

Chapter 2

OTFT Parameters, Structures, Models, Materials, Fabrication and Applications - A Review

Solution Manual of Numerical Problems

- Q 1.** For a *p*-type top gate top contact organic thin film transistor with $\mu=0.14\text{cm}^2/\text{Vs}$, $\epsilon_r=3.9$, $t_{ox}=200\text{nm}$, $W=1\text{mm}$, $L=30\mu\text{m}$ and $V_t=-3.2\text{V}$, examine the relationship between the current and the terminal voltages.

Solution:

$$I_{ds} = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{gs} - V_t)^2$$

$$C_{ox} = \frac{\epsilon_0 \epsilon_r}{t_{ox}} = \frac{3.9 \times 8.85 \times 10^{-12} \text{ F/m}}{200 \times 10^{-9}}$$

$$C_{ox} = 0.172 \times 10^{-3} \text{ F/m}^2$$

$$I_{ds} = \frac{1}{2} \times 0.14 \times 10^{-4} \times 0.172 \times 10^{-3} \times \left(\frac{1 \times 10^{-3}}{30 \times 10^{-6}} \right) (V_{gs} - V_t)^2$$

$$I_{ds} = 39.9 \times 10^{-9} (V_{gs} - V_t)^2$$

Q 2. Using field dependent mobility concept in organic thin film transistor, find zero bias mobility (μ_0). The device mobility $\mu=0.02\text{cm}^2/\text{V}\cdot\text{s}$, enhancement factor is 0.2, and source-gate voltage (V_{gs}) are of -14V and threshold voltage (V_t) of -3.2V.

Solution:

$$\mu = \mu_0 (V_{gs} - V_t)^\alpha$$

$$0.02 = \mu_0 (-14 - (-3.2))^{0.2}$$

$$0.02 = \mu_0 (10.8)^{0.2}$$

$$\mu_0 = \frac{0.02}{1.609}$$

$$\mu_0 = 0.0124\text{cm}^2/\text{Vs}.$$

Q 3. Extract the current On-Off ratio (I_{on}/I_{off}) of an organic thin film transistor with $\mu=0.015\text{cm}^2/\text{Vs}$, $V_{ds} = -10\text{V}$, $V_{gs} = -10\text{V}$, $V_t = -1.3\text{V}$, $C_{ox}=800\text{nF}/\text{cm}^2$, 20nm of OSC thickness (t_{osc}) and $\sigma = 1\text{S}/\text{cm}$.

Solution:

$$\frac{I_{on}}{I_{off}} = \frac{C_i \mu (V_{gs} - V_t)^2}{t_{osc} V_{ds} \sigma}$$

$$\frac{I_{on}}{I_{off}} = \frac{800\text{nF}/\text{cm}^2 \times 0.015\text{cm}^2/\text{Vs} \times (10 - 1.3)^2}{20\text{nm} \times 10\text{V} \times 1\text{S}/\text{cm}}$$

$$\frac{I_{on}}{I_{off}} = 454.14 \times 10^{-4} = 0.045$$

Q 4. Find the operating mode and estimate the drive current of an organic thin film transistor for the given parameters: $\mu=1.64\text{cm}^2/\text{Vs}$, $W=120\mu\text{m}$, $L=10\mu\text{m}$, $C_{ox}=800\text{nF}/\text{cm}^2$, $V_{gs}=1.6\text{V}$, $V_{ds}=2\text{V}$ and $V_t=1.2\text{V}$.

Solution:

$$V_{gs} - V_t = 1.6 - 1.2$$

$$V_{gs} - V_t \leq V_{ds}$$

Hence the device is operating in saturation mode.

$$I_d = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{gs} - V_t)^2 = \frac{1}{2} \times 1.64 \text{cm}^2 / V_s \times 800 \text{nF} / \text{cm}^2 \times \left(\frac{120}{10} \right) (1.6 - 1.2)^2 V$$

$$I_d = 1.259 \mu A$$