Exploratory Data and Root Cause Analysis for Semiconductor Testing

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Methods

The primary tool used to perform data analysis in the project is Python. The following tasks have/will be performed:

- Generating graph booklets of relations between key electric properties
- Quantification of variation and quality with methods such as non-linear regression and least squares
- Algorithms to identify abnormal samples

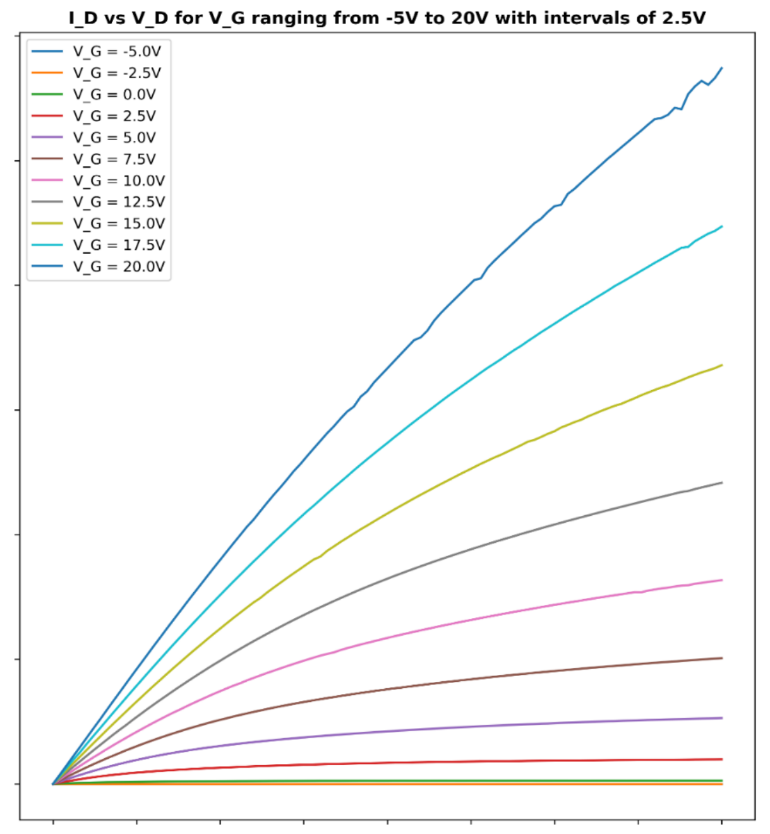

Figure 2: Depiction of a MOSFET devices that are on it, and the resulting graph of the relation between drain current and drain voltage for different gate voltages

