

task_kyt15w11e3sempb2_with_calculation

Student Group

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Exercise E2 Resistivity and temperature dependent Resistance (written test, approx. 7 % of a 60-minute written test, SS2023)

The conductivity of a dielectric material is given by the Arrhenius law, which is described by the equation $\rho = \rho_0 \exp(-E_a/kT)$. The activation energy E_a is given by $E_a = 0.8 \text{ eV}$. The resistivity of the dielectric material is $\rho(20 \text{ }^\circ\text{C}) = 10^{17} \text{ } \Omega \cdot \text{m}$. Calculate the resistance for the dielectric material for $20 \text{ }^\circ\text{C}$ and $55 \text{ }^\circ\text{C}$ between the plates of a capacitor with a surface area $A = 1 \text{ cm}^2$ and a thickness $d = 1 \text{ mm}$.

Solution
The resistivity of the dielectric material is $\rho_{\text{PP}}(20 \text{ }^\circ\text{C}) = 10^{17} \text{ } \Omega \cdot \text{m}$.

For the given material the temperature coefficients in the range of $20 \text{ }^\circ\text{C}$ and $55 \text{ }^\circ\text{C}$

are given as $\alpha = -0.048 \text{ } 1/\text{K}$ and $\beta = +0.00057 \text{ } 1/\text{K}^2$.

$$\begin{aligned} R(55 \text{ }^\circ\text{C}) &= R(20 \text{ }^\circ\text{C}) \cdot (1 + \alpha \cdot \Delta T + \beta \cdot T^2 + \dots) \\ &= 80 \text{ } \Omega \cdot \text{m} \cdot (1 - 0.048 \text{ } 1/\text{K} \cdot (35 \text{ }^\circ\text{C}) + 0.00057 \text{ } 1/\text{K}^2 \cdot \Delta T^2) \end{aligned}$$

Calculate the resistance for the dielectric material for $20 \text{ }^\circ\text{C}$.

Solution

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\begin{align*} R(20 \sim \text{°C}) &= \rho \cdot \left\{ \frac{d}{A} \right\} \cdot 10^{17} \sim \Omega \\ \text{m} \cdot \left\{ \frac{0.8 \cdot 10^{-6} \sim \text{m}}{1 \sim \text{m}^2} \right\} \end{align*}
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