Simulation Based Characterization of CdS Thin Film Transistor

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Introduction: Polycrystalline cadmium sulfide (CdS) Field Effect Transistor (TFT) simulation is carried out using the drift-diffusion model. The channel and width of the device are both 80 μm. The physical models are formulated by assuming a uniform trap distribution in the semiconductor channel [1,2]. Analytical trap density with Gaussian distribution was applied. Based on the work of Orouji *et al*. [3], for polysilicon, Caughey-Thomas mobility model is used [1].

Parameter	Value
Band-gap	2.42 eV [42]
Electron affinity	4.0 eV [43]
Electron low field mobility	4.3 cm^2/V-s
Hole low field mobility	0.3 cm^2/V-s
Thomas Claughey beta parameters	Bn = 2, βp = 1
Relative permittivity	8.9 [42]
Density of states	10^{21} cm^{-3}
Interface charge (number density)	10^{11} cm^{-2} [39]

Table CdS material parameters

Computational Methods:

COMSOL Semiconductor module is used to solve Poisson and Continuity equations:

$$-\nabla\cdot(\,\varepsilon\nabla V) = q(p - n + N_D^+ - N_A^-\,)$$

$$\frac{\partial n}{\partial t} = -\frac{1}{q}J_n - U_n$$

$$\frac{\partial p}{\partial t} = -\frac{1}{q}J_p - U_p$$

Figure 1 shows the simulated device with 10 μm long gold S/D electrodes at the top and a 100μm chromium gate electrode at the bottom. The gate oxide is a 90 nm thick HfO2.

