced concentration of holes.

Additional current that emerges as a result of field capacity under high fields can be calculated by the formula:

$$I_{ем} = G_{ем} E, \qquad (5)$$

$G_{ем} = K_\phi q \mu_p P(E) N_l$; $P(E) = A\exp\left(\frac{q\lambda E - B}{kT}\right)$ - probability of emission contributing to the conductivity of the MC based on AS; B - ionization threshold (eV); A - scale factor.

Current I_0 is prevailing under low electric fields, and $I_{ем}$ - under high ones.

III. CONCLUSION

The given equations can be used to determine the emission parameters of mathematical models of MC based on AS by comparing the experimental and calculated CVC measured in a wide range of electric fields.

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REFERENCES

[1] Y.V. Anufriev, “Temperature dependence of the voltage turn-on non-volatile memory cells on the base of chalco-genide semiconductors”, Journal of the Moscow Power Engineering Institute. M.: MPEI, 2007. №6, pp.144-147.

[2] N. Mott, E. Davis, “Electronic Processes in Non Crystalline Materials (2 volumes)”, M.: Mir, 1982.

[3] E. N. Voronkov, “Calculation of threshold voltage for phase-change memory device”, J. Non-Cryst. Solids, 2007, Vol.353, pp.2591-2594.