The Consortium for Enabling Technologies and Innovation

Virtual Summer Meeting for Young Researchers

Level 1 CMOS Parameter Extraction

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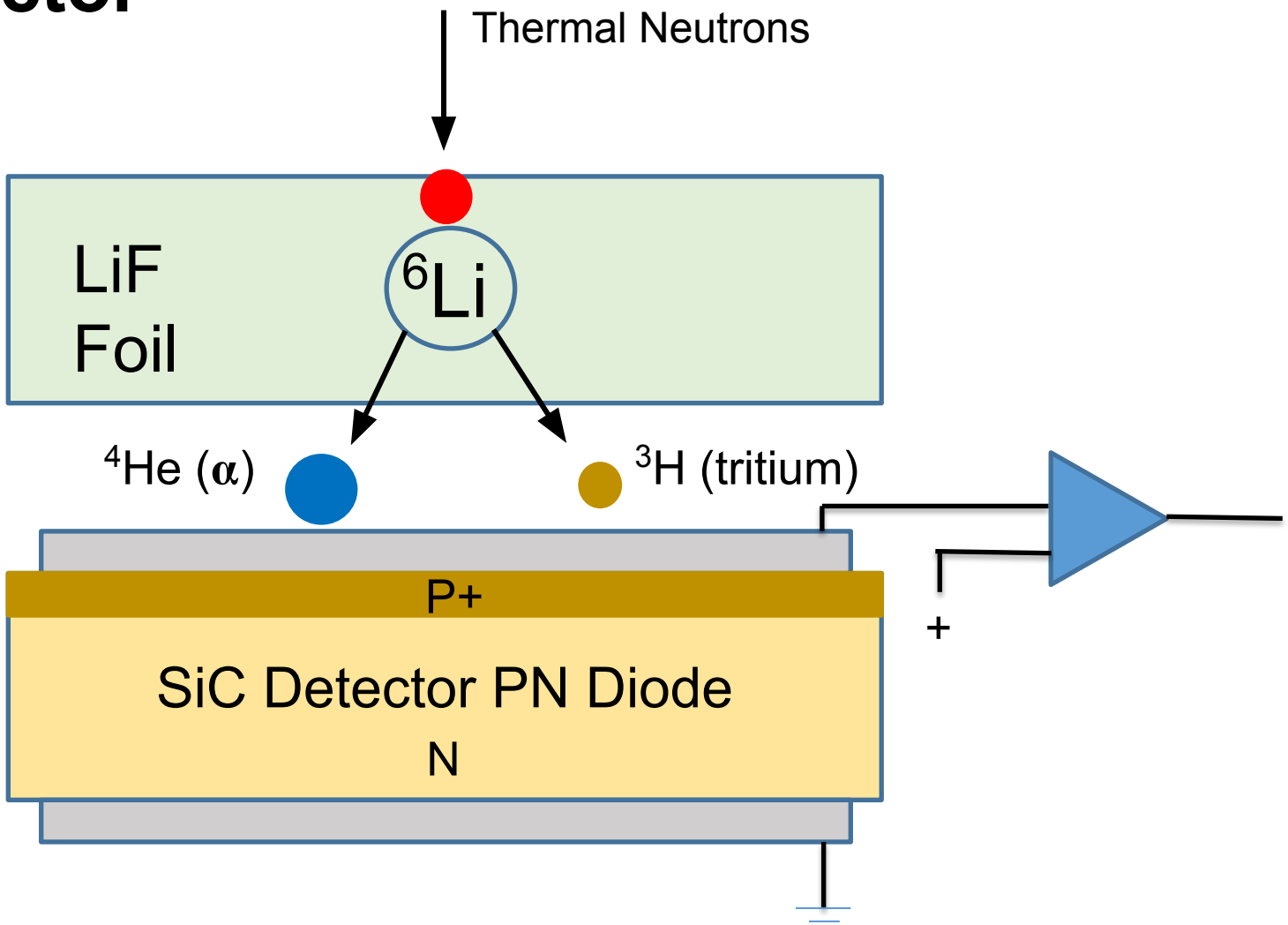
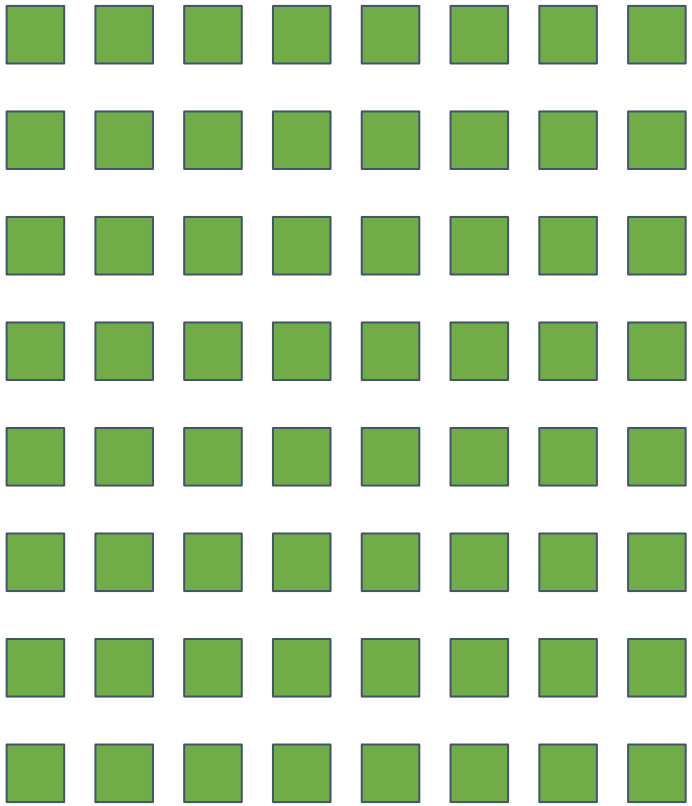
ETI

