

High-Voltage Silicon JFET for HV Multiplexing for the ATLAS MicroStrip Staves

Gabriele Giacomini, Wei Chen, David Lynn
Brookhaven National Laboratory

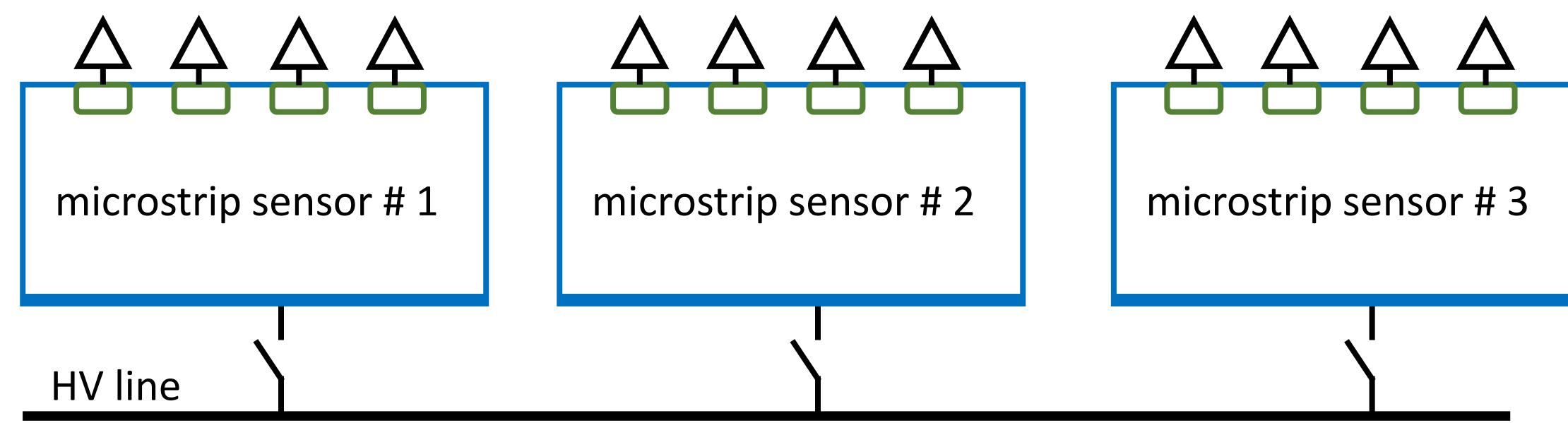
BROOKHAVEN
NATIONAL LABORATORY

70 YEARS OF DISCOVERY
A CENTURY OF SERVICE

U.S. DEPARTMENT OF **ENERGY**

The HV Mux

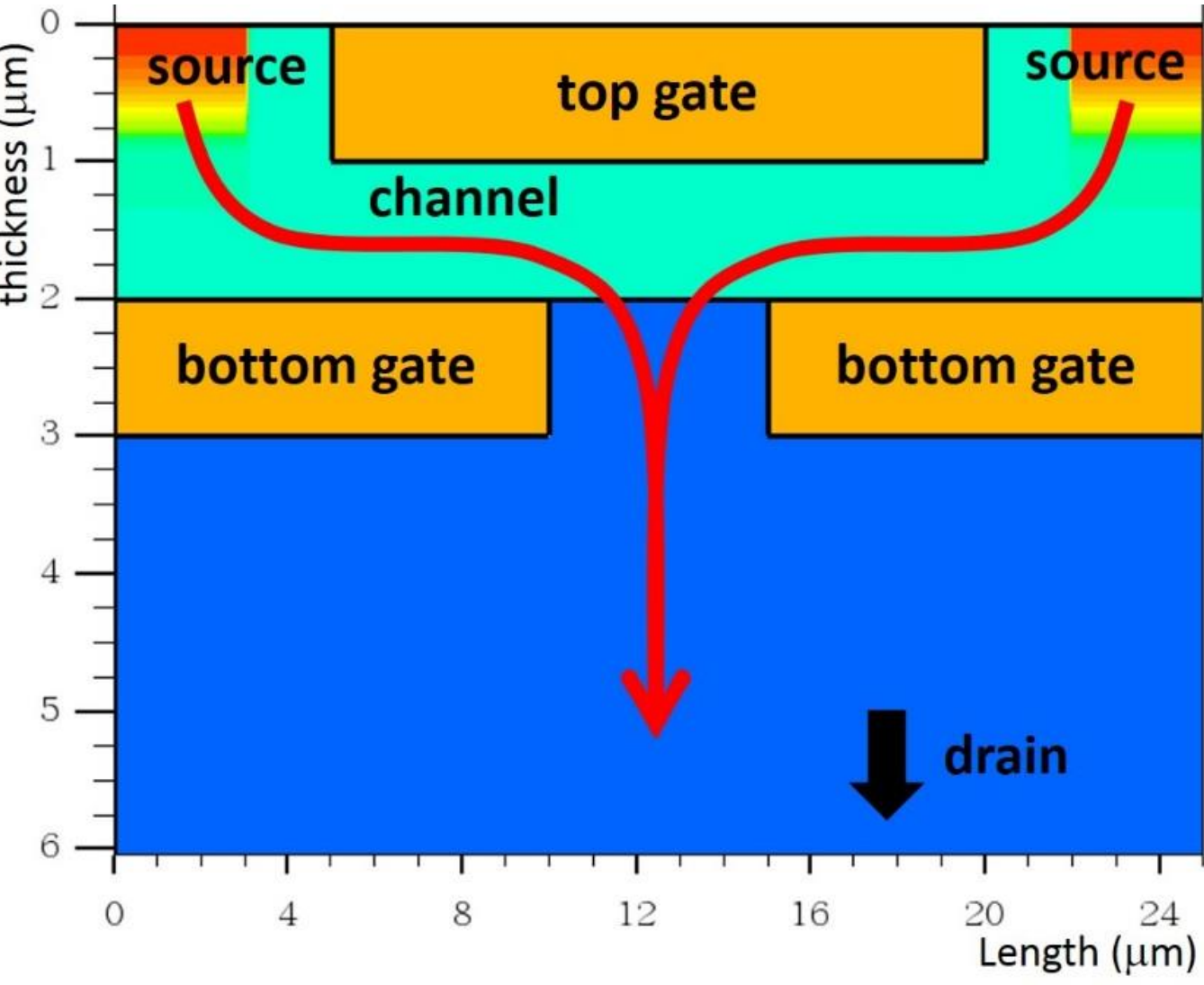
In the ATLAS Inner Tracker (Itk) upgrade, a few silicon microstrip detectors will be biased together by a single common High-Voltage line. There is a need for a switch that excludes a faulty sensor, to be placed between each strip sensor and the common HV line, so that the other good detectors on the same stave can work normally.