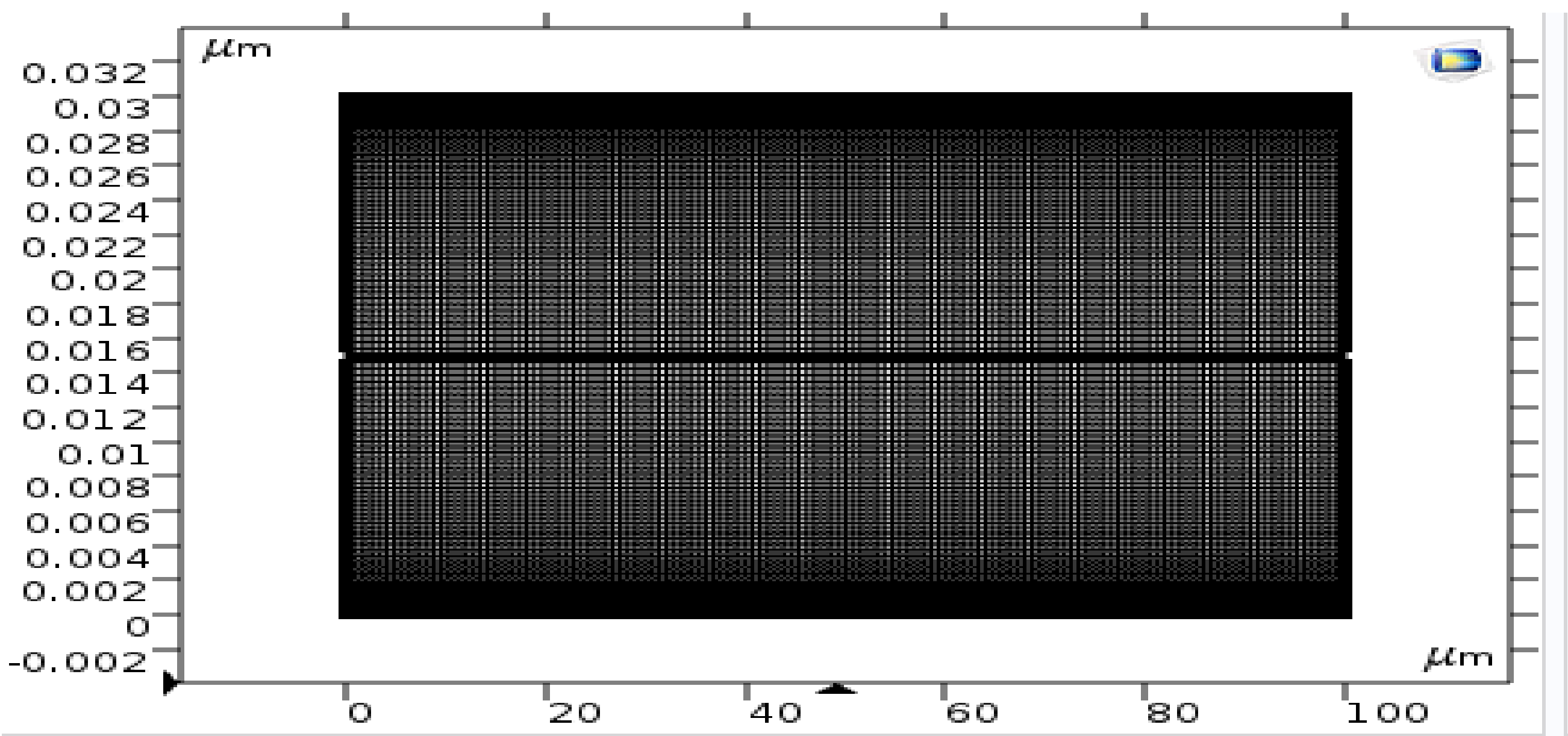

Figure 1. Geometry of the device

Results: I-V characteristics of the transistor are given below. The family of curves are for gate voltages 5V, 10V, and 15V. The transfer curve is simulated at the drain voltage of 20 V