National Nuclear Security Administration

Neutron Detector



8x8 Neutron Sensor Array



- Each cell contains a SiC diode and Active Pixel Sensor (APS) to sense fast neutrons by direct carbon scattering or thermal neutrons by adding a converter
- Current efforts are underway to model the components used in each cell
- Once cells are designed, they will be interconnected to create a larger detection area and the information from each cell can be read

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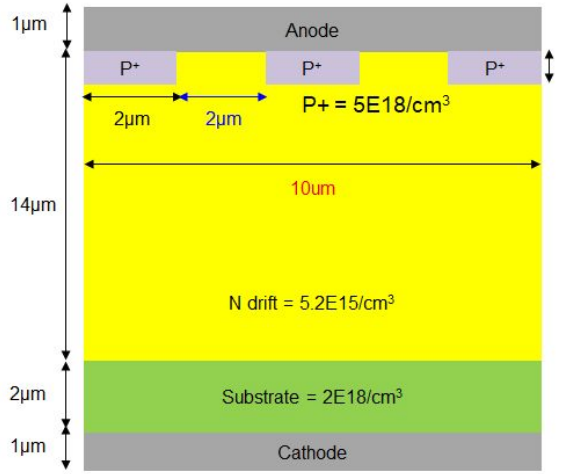
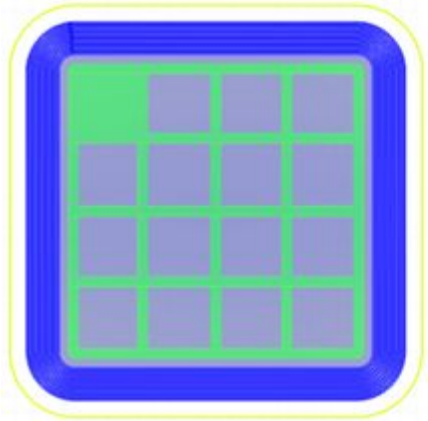
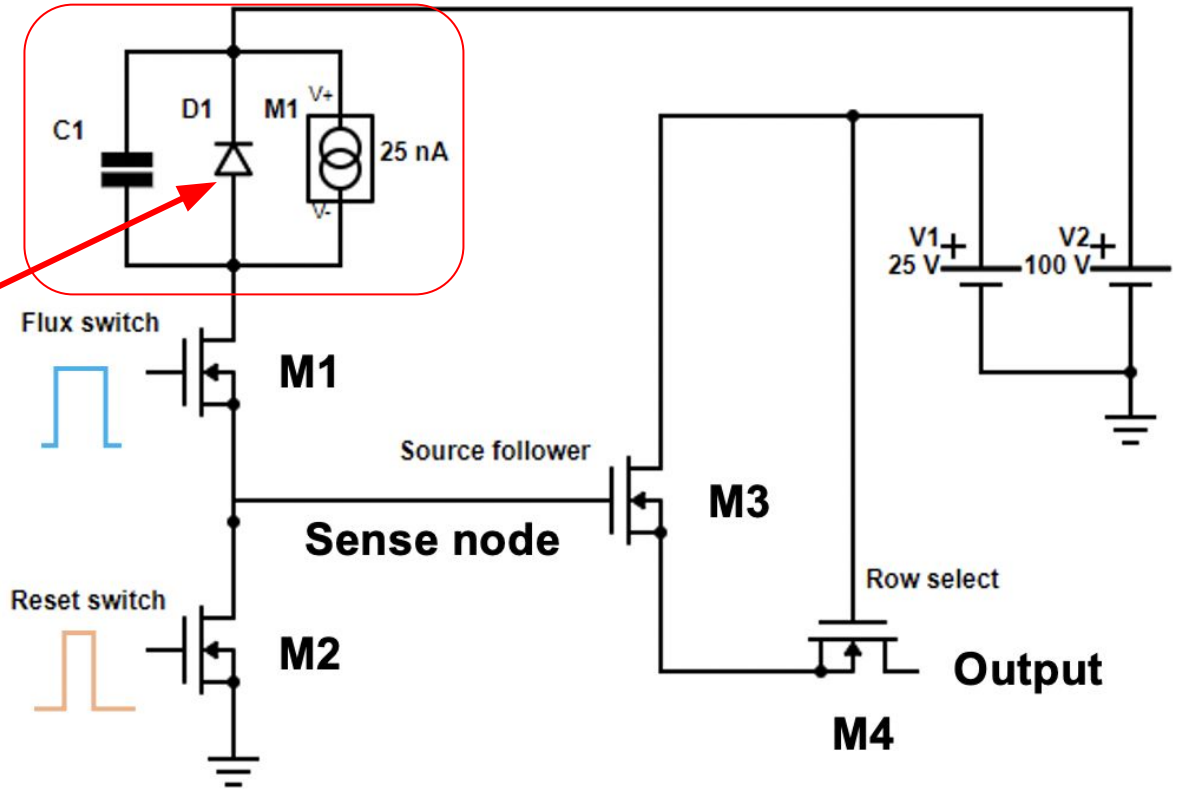
SiC Neutron Detector