Operation in magnetic fields excludes electro-mechanical switches, rad-hardness excludes power MOSFETs, GaN JFETs show good results but:

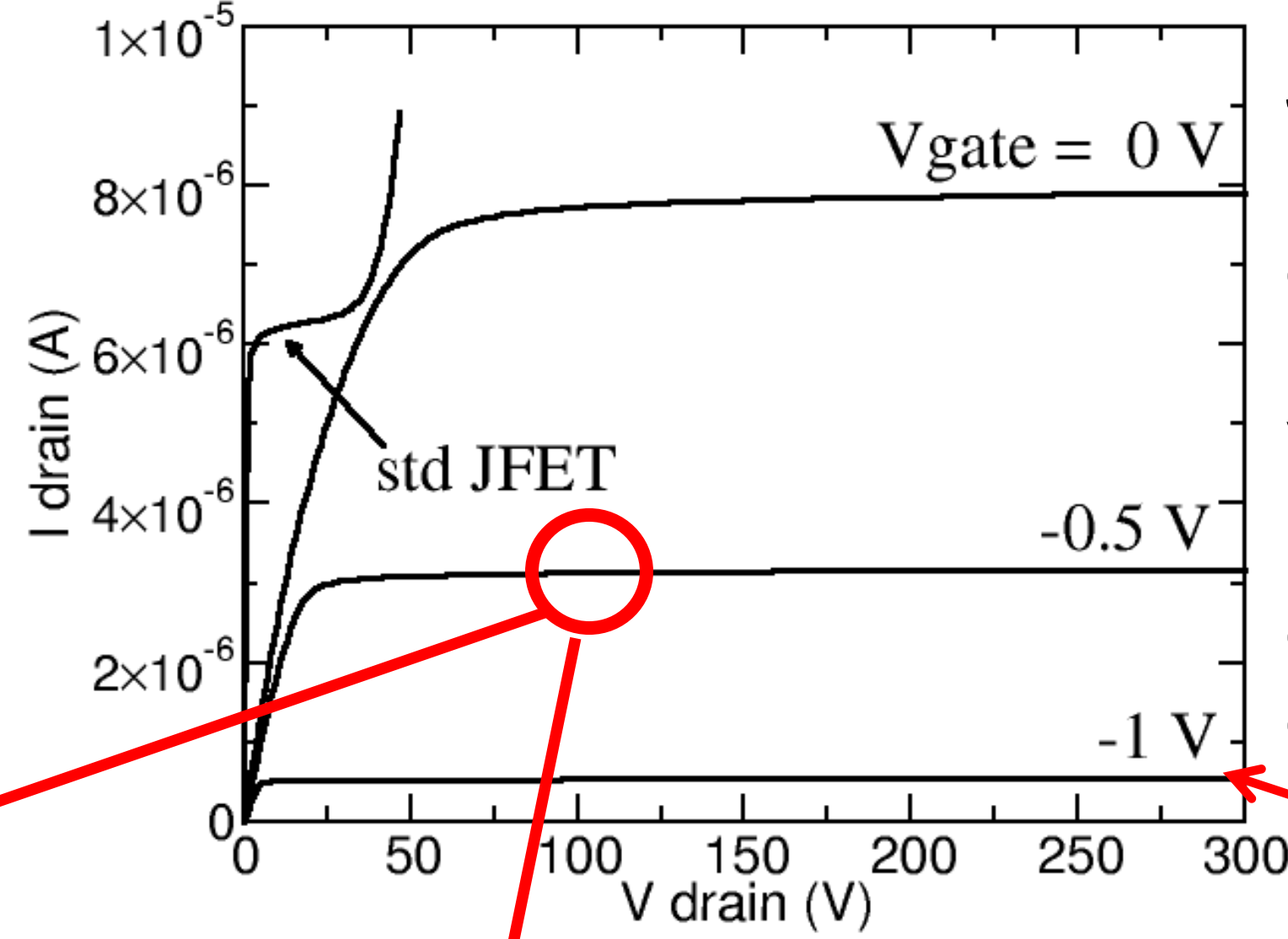
Can we do a HV silicon JFET?

