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Isothermal Discharge Current and Trap Characteristics of Epoxy Resin at Low Temperature

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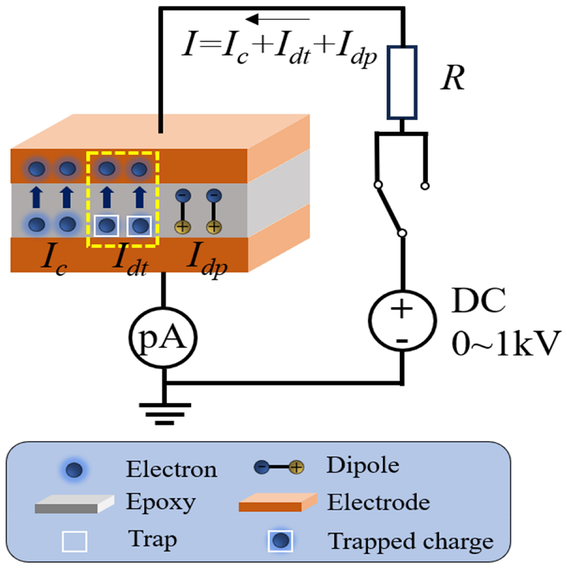
1.INTRODUCTION

- Epoxy resin has diverse and complex internal defects. This can affect the material's performance in terms of mechanical and breakdown strength.
- A Corona injection was performed using a needle-plate electrode. The isothermal discharge current method (IDC) was used to test a bisphenol F epoxy resin sample (using DETD as a curing agent)
- The migration characteristics of space charges were investigated at both 77 K and room temperature and the trap characteristics at different temperatures were obtained.
- The results indicate that temperature has a negative effect on the intrinsic conductance current, dipole polarization current, and de-trapping current, which suggests that the trap properties of epoxy resins are strongly influenced by temperature.

2.PRINCIPLES

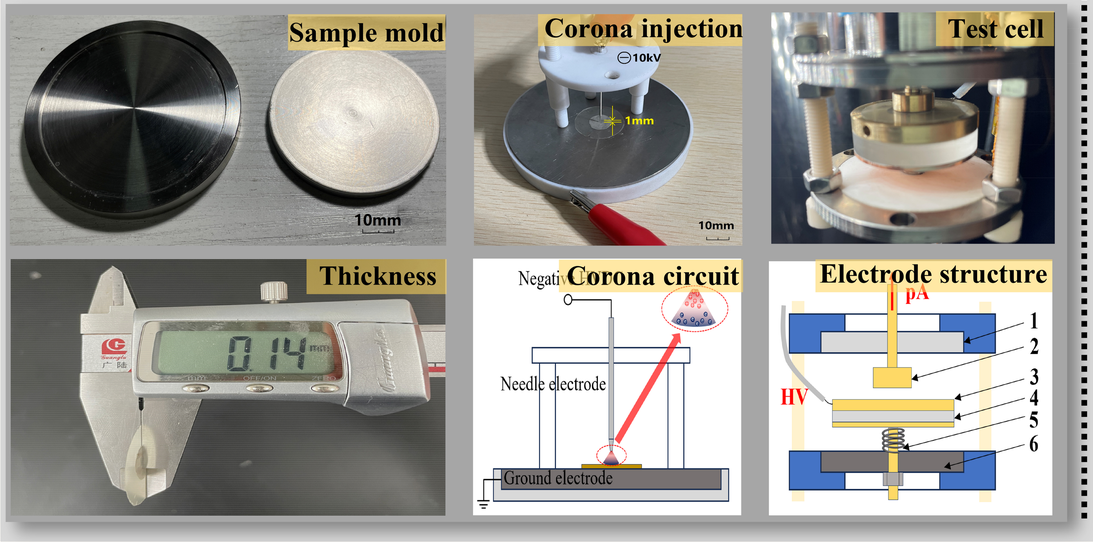


$$I = I_{dt} + I_{dp} + I_c \quad \cdots\cdots\cdots\cdots \quad (1)$$

$$j(E) = \frac{qdk_BT}{2t}N(E) \quad \cdots\cdots\cdots\cdots \quad (2)$$

$$\Delta E = k_BTln(vt) + \sqrt{\frac{q^3E}{\pi\varepsilon}} \quad \cdots\cdots \quad (3)$$