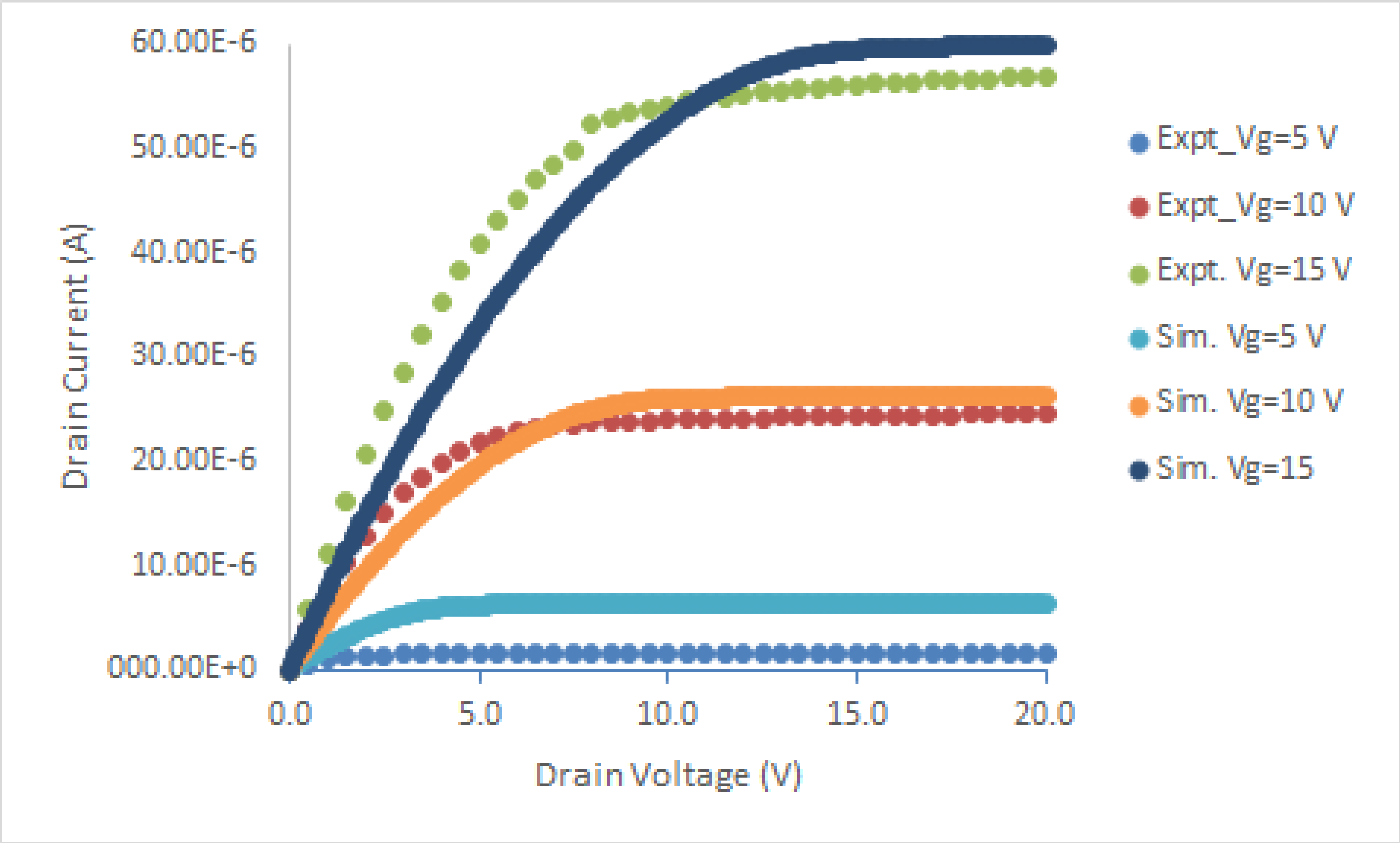

Figure 2. Id – Vd curves for different gate voltages

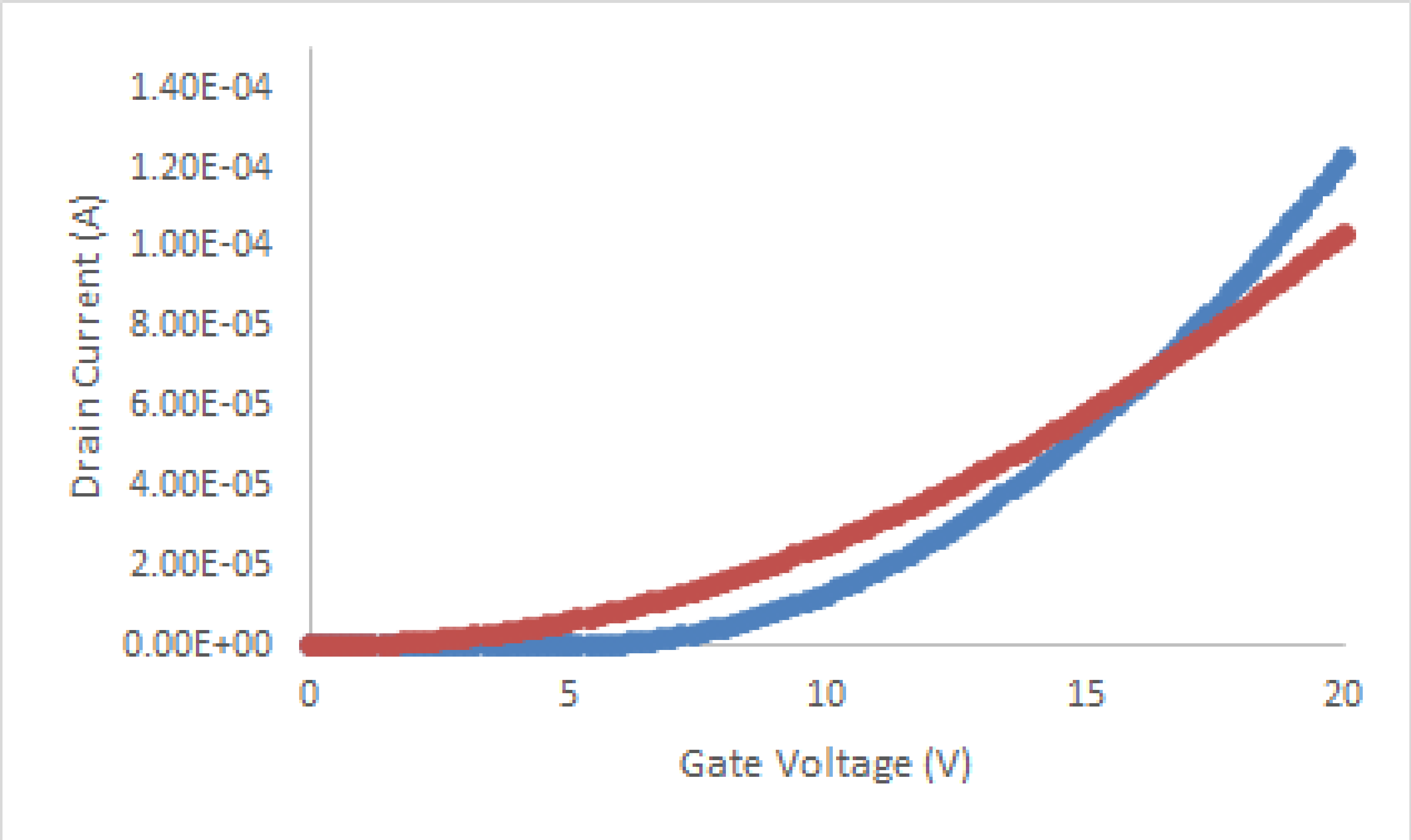

Figure 3. Id – Vg curve of the transistor at Vd=20 V

Conclusions: The thin film transistor is simulated successfully using COMSOL semiconductor module. The threshold voltage extracted from the simulation is a little less than that of experiment. The main issue was convergence and long simulation time. Future work will focus on getting the best match with experiment by using user defined equations..

References:

1. Ahmed, S. S., Kim, D. M., and Shichijo, H., *IEEE Electron Device Lett.*, **6**, (313 – 315) (1985)
2. Ono, K., Aoyama, T., Konishi, N., and Miyata, K., *IEEE Trans. Electron Devices*, **39**, 792 - 802 (1992)
3. Orouji, A. A., and Kumar, M. J., *IEEE Transactions on Device and Materials Reliability*, **5**, 675 – 682 (2005)

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