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Electrical and Computer Engineering

"I-V Characteristics of a Static Random Access Memory Cell Utilizing Ferroelectric Transistors"

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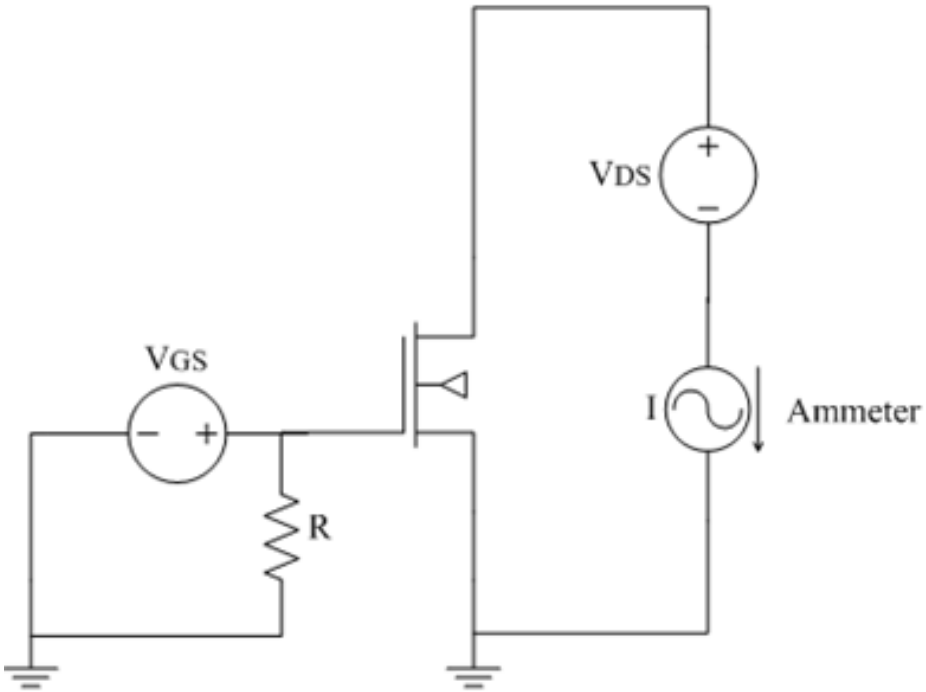
Introduction

- SRAM utilizing Ferroelectric FETs may make high speed memory possible with significant retention times without power (Retention times of 24 hours have been measured)
- Ferroelectric Field-Effect Transistor features polarization due to the ferroelectric layer between the substrate and the gate.
- After removal of the applied input voltage, the polarization still exists, thus the FeFET features unique I-V characteristics
- Current-Voltage (I-V) Characteristics Presented
  - FeFET
  - Resistive Load Static Random Access Memory (SRAM) Cell
- I-V FeFET Model Developed
- Comparison
  - Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET) and FeFET

