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 μ=0.14cm^2/Vs, ε_r=3.9, t_{ox}=200nm, W=1mm, L=30µm and V_t=-3.2V, examine the relationship between the current and the terminal voltages.

Solution:

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

$$C_{ox} = \frac{\varepsilon_0\varepsilon_r}{t_{ox}} = \frac{3.9\times 8.85\times 10^{-12}\,F/m}{200\times 10^{-9}}$$

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

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

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

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

Solution:

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

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

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

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

$$\mu_0 = 0.0124 cm^2 / Vs \, .$$

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

Solution:

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

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

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

Q 4. Find the operating mode and estimate the drive current of an organic thin film transistor for the given parameters: μ=1.64cm^2/Vs, W=120µm, L=10µm, C_{ox} =800nF/cm^2, Vgs =1.6V, Vds=2V and V_t =1.2V.

Solution:

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

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

Hence the device is operating in saturation mode.

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

$$I_d = 1.259\mu A$$