The HV vertical silicon JFET



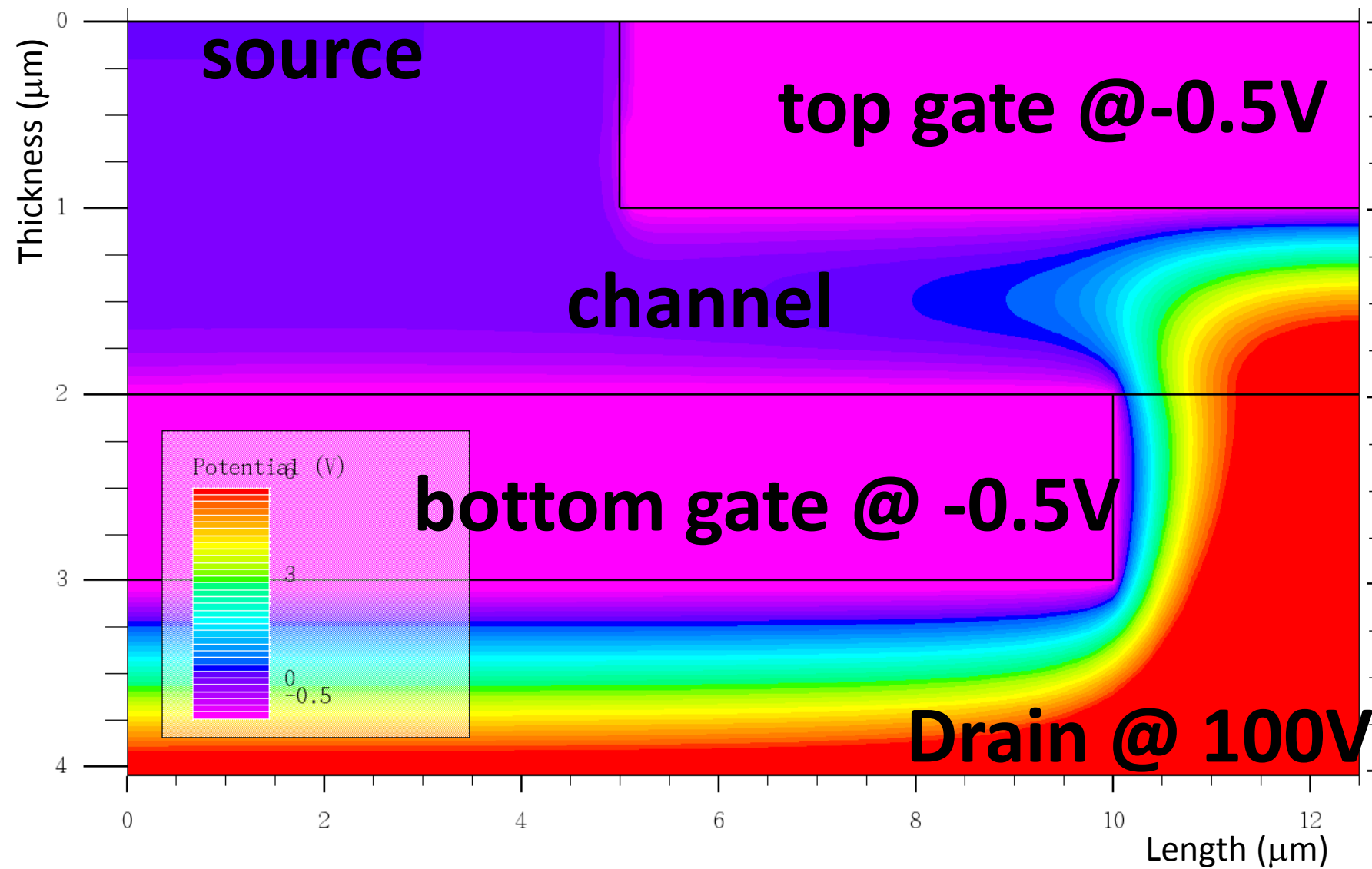
As well as other silicon power devices, it is based on a vertical structure, where the drain is the silicon substrate (or the epitaxial layer). A gap in the bottom gate allows the source-to-drain current to go through

(TCAD simulations)