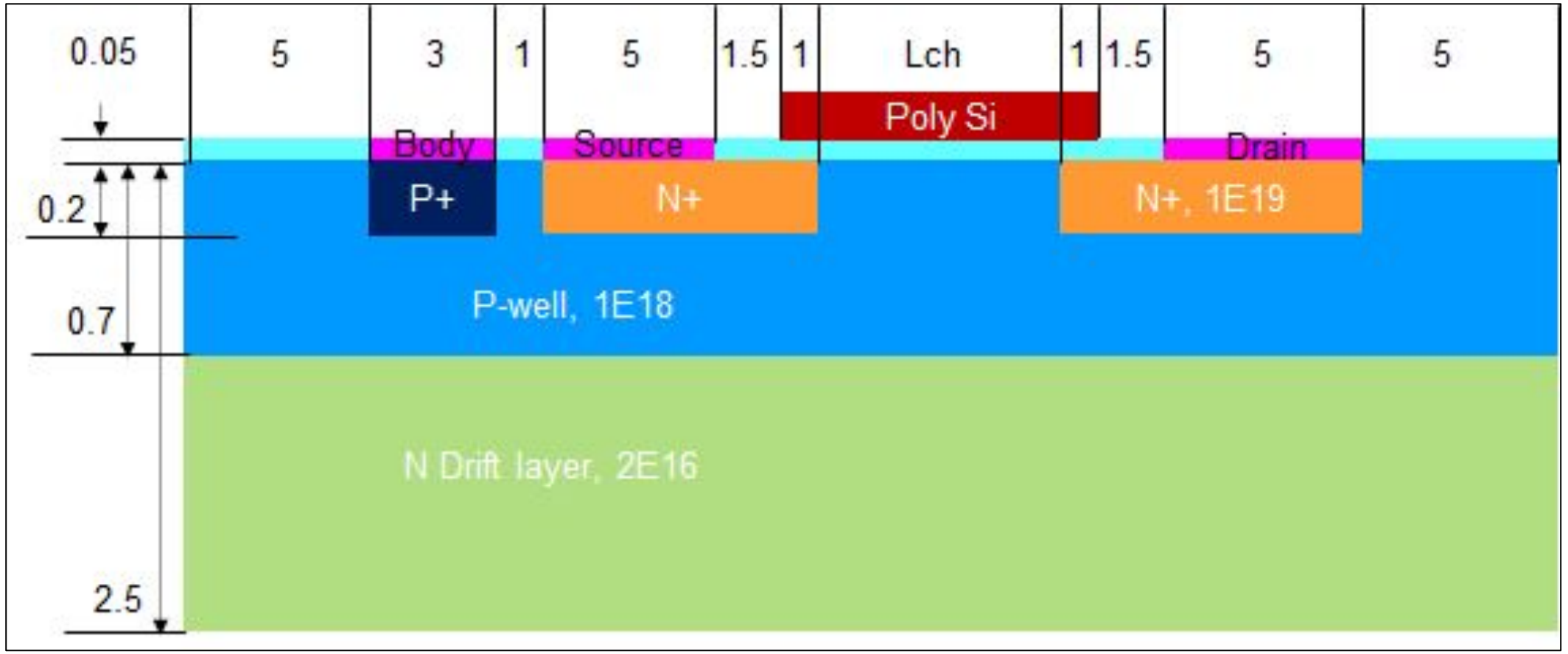


Layers
- Field stop
- Guard rings
- Ohmic metal
- Top metal
- Polymide

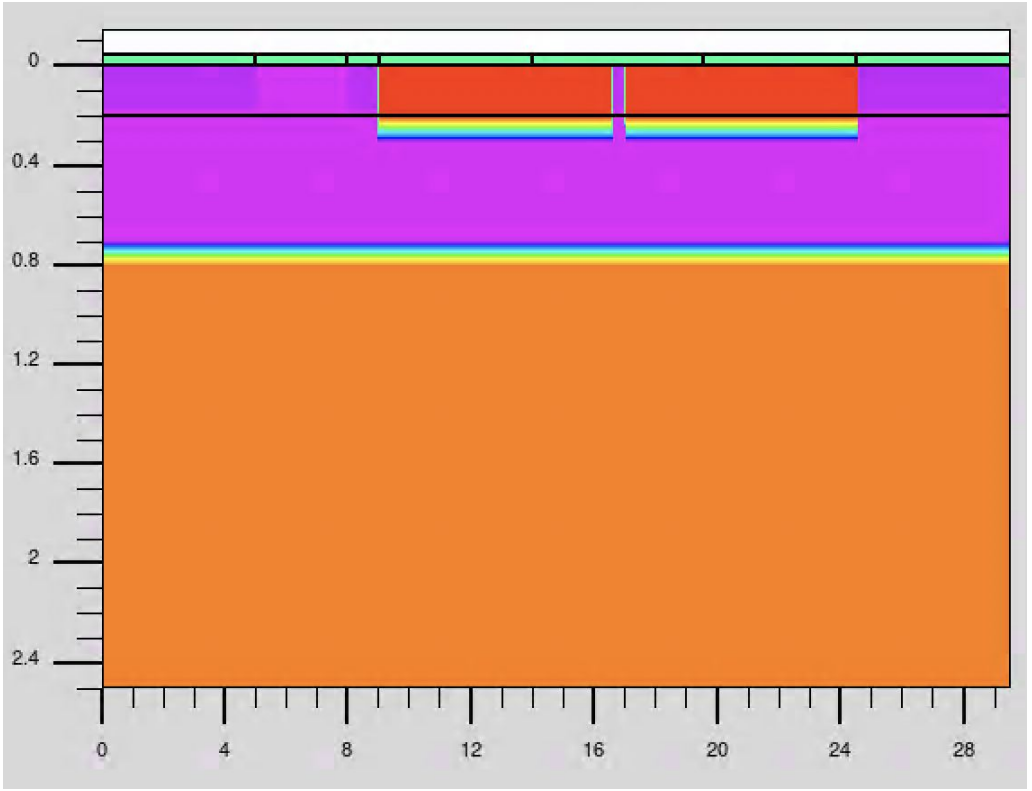


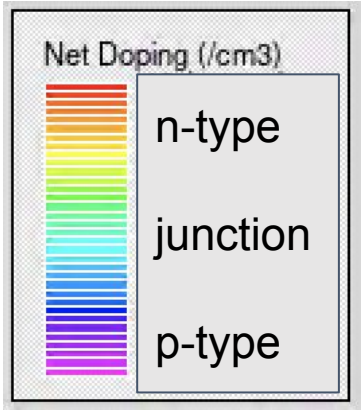
NMOS Structure

Lch: 0.5 um and 2 um



SILVACO: Net Doping of NMOS Structure





Silvaco uses the finite element method to solve equations in order to simulate the device characteristics.

