Analysis of Depolarizing Currents in Structures with a Continuous Distribution of Relaxation Times

Yu.A.Tonkoshkur

Abstract – **A method of applying the Kohlrausch-Williams-Watts function to the isothermal depolarization currents analysis in structures with a spread of relaxation times was proposed and substantiated.**

Keywords - **Isothermal depolarization currents, relaxation time, varistor ceramics.**

I. Introduction

The task of analysis and reconstruction of the relaxation function of isothermal depolarization current (IDC) is encountered in studying and checking localized states in disordered inhomogeneous structures, in particular, in metal oxide varistor ceramics [1].

One promising solution to this problem, allowing one to take into account the spread of relaxation times, appears to be the use of approximation of the kinetics of IDC Kohlrausch-Williams-Watts function (KWW) [2].

In this paper algorithms based on the use of KWW function for determining its parameters and reconstruction of the IDC relaxation function are proposed and tested.

II. Methods of Analysis

When testing the proposed algorithms, the source data consisted of tabular dependence of $j_{ID}^{(k)}$ on t_k, (k=0,1,…K; K is the number of its points) obtained via tabulation of the KWW function determined as:

$$j_{ID}(t) = j_0 \exp\left[-\left(t/t\right)^b\right], \qquad (1)$$

where t (the most probable relaxation time), b (parameter defining their variation), j_0 (constant) are set.

It is established that in the absence of fixation of the final section of a lasting current relaxation, its spectral characteristics found with the help of the numerical integral sine transformation are distorted in absolute parameters (height and frequency of the peak) and in shape (there is a series of small peaks following the main one).

For determining the value of the unknown factor b coordinates $t\times\left[d\left(\log j_{ID}^{(k)}\right)/dt\right]$ and $\log\left(j_{ID}^{(k)}\right)$ can be used, in which the dependence (1) is rectified, and the coefficient is the tangent of its slope $b = \Delta\left\{t\times\left[d\left(\log j_{ID}\right)/dt\right]\right\}/\Delta\log\left(j_{ID}\right)$.

It is possible to determine the remaining unknown parameters through representing the source tabulated data in $\ln\left(j_{ID}^{(k)}\right)$ и $\left(t_k\right)^b$ coordinates. The approximating dependence (1) also represents a straight line and, thus, one can obtain $t = \left[-\Delta\ln\left(j_{ID}\right)/\Delta\left(t^b\right)\right]^{-1/b}$ and

$$j_0 = \exp\left\{\ln\left[j_{ID}(t)\right] + \left(t/t\right)^b\right\}.$$

The proposed method is also suitable for determining parameters of the relaxation dependencies, which are approximated by two or more functions of this kind (fig.1)

$$j_{ID}(t) = \sum_{i=1}^{m} j_{0i}\exp\left[-\left(t/t_i\right)^{b_i}\right] \qquad (2)$$

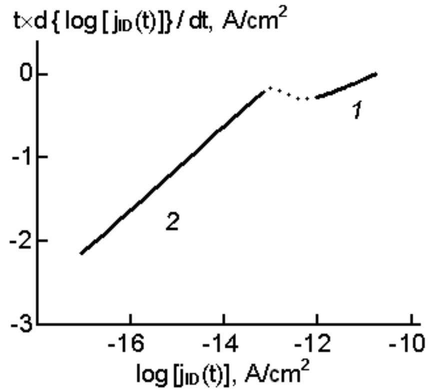

Fig.1 Time dependence of the IDC (2) with two relaxation areas

The above estimates can be refined with the use of the least squares method by minimizing the following function of parameters β_i, τ_i and j_{0i}.

$$\sum_{k=0}^{n}\left\{j_{ID}^{(k)} - \sum_{i=1}^{m} j_{0i}\exp\left[-\left(t_k/t_i\right)^{b_i}\right]\right\}^2 = \min \qquad (3)$$

The determined values of parameter β_i, τ_i and j_{0i} (i=1 and 2) are in satisfactory agreement with those accepted in the generation of the tested dependency.

III. Conclusion

The applicability of KWW function for the analysis of the kinetic dependences of IDC, having areas with a continuous distribution of relaxation times where shown.

References

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Ju.A.Tonkoshkur - Dnepropetrovsk National University named after O.Gonchar, Gagarina avenue,72 , Dnepropetrovsk, 49050, UKRAINE,
E-mail:tonkoshkur@gmail.com