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Behavior of Electrical Pressure with temperature and electric field for <110> And <110>+ <111> tunneling model

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***Abstract**: In the present paper we have investigated theoretically the variation of electrical pressure with temperature and electric field for <110> &<110>+<111> tunneling model. Which may be used to explain various experimentally available data and may be also used for further theoretical investigations?*

***Keywords**: Dielectric constant, tunneling model & Electrical Pressure.*

I. Introduction

The tremendous increase in the variety and need of materials for new applications and more efficient service requirement have through about may change in altitudes and view point. Literature survey shows that impurities in solids play more important role than pure materials because a small amount of foreign impurity results alternation of thermal, electrical, magnetic and other behavior of pure crystals. Due to their structure alkali halides are the ideal parts for a variety of impurities and other defects. The phenomenon logic & tunneling models provides a powerful conceptual framework for analyzing the various properties of doped alkali halide and other ionic solid and liquids. That opens a new era in field of green electronics. Various attempts [1,2] to explain the experimental data were made using tunneling model but got limited success. Many experimental results for systems such as OH^- and CN^- ions in alkali halide matrices [3,4] and impurities like HCl, HBr etc impurities in rare gas matrices [5] have successfully explained. The effect of externally applied electric field on induced dipole moment of the impurity was studied by Gomez et al [6] using tunneling models.

II. Theory

The electric field polarization for the <110> off-centered model and for the model of simultaneous minima along the direction <110> + <111> has been explained by Pandey et al [7]. Further theoretical expression for polarization, dielectric constant etc for various tunneling model like <100> & <100> + <111> etc has been given by Raj Kumar et al[8,9,10,11,12,13,14,15]. In the present paper we have attempted to find out the expression for electrical pressure for the <110> and <110> + <111> tunneling model.

The expression of electrical pressure is given by relation:

$$\boldsymbol{S = \frac{\sigma^2}{2\frac{dP}{dE}}} \qquad 1.1$$

Where σ is surface charge density.

Case 1: The expression for polarization for <110> tunneling model

$$P = N\mu/\sqrt{2}\,[(e^{X/\sqrt{2}} - e^{-X/\sqrt{2}})/ (1+e^{X/\sqrt{2}}+e^{-X/\sqrt{2}})] \qquad 1.2$$

Where X=μE/kT

Differentiating equation (1.2) with respect to electric field we get dielectric constant

$$dP/dE=N\mu^2/2kT[(4+e^{X/\sqrt{2}} + e^{-X/\sqrt{2}})/(1+ e^{X/\sqrt{2}} +e^{-X/\sqrt{2}})^2] \qquad 1.3$$

Using equation 1.3 in equation1.1 we have electrical pressure

$$S = \sigma^2 kT/ N\mu^2\, [(1+ e^{X/\sqrt{2}} +e^{-X/\sqrt{2}})^2 / (4+e^{X/\sqrt{2}} + e^{-X/\sqrt{2}})] \qquad 1.4$$

Case 2: The expression for polarization for <110>+ <111> tunneling model

$$P =N\,[\mu_1/\sqrt{2}\, \{[(e^{X_1/\sqrt{2}} - e^{-X_1/\sqrt{2}}) + \mu_2 / \sqrt{3}\, (e^{X_2/\sqrt{3}} - e^{-X_2/\sqrt{3}})] / [1+ e^{X_1/\sqrt{2}} + e^{-X_1/\sqrt{2}} + e^{X_2/\sqrt{3}} + e^{-X_2/\sqrt{3}}]\} \qquad 1.5$$

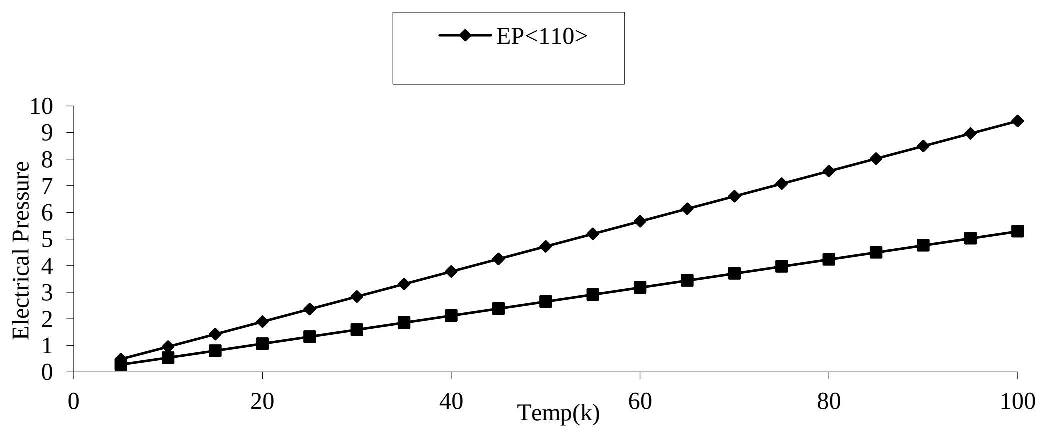
With understanding $X_1 = \mu_1 E / kT$, $X_2 = \mu_2 E/kT$
Differentiating equation (1.5) with respect to electric field we get dielectric constant