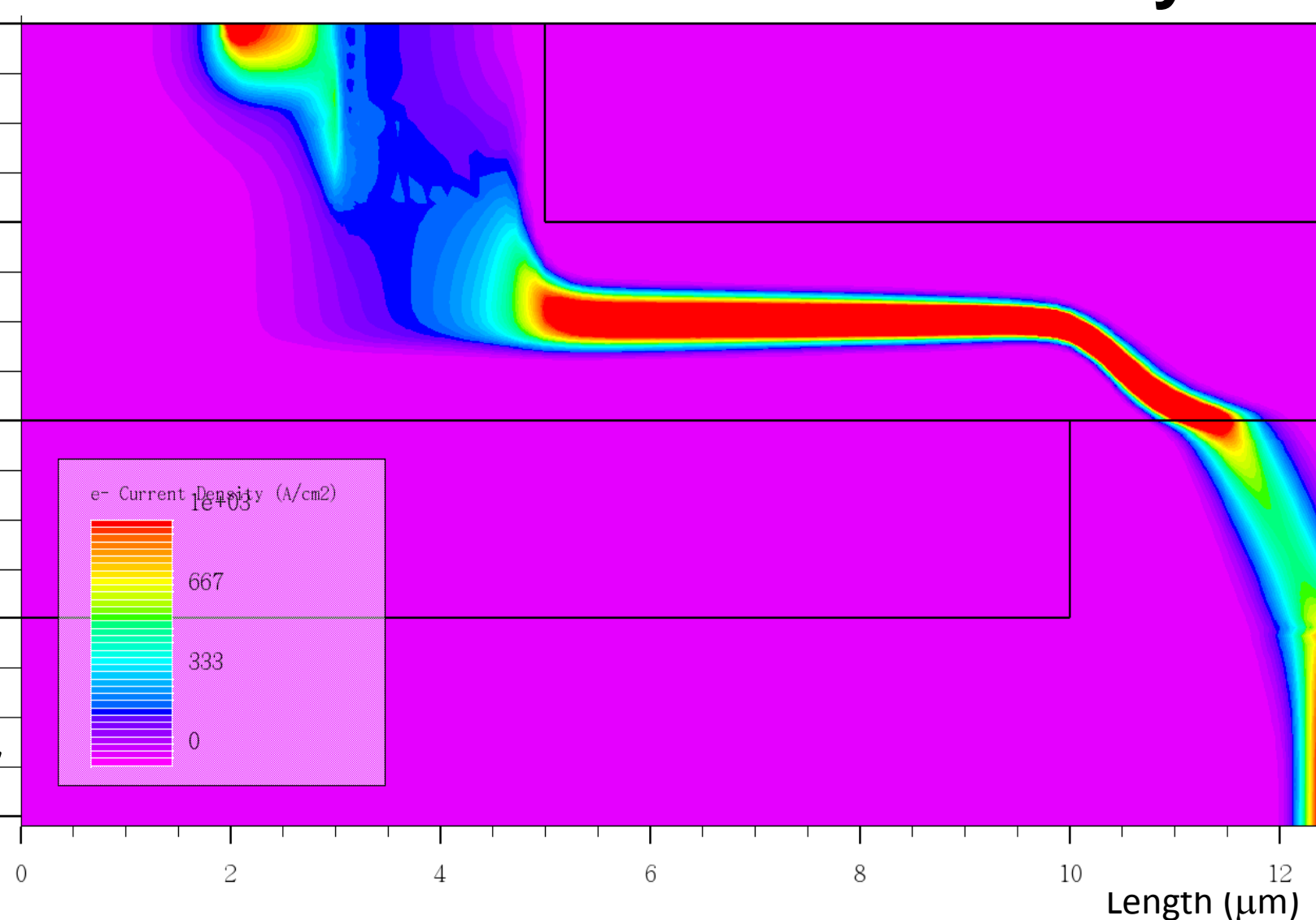


Compared with a standard JFET, much larger voltage can be applied to the drain, while the saturation currents are the same. $V_{d,sat}$ however, is much larger and strongly depends on the channel doping.