- Poisson's Equation

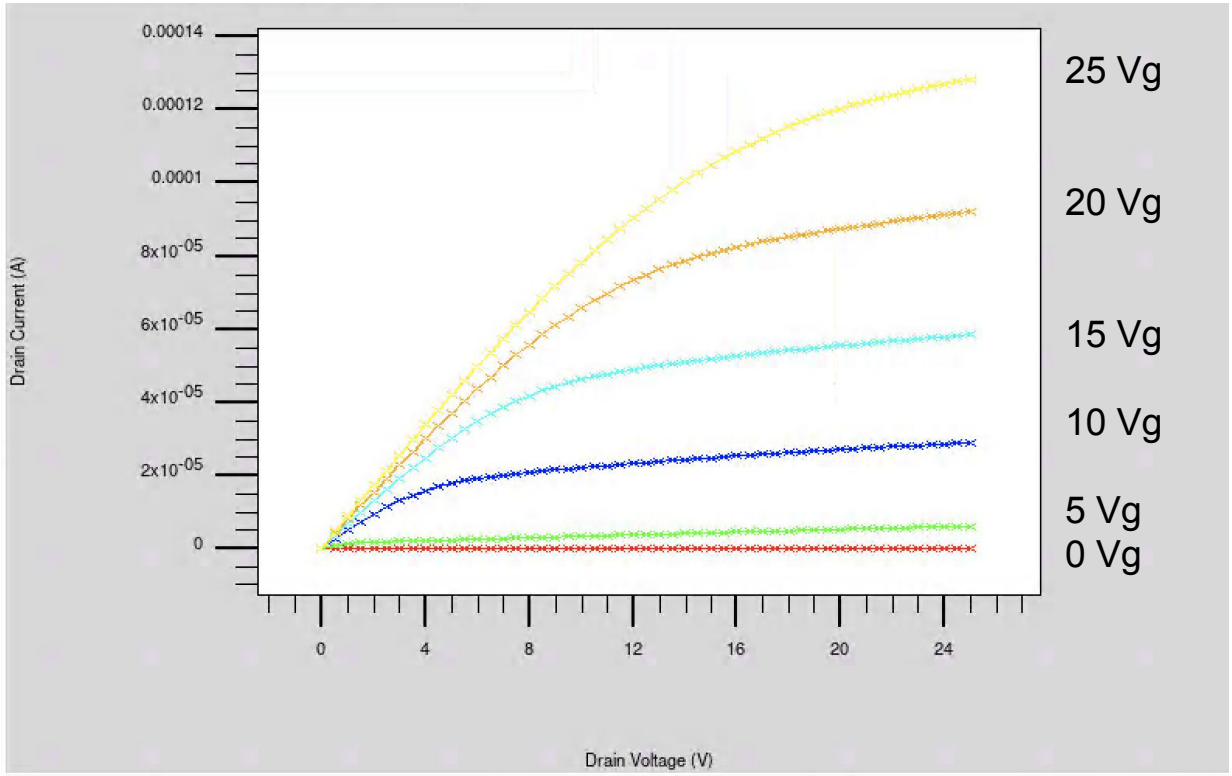
$$-\nabla^2 V = \frac{\rho}{\varepsilon}$$

- Continuity Equation

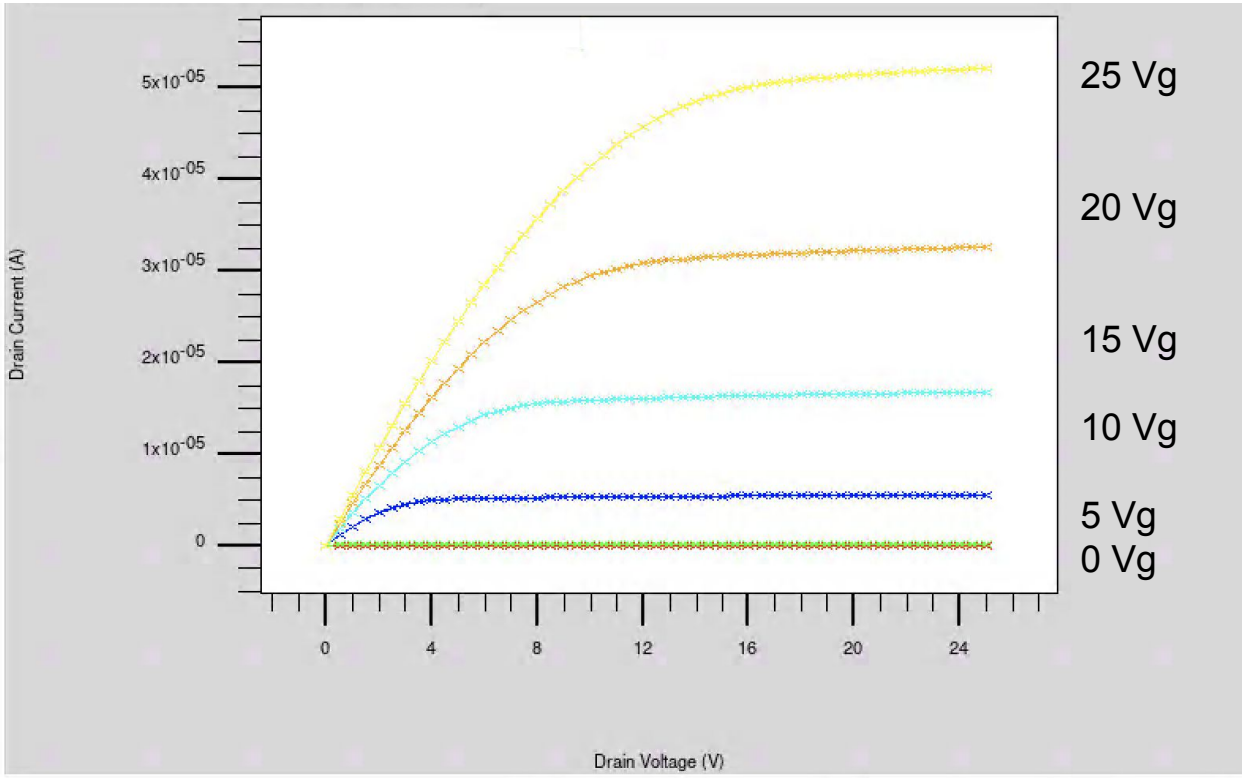
$$-\frac{d\rho}{dt} = \nabla \cdot (\mu\rho\nabla V + D\nabla\rho)$$