FeFET Properties

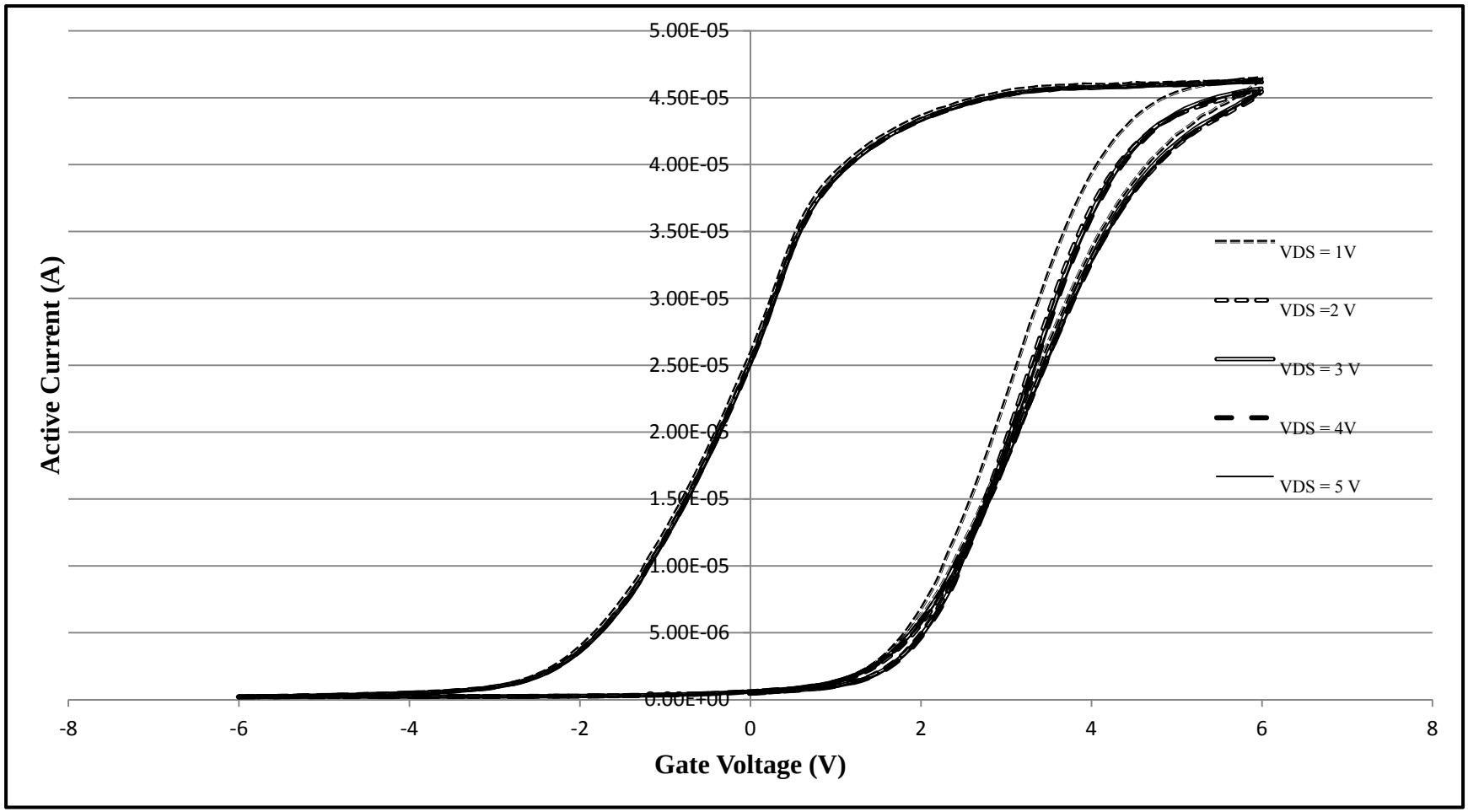
- Ferroelectrics feature properties including
  - Polarization
    - Positive and Negative
  - Hysteresis
    - History dependence
  - Nonlinearity
- The ferroelectric layer gives FeFET unique I-V characteristics
  - Unlike the MOSFET, the I-V characteristics feature a hysteresis trend