$$dP/dE = N/kT \{[(2\mu_1^2 + 4\mu_2^2 /3) + \mu_1^2/2(e^{X_1/\sqrt{2}} + e^{-X_1/\sqrt{2}}) + \mu_2^2/3(e^{X_2/\sqrt{3}} + e^{-X_2/\sqrt{3}}) + (\mu_1^2/2 + \mu_2^2/3)(e^{X_1/\sqrt{2}} + e^{-X_1/\sqrt{2}})(e^{X_2/\sqrt{3}} + e^{-X_2/\sqrt{3}}) - 2\mu_1\mu_2/\sqrt{6}(e^{X_1/\sqrt{2}}\ e^{-X_1/\sqrt{2}})(e^{X_2/\sqrt{3}} - e^{-X_2/\sqrt{3}})] / [1 + e^{X_1/\sqrt{2}} + e^{-X_1/\sqrt{2}} + e^{X_2/\sqrt{3}} + e^{-X_2/\sqrt{3}}]^2\} \qquad 1.6$$

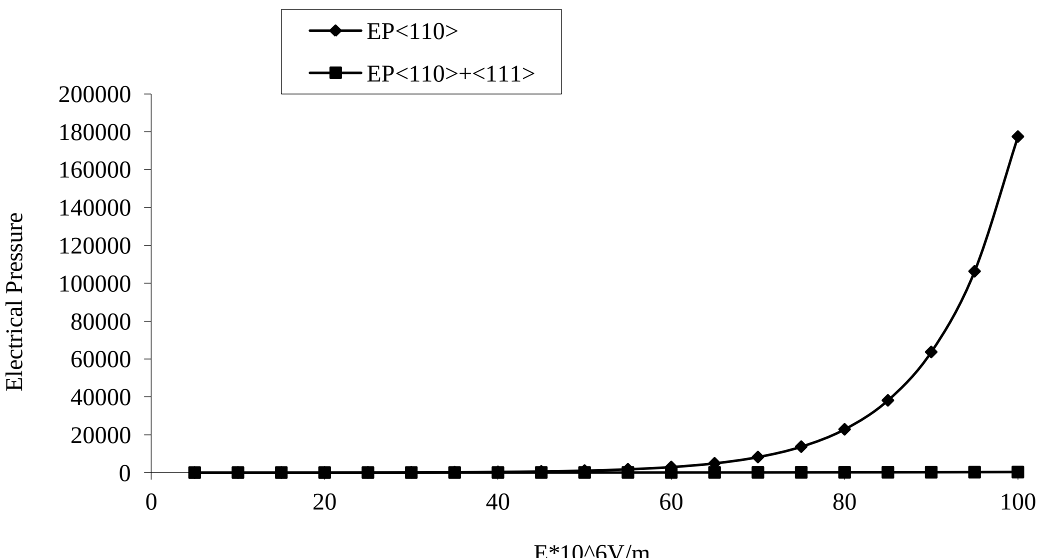
Using equation (1.6) in equation (1.1) we have electrical pressure

$$S = \sigma^2 kT/2N \{[1 + e^{X_1/\sqrt{2}} + e^{-X_1/\sqrt{2}} + e^{X_2/\sqrt{3}} + e^{-X_2/\sqrt{3}}]^2 / [(2\mu_1^2 + 4\mu_2^2/3) + \mu_1^2/2(e^{X_1/\sqrt{2}} + e^{-X_1/\sqrt{2}}) + \mu_2^2/3(e^{X_2/\sqrt{3}} + e^{-X_2/\sqrt{3}}) + (\mu_1^2/2 + \mu_2^2/3)(e^{X_1/\sqrt{2}} + e^{-X_1/\sqrt{2}})(e^{X_2/\sqrt{3}} + e^{-X_2/\sqrt{3}}) - 2\mu_1\mu_2/\sqrt{6}(e^{X_1/\sqrt{2}} - e^{-X_1/\sqrt{2}})(e^{X_2/\sqrt{3}} - e^{-X_2/\sqrt{3}})]\} \qquad 1.7$$

The expression for electrical pressure are listed by equation 1.4 &1.7 for <110> & <110>+<111> tunneling models respectively. The variation of electrical pressure with temperature at steady electric field is given in fig 1.1 and the variation of electrical pressure with electric field at constant T=10K is given in fig 1.2.



Variation of electrical pressure with temperature at steady electric field 10^6 V/m



Variation of electrical pressure with electric field at constant 10K

III. Result and Discussion-

The result of present theoretical investigated for the <110> and <110>+<111> tunneling model is given by equation1.4 &1.7 .Fig 1.1 and fig 1.2 shows the variation of electrical pressure with temperature and electric field for <110> & <110>+<111> tunneling model respectively. From fig 1.1 it is seen that the electrical pressure increases with increases of temperature at constant electrical field 10^6 V/m. From fig 1.2 it is concluded that electric pressure increases suddenly with increase electric field afterward 70*10^6V/m for system<110> while for system <110>+<111> in electrical pressure slowly increases with increases electric field. This theoretical study will be useful in future theoretical as well as experimental investigations.

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