ID-VD Plots: Vg steps of 5 V from 0 to 25 V

Lch 0.5 um



Lch 2 um



Fundamental Level 1 SPICE Parameters

Linear Region

$$I_{ds} = \mathbf{KP}\frac{W}{L}\left\{(V_{gs} - V_{th} - \frac{1}{2}V_{ds})V_{ds}\right\}$$

Saturation Region + Channel Length Modulation

$$I_{ds} = \mathbf{KP}\frac{W}{2L}(V_{gs} - V_{th})^2(1 + \mathbf{LAMBDA}V_{ds})$$

Body Effect

$$V_{TH} = \mathbf{VTO} + \mathbf{GAMMA}(\sqrt{2\mathbf{PHI} + V_{sb}} + \sqrt{2\mathbf{PHI}})$$

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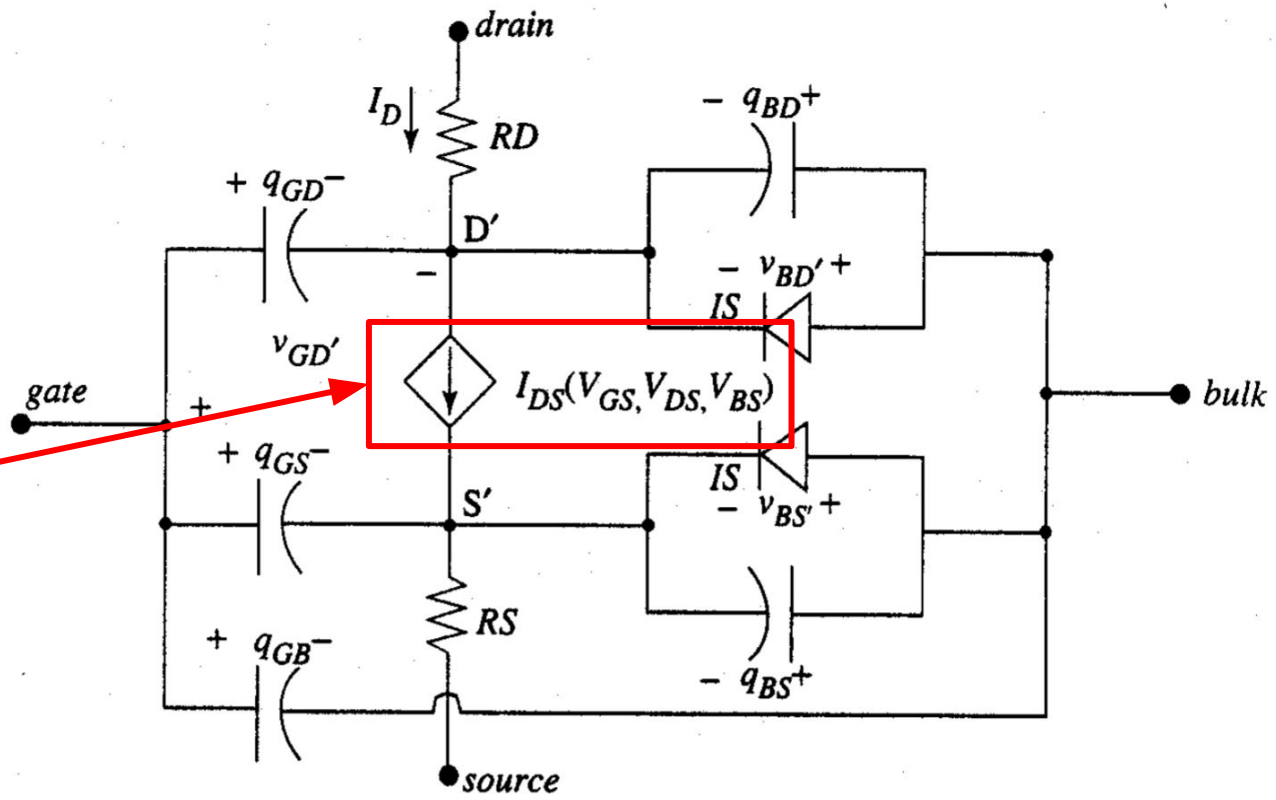
MATLAB: Level 1 SPICE Parameters