FeFET I-V Characterization

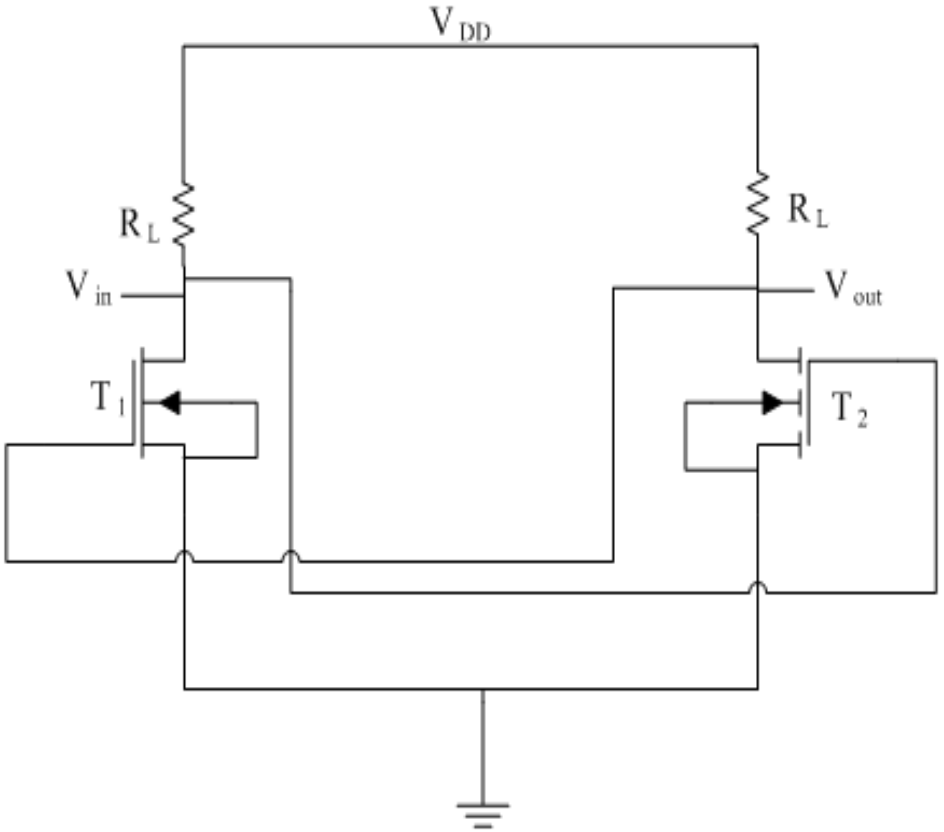


- Ferroelectric Transistor was 10 μm wide and 10 μm long, provided by Radiant Technologies Inc.
- FeFET featured a PZT ferroelectric layer
- FeFET active current was measured with test circuit, shown left
- PZT ferroelectric layer was properly polarized
- The drain-to-source voltage (V_{DS}) was varied for a range of gate-to-source voltages (V_{GS}) and the drain current was measured

ND1 Active Current for Various V_{DS}

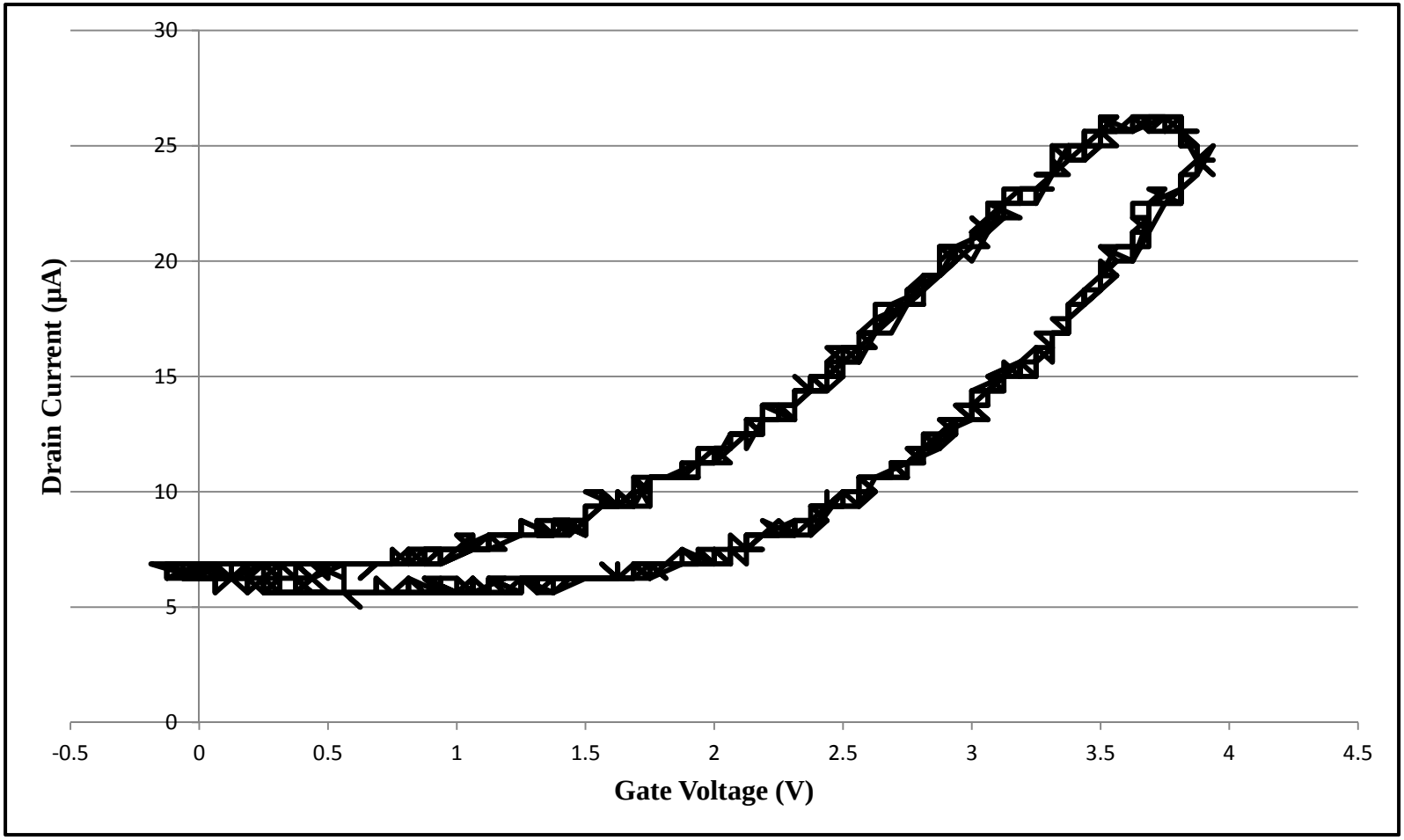


SRAM Cell Operation