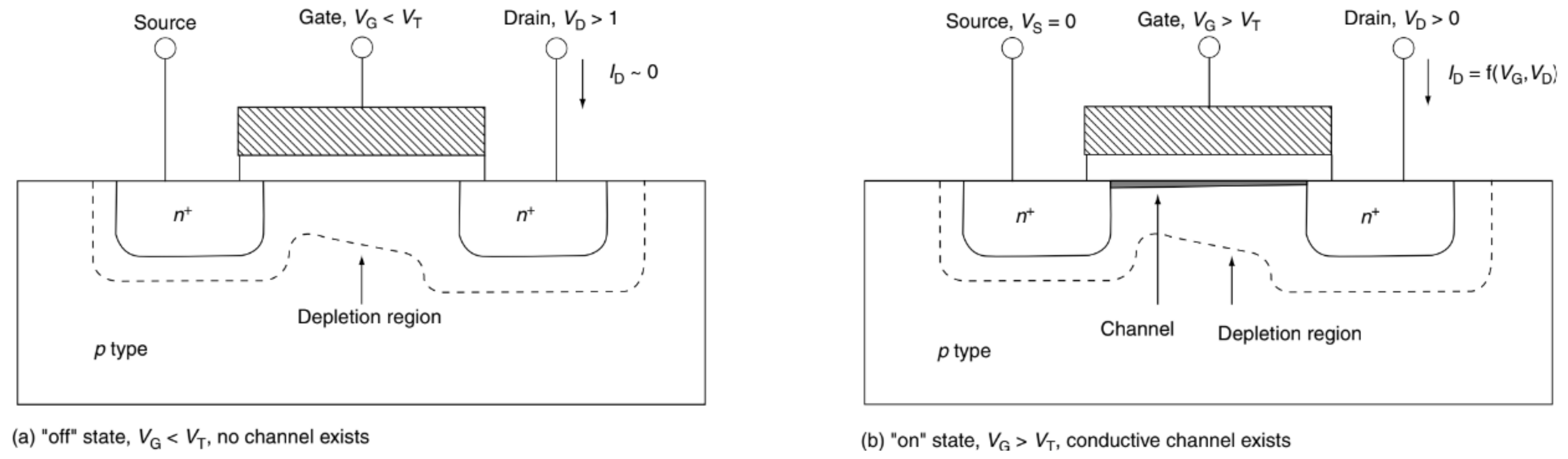

Figure 3: Illustration of how the metal oxide semiconductor field effect transistor (MOSFET) acts when "on" and "off"

Research motivation

Increased awareness regarding the quality issues and improvement of the production system

Preliminary Results

The data from the manufacturing process have the following structure:

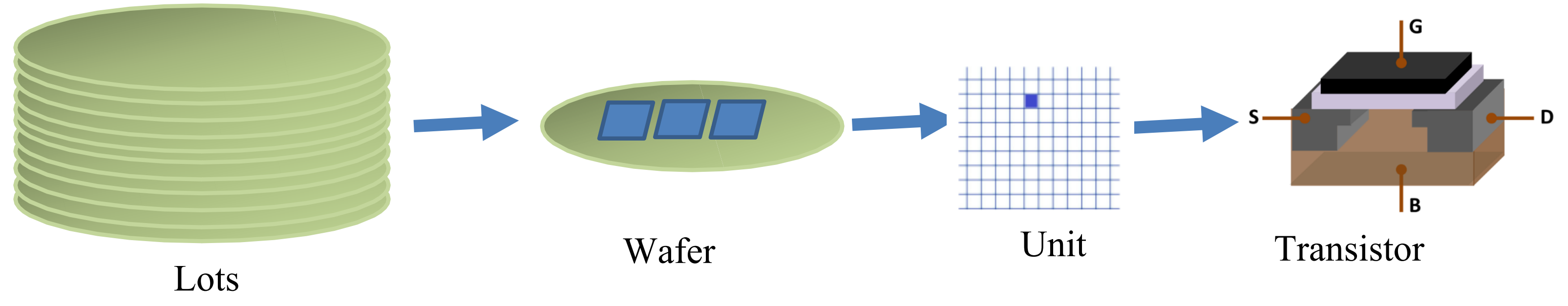

Figure 1: Hierarchy of the manufacturing process

Selected Transistor devices on each unit are tested

- Voltage of gate (V_G) varied between -5V ~ 20V with 2.5V interval
- Voltage of drain (V_D) varied between 0V ~ 20V with 0.2V interval
- Under each interval of V_G and V_D, the gate current (I_G) and drain current (I_D) are measured
- A data block of 101 x 11 x 4 is obtained from each MOSFET
- The MOSFET have three regions of operation, the subthreshold, triode and saturation regions

$$I_D = \begin{cases} \text{(a) Subthreshold region} & I_o \exp(-q(V_T - V_G)/mkT) \quad \text{for } V_G < V_T \\ \text{(b) Triode region} & \mu_n C_{ox}(W/L)(V_G - V_T - V_D/2)V_D \quad \text{for } V_G > V_T \text{ and} \\ & V_D < V_G - V_T \\ \text{(c) Saturation region} & \mu_n C_{ox}(W/2L)(V_G - V_T)^2 \quad \text{for } V_G > V_T \text{ and } V_D > V_G - V_T \end{cases}$$

- The equations above will help model each regions
- Identifying the characteristics of these regions is key to flagging defective/abnormal MOSFET, variation, and assessing quality

Abstract

Data produced from electrical tests on metal oxide semiconductor field effect transistor (MOSFET) components can be used to:

- Discover variability patterns
- Associate variation with quality and measurement issues
- Propose tentative statistical models to describe data

The purpose of this research is to draw conclusion regarding:

- Defects of individual transistor devices
- Quality of wafers they exist on and the entire production line

Next Steps

- Continue to analyze different data files
- Share findings with ASU Flexible Electronics and Display Center team

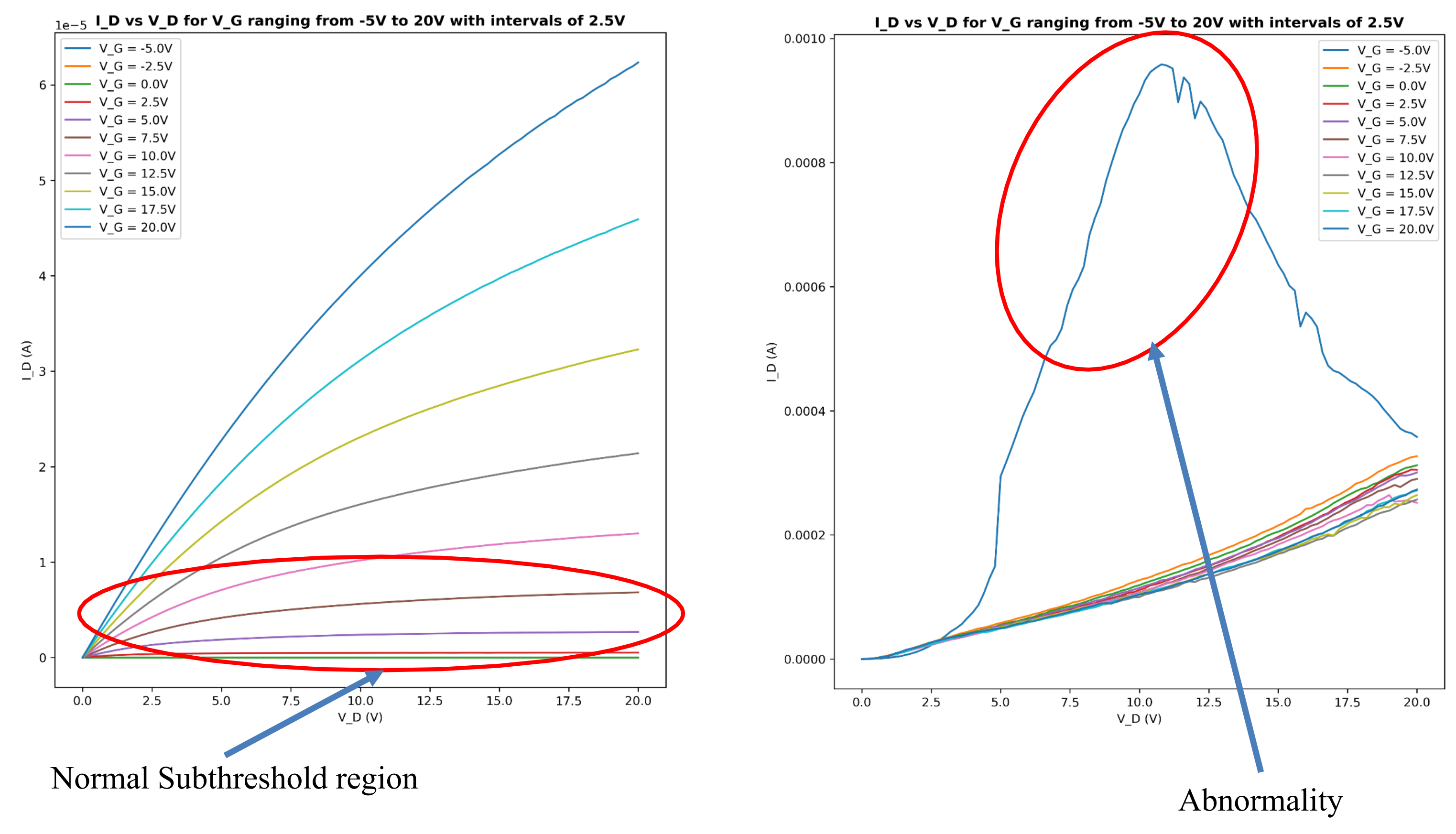

Figure 2: Abnormal (left) and Normal (right) relation between I_D and V_D

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