- Gamma = slope of Vth vs. $(\sqrt{2\phi_F + V_{sb}} + \sqrt{2\phi_F})$
- PHI = $\frac{2KT}{q} ln(\frac{\mathbf{NSUB}}{n_i})$
- KP = U0 * COX

	Lch = 0.5 um	Lch = 2 um	Units
L	0.5	2	μm
W	1	1	μm
NSUB	2E17	2E17	cm^(-3)
GAMMA	3.1057	3.9116	V^0.5
PHI	3.2501	3.2501	V
KP	1.1328E-06	1.1328E-06	A/V^2
VT0	3.468	3.6768	V
LAMBDA	0.0400	0.0037	1/V

SPICE Model Statements

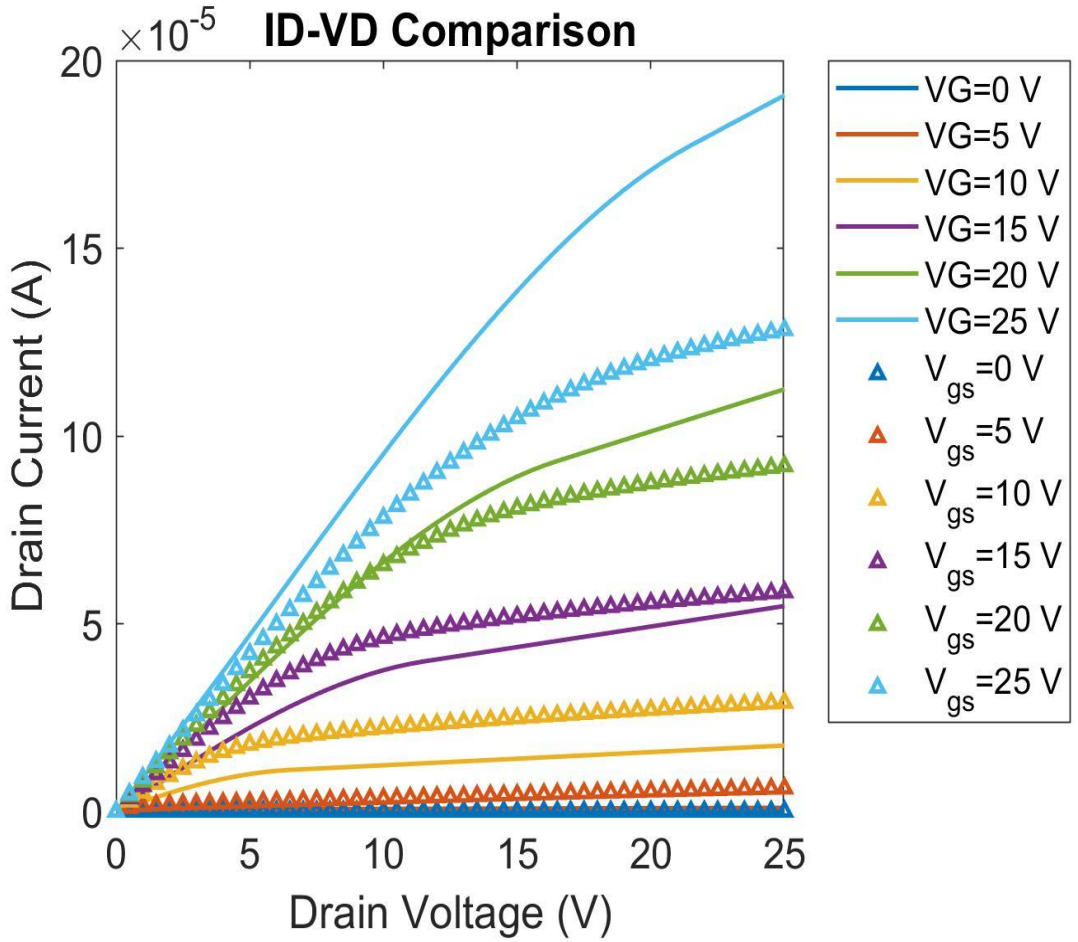
```
*** MODEL Descriptions ***
.model testmos nmos (
+LEVEL = 1 L=0.5u W=1u
+VTO = 3.4680   GAMMA = 3.1057 KP = 2.05707E-7
+LAMBDA = 0.04
+NSUB = 1.1149e+17 PHI = 3.2501)
```