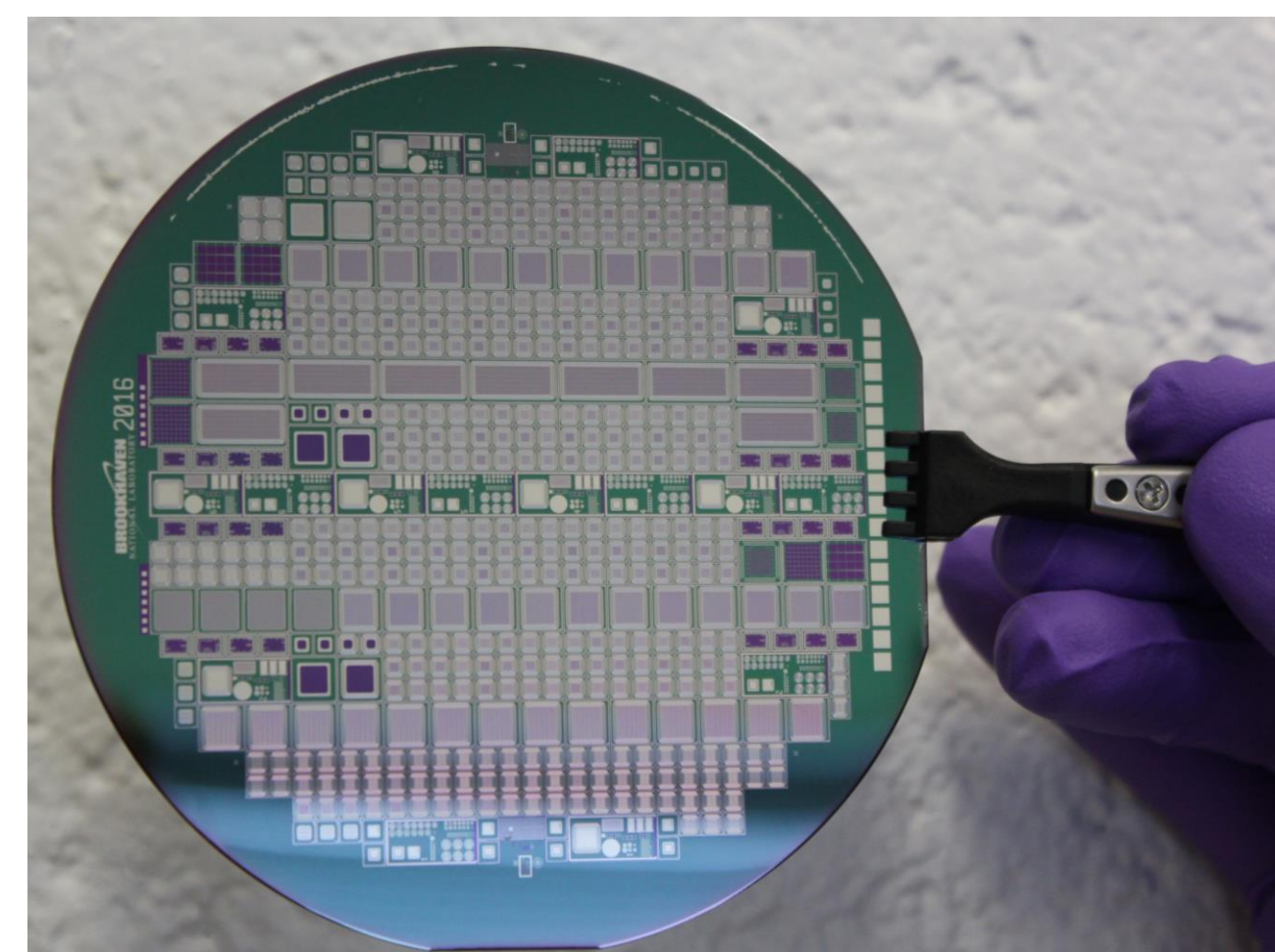
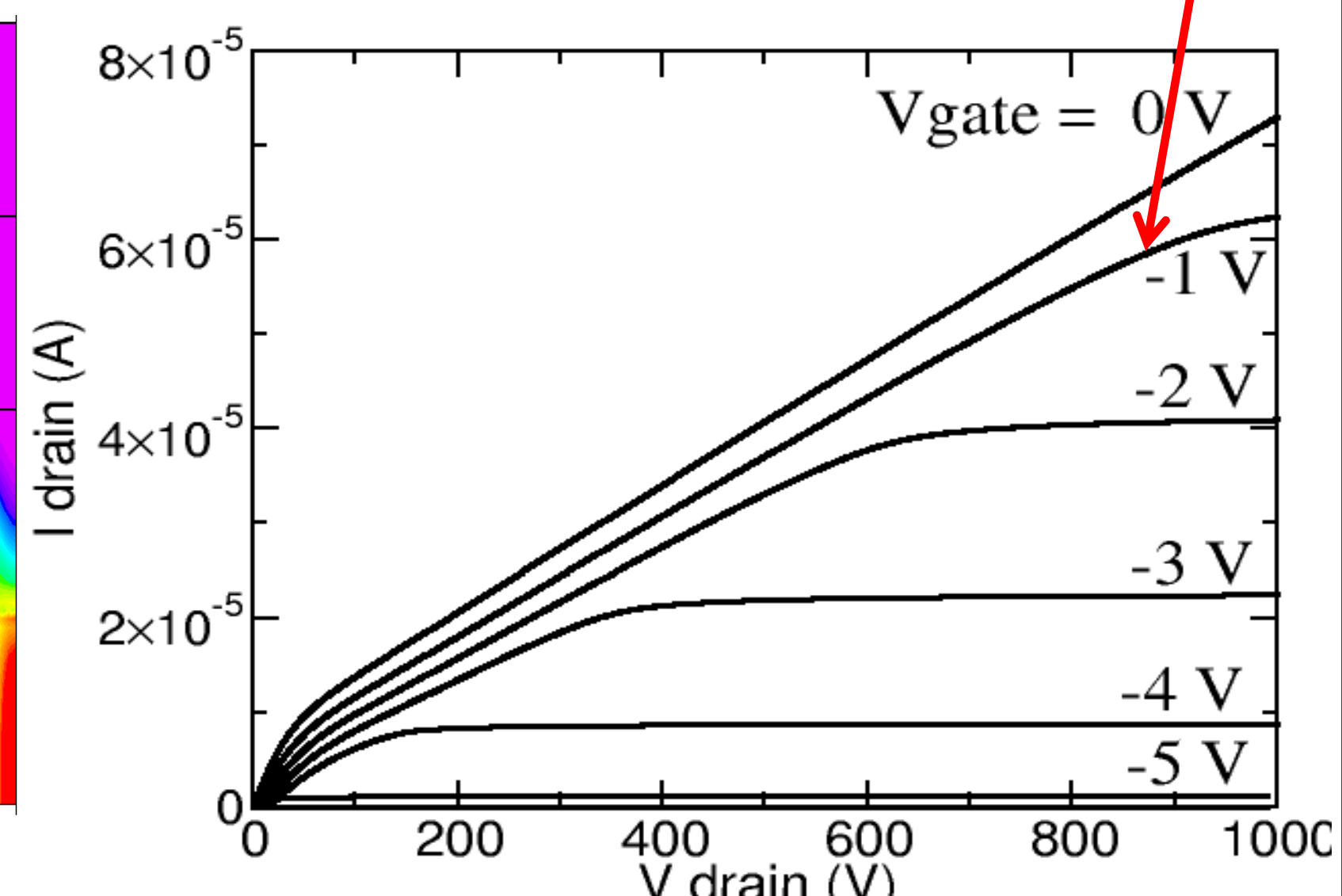
Electrostatic Potential



