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AIM

To study variation of dielectric constant of Barium Titanate with temperature and frequency and to determine critical exponent & Curies Constant

APPARATUS

LCR Meter, Multimeter, Temperature controller, Oven Probe Arrangement ceramic sample

Description of Apparatus

- LCR Meter : It is an LCR measuring bridge, an impedance measuring instrument that allow automatic measurement of resistance, capacitance, inductance and many other parameters
- Temperature Controller : It is used to regulate the temperature of the material to study the variation with temperature
- Probe Arrangement : It has 2 probes, which are in contact with two surfaces of sample.

WORKING FORMULA

All specimens have a sharp phase transition and follows Curies law

$$X = \frac{C}{T - T_c}$$

C = Curie Constant T_c = Curie - Weiss Temperature

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(a) The modified Curie Weiss Law

$$\frac{1}{K} - \frac{1}{K_{max}} = \frac{(T - T_m)^{\gamma}}{C'}$$

$$\log\left[\frac{1}{K} - \frac{1}{K_{max}}\right] = \gamma \log(T - T_m) - \log(C')$$

K_{max} - Max value of dielectric Constant
T_m - Temperature corresponding K_{max}
γ - Critical Exponent for diffused phase Transformation

PRECAUTIONS

- The probes should not be in contact. A piece of cardboard should be placed between them. If they are in contact with each other, it will result in short circuit
- The clips should touch the tips of probe. This is because it is the upper end of probe which is in contact with electrodes inside
- Connect the appropriate BNC connectors provided with the instrument to appropriate slots. The red connectors to HD and HS slot and black leads to LD and LS slots on LCR Meter.
- A Good capacitor is with low series equivalent resistance, ie low dissipation. Hence, will choose the the frequency one should take care that dissipation is minimum
- More Number of reading should be taken near the curie temperature (120-140°C)

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OBSERVATIONS

- Least count of LCR Meter for measuring capacitance = 0.001nf
- Least count of Temperature coefficient = 0.1 °C
- Thickness of sample = 1.04 mm
- Area of sample = 25.06mm. (Diameter)
- Capacitance = $\frac{\pi \times (12.53)^2 \times 8.85 \times 10^{-12} \times 10^{-3}}{1.04}$ = 4.2pF

$C_0 = \frac{A\varepsilon_0}{d}$ = 4.2pF

CALCULATIONS

Curies temperature are obtained from graph

T_c = 102°C

According to modified Curies - Weins law

$$\log\left[\frac{1}{k} - \frac{1}{k_{max}}\right] = \gamma \log(T - T_m) - \log(c_1)$$

When plotted $\log[T - T_m]$ on x-axis and $\log\left(\frac{1}{k} - \frac{1}{k_{max}}\right)$ on y axis we get

γ = slope = 1.2730 $\log c_1$ = intercept = -11.7314

$c_1 = e^{11.7314}$ = 12447 x 10^5 k

Error in slope: 0.00893 Error in Intercept = 0.0009

RESULT

Curie temperature : 102°C.

Curie - Weins Constant: $1.2447 \times 10^5 \pm 0.0009$

γ (diffusivity): 1.2730

Dielectric const V/s temperature for the 4 frequencies has been plotted with its variation observed

error ?

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SOURCES OF ERROR

There might be error in measuring thickness and diameter of the sample

- Error if two probes are not separated by a cardboard piece.
- Error due to loose connections of wire

Discussion.7

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