3.EXPERIMENTS



a) Sample preparation

Sample: bisphenol F epoxy resin with DETD as the curing agent.
Mold: self-designed stainless steel with 0.1mm deep groove.
Process: 12 hours@80℃ then 2 hours@150℃,

b) Corona charge injection

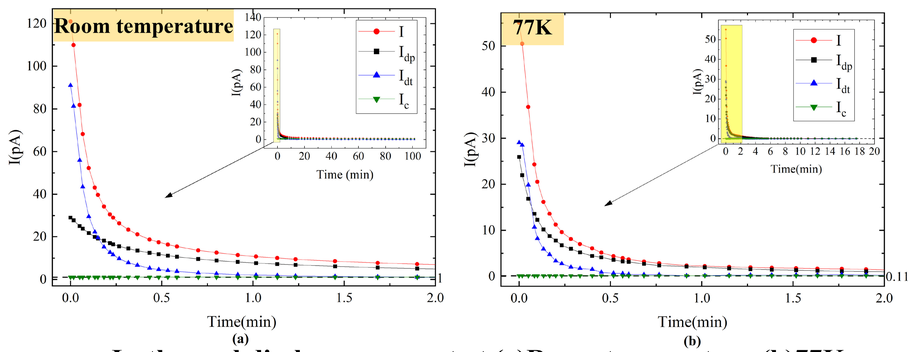
Circuit: needle-plate electrodes(stainless steel)
Voltage: -10kV for 30min and grounded for 10min

c) Isothermal discharge current measurement

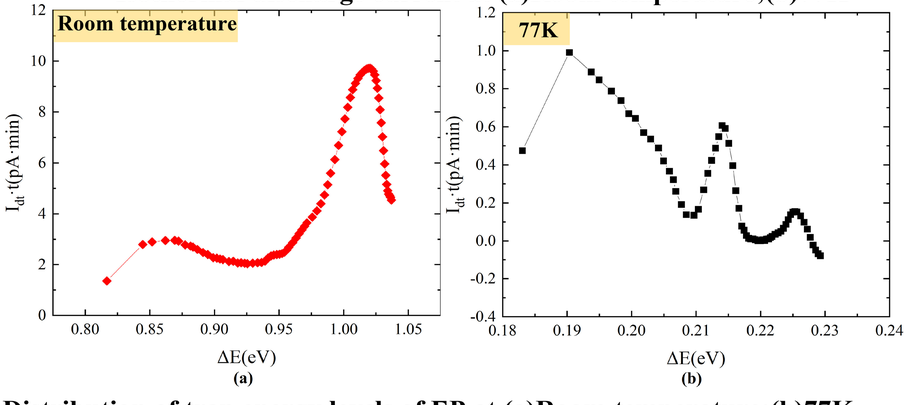
Equipment: Keithley6517b electrometer(10fA)
Insulator: sapphire, ceramics and teflon
Cryostat: self-designed cryostat(with a GM cryocooler)
Noise: 0.05pA with sample mounted and 0.01pA for open circuit
Electrode: brass electrodes, 304 stainless steel lead

1. sapphire; 2. brass upper electrode; 3. brass lower electrode; 4. sapphire; 5. titanium spring; 6. alumina ceramic

4.RESULTS



Isothermal discharge current at (a)Room temperature;(b)77K



Distribution of trap energy levels of EP at (a)Room temperature;(b)77K

DISCUSSTION

- The initial values of all types of currents are always larger at room temperature than at low temperature.
- Lower temperatures will decrease the decay time of Idt from 2 min to 0.75 min.
- The states with trap depths of 0.86 eV and 1.02 eV at room temperature have a higher density in the localized state.
- At 77K, the corresponding values are ~0.19 eV, 0.214 eV and 0.225 eV.

5.CONSLUSION

- The de-trapping rate of the epoxy resin increases and the dipole depolarization time is shortened at 77K.
- the proportion of the current originating from charge de-trapping is decreasing at low temperatures.
- The localized states are concentrated around 0.86 eV and 1.02 eV at room temperature and ~0.19 eV, 0.214 eV and 0.225 eV at low temperature.
- The density of the energy states is shifted to the high energy level at room temperature and to the low energy level at 77K.