Electron Current Density

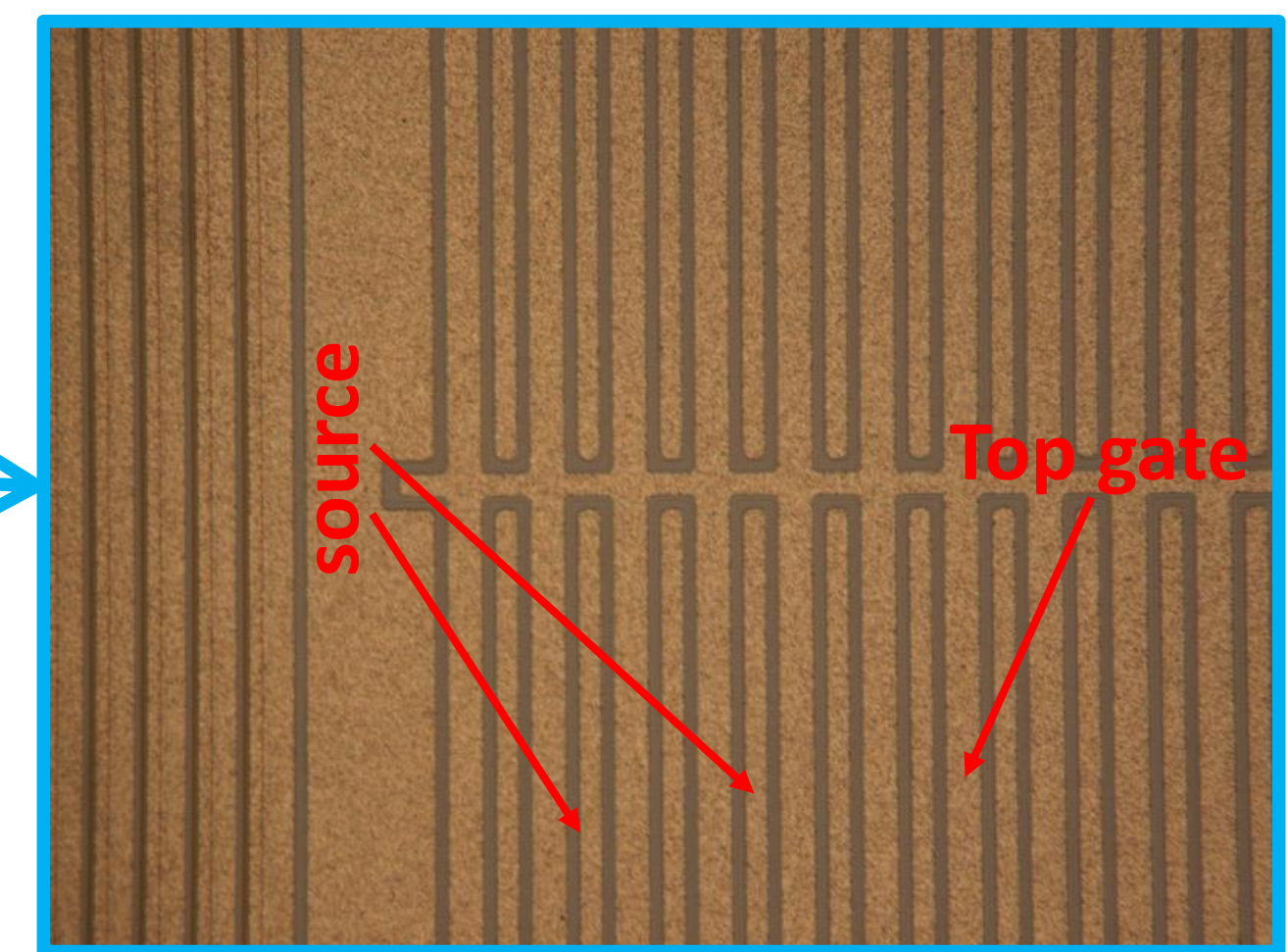
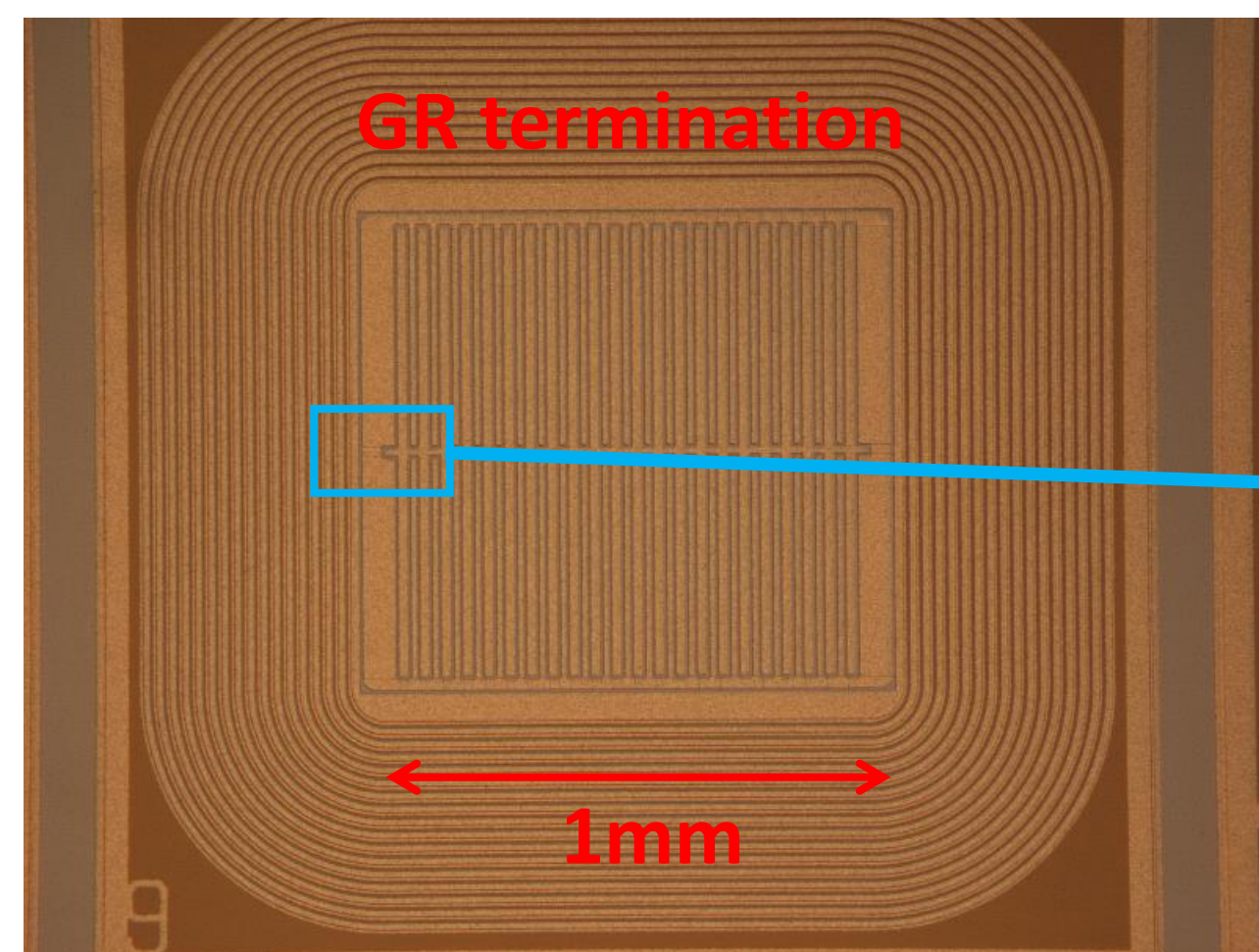


