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A Characteristic Parameter for Similar Dopants in Same Host Lattice

A. K. NISHAD
Department of Physics, St. Andrew's College, Gorakhpur, U. P., India

Abstract- The depolarization current in ionic thermo current measurement is an asymmetric curve with its maximum depolarization current at T_M. It has been observed that relaxation time τ_M at T_M is fixed for the divalent doped KCl lattice when data of similar dopants recorded at the same heating rate are considered.

Indexed Terms- activation, depolarization, dielectric

I. INTRODUCTION

When alkali halide crystal are doped with divalent dopants, impurity vacancy (IV) dipoles are created in the crystal. The reorientational behavior of IV dipoles is studied through ionic thermo current (ITC) measurements [1]. The depolarization current obtained in ITC measurement is an asymmetric curve with its maximum depolarization current at T_M . The value of T_M is different at different heating rate for same lattice: dopants system. Also, the values of T_M are different for different lattice : dopant system at the same heating rate. The dielectric relaxation parameters the activation energy (E_a) and pre exponential factor of (τ_0) are also different for different lattice : dopant system. If ITC data for similar type of dopant in same host lattice is considered as same heating rate, then one can expect that there should be same characteristic parameters which is fixed for similar lattice : dopant system. In the search for such parameters it is found that the relaxation time τ_M at T_M is fixed for the divalent doped KCl lattice when data of similar dopants recorded at the same heating rate are considered.

II. THEORY

The depolarization current ITC measurement can be expressed as [1].

$$I(T) = \left(\frac{Q}{\tau}\right) \exp\left[-\frac{1}{b\,\tau_0}\int_{T_F}^{T} \exp\left(-\frac{E_a}{kT}\right)dT\right] \quad (1)$$

Where Q is total charge released, τ is relaxation time at temperature T, b is linear heating rate, k is Boltzmann constant, T_F is the temperature wherefrom the depolarization current starts to appear [2,3]. Eqn. (1) represent an asymmetric curve with the maximum depolarization current at T_M given by

$$T_M^2 = \frac{bE_a\,\tau_M}{k} \quad (2)$$

Where τ_M is expressed by Arrhenius relation

$$\tau_M = \tau_0 \exp\left[\frac{E_a}{kT_M}\right] \quad (3)$$

From eqn. (2), we can write

$$\tau_M = \frac{kT_M^2}{bE_a} \quad (4)$$

In a particular alkali halide host lattice, the value of E_a and τ_0 are be found to be different for different divalent dopant as shown in Table 1. Since the lattice is the same in which similar dopants are doped, one may think of characteristic parameter which is fixed for lattice: dopants system. In the quest of searching such parameter, the values of τ_M for different dopants are calculated using eqn. (4) as shown in Table 1. It is obvious from the table that values of τ_M are found to be nearly constant for different dropants. Therefore, the relaxation time τ_M can be considered as characteristic parameters for similar dopants at the same host lattice when data at the same heating rate is considered.

RESULT AND CONCLUSION

The environment in which an IV dipole relaxes is changed with the change in the dopant. Consequently, E_a and τ_0 and also T_M change. The extent of change in

E_a, τ_0 τ and T_M change of a dopant may be regulated in such a way that τ_M τ happens to be the same. Therefore τ_M is characteristic parameter in a particular lattice: dopant system recorded at the same heating rate.

TABLE – 1

System	b (Ks^{-1})	T_M (K)	E_a (eV)	τ_O (s)	τ_M (s)	Reference
KCl:Ba^{2+}						
KCl:Pb^{2+}	0.1	233	0.71	$3.2x10^{-14}$	66	4
KCl:Sr^{2+}	0.1	223.5	0.65	$2.1x10^{-13}$	66	4
KCl:Sm^{2+}	0.1	222.5	0.63	$3.7x10^{-13}$	68	4
KCl:Eu^{2+}	0.1	227	0.70	$2.7x10^{-14}$	63	4
KCl:Ca^{2+}	0.1	224	0.68	$3.7x10^{-14}$	64	4
KCl:Yb^{2+}	0.1	210.5	0.61	$3.0x10^{-13}$	63	4
KCl:Ni^{2+}	0.1	215	0.67	$1.1x10^{-14}$	60	4
KCl:Mg^{2+}	0.1	186	0.46	$0.46x10^{-11}$	65	4
KCl:Mn^{2+}	0.1	189	0.49	$3.8x10^{-12}$	63	4
KCl:Sr^{2+}	0.1	192	0.49	$6.3x10^{-12}$	65	4
	0.1	223	0.66	$1.2x10^{-13}$	65	4

The constancy of τ_M as obtained in Table-1 proves that τ_M is characteristic parameter.

Following are the specific features of τ τ_M :

I. The value of τ τ_M is fixed for the divalent doped KCl lattice and is independent of similar dopants embedded into it provided the data recorded at same b are considered.

II. The value of τ τ_M changes when b considered in (i) is changed. An increase in b shifts T_M toward higher temperature which in turn decreases the value of τ_M.

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