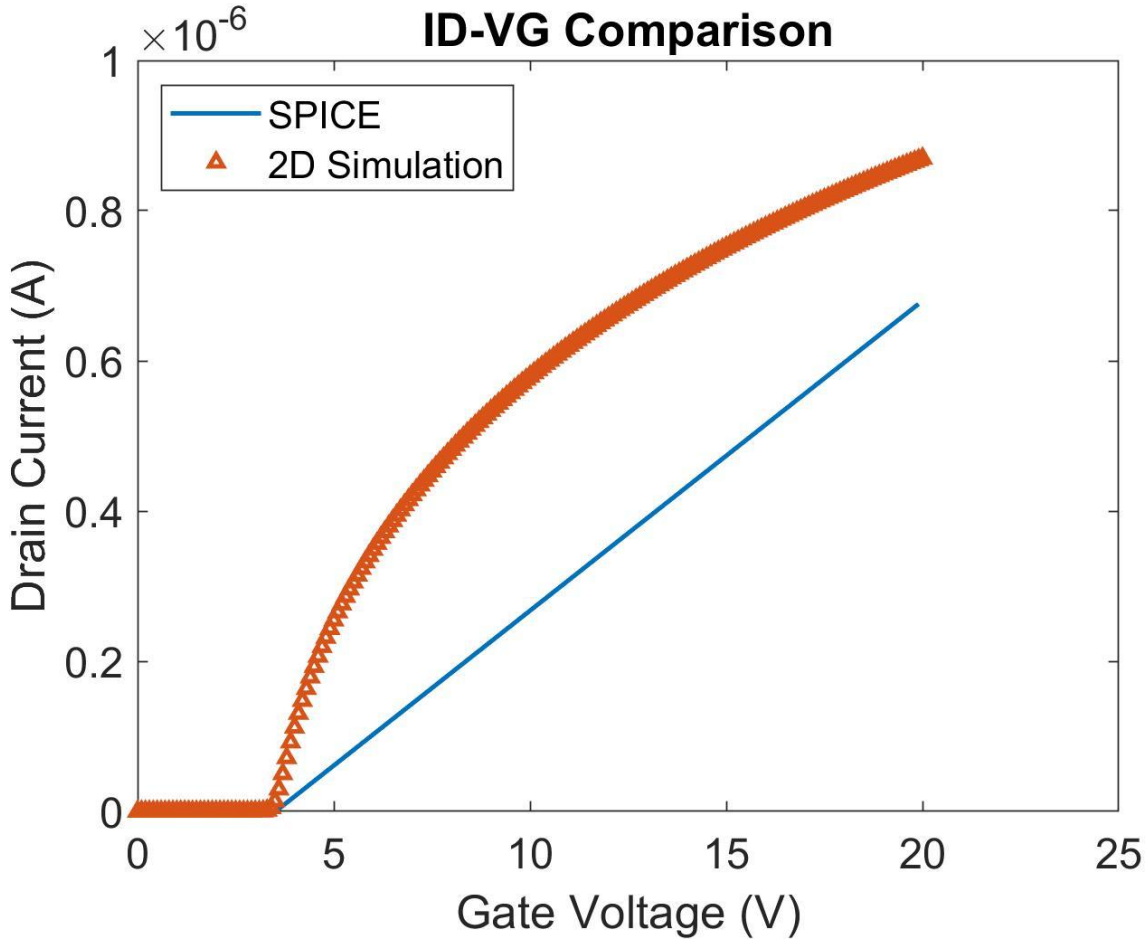


NMOS Level 1 SPICE Model, Adapted from: Anon, *SPICE LEVEL 1 MOSFET MODEL*, CSIT Laboratory. Available at: http://www.csit-sun.pub.ro [Accessed June 30, 2020].

Slivaco-SPICE Comparison

Lch = 0.5 um





Future Work

- Analyze PMOS side of device
- Develop Level 2 models for both devices
- Obtain laboratory measurements to verify our results
- Design the layout of the 8x8 array in Cadence

Acknowledgement

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