Channel doping = 10^{16} vs $3 \times 10^{16} \text{ cm}^{-3}$



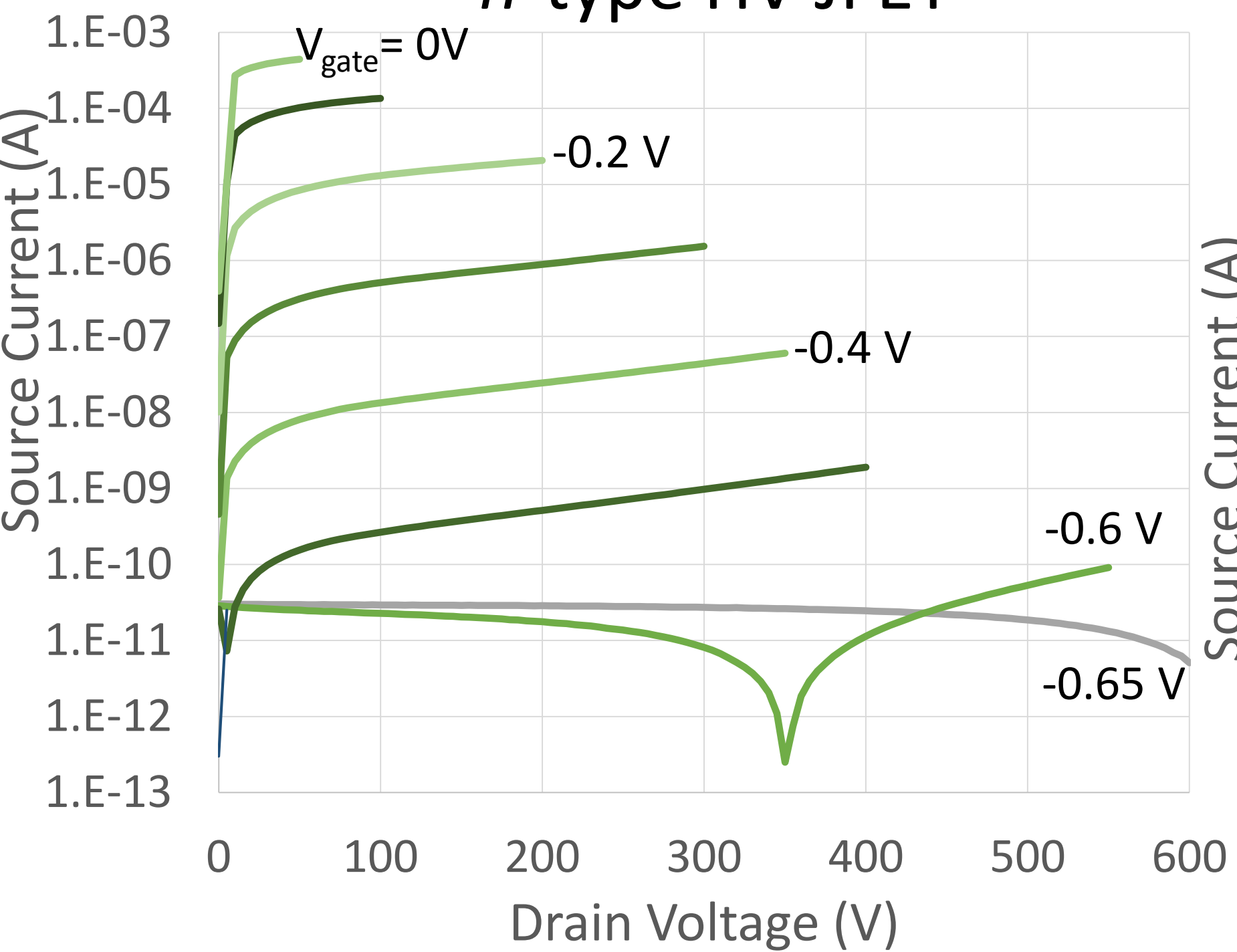
- 4" wafers
- n- and p-type wafers
- epitaxial thickness = $50 \mu\text{m}$
- epi doping $\sim 10^{14} \text{ cm}^{-3}$

4-implant 6-mask fabrication carried out in the Class-100 Clean-Room of Instrumentation Division at BNL.

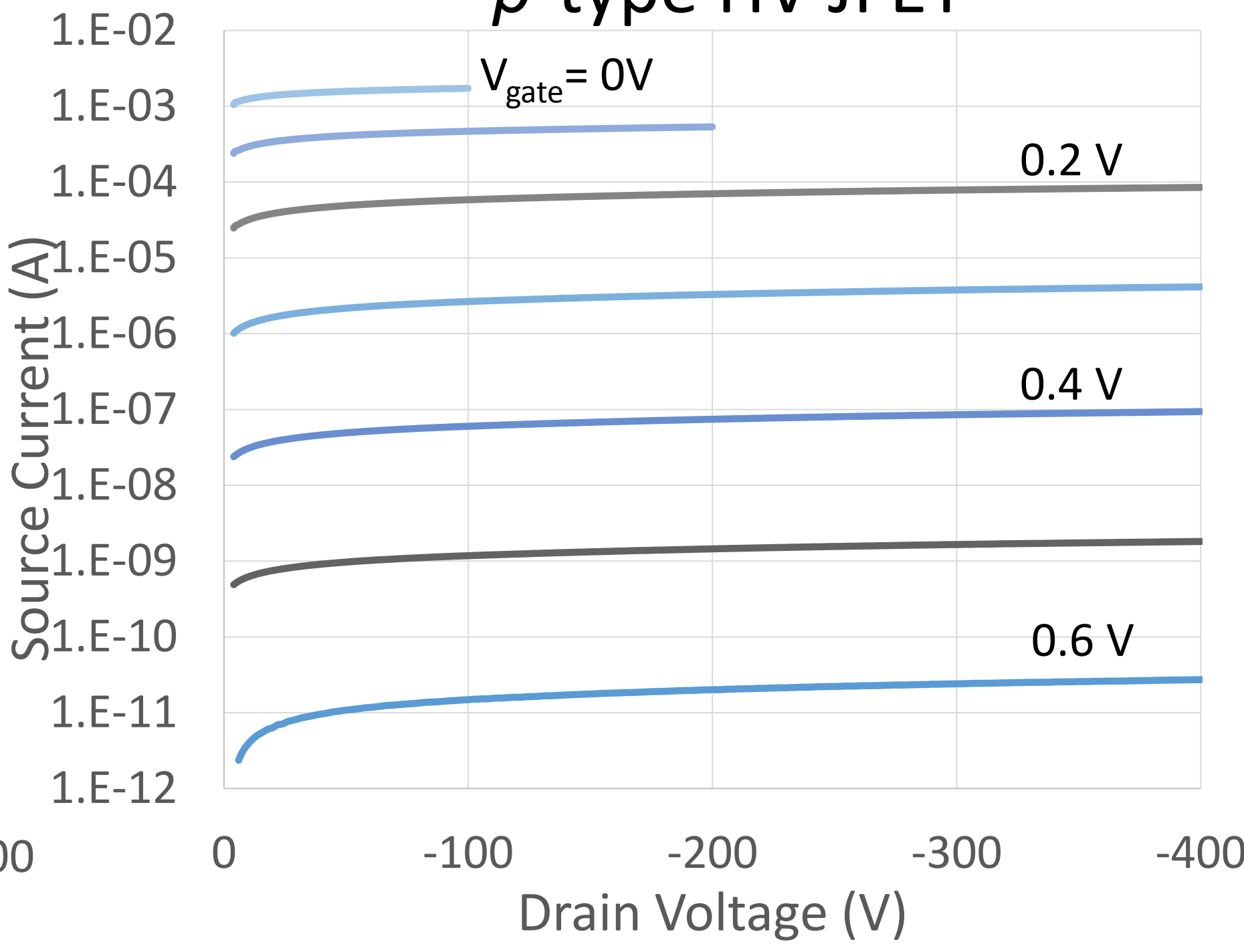


Measured output characteristics

n-type HV JFET



p-type HV JFET



This HV silicon vertical JFET exhibits (before irradiation) all the specs required (or preferred) for the HV Mux switch:

- It can operate in 2T magnetic field
- Voltage $> 600\text{V}$ ($> 300\text{V}$ possible)
- Size $< 10 \text{ mm} \times 10 \text{ mm}$
- $|V_{th}| < 2.0 \text{ V}$
- Normally on
- Temperature Range: $+40\text{C}$ to -40C
- $R_{ds \text{ on}} < 10 \text{ ohms}$
- $R_{ds \text{ off}} > 100 \text{ Meg}$

However, these characteristics must be checked after irradiation to 50 Mrad , $1.2 \times 10^{15} \text{ n}_{eq}/\text{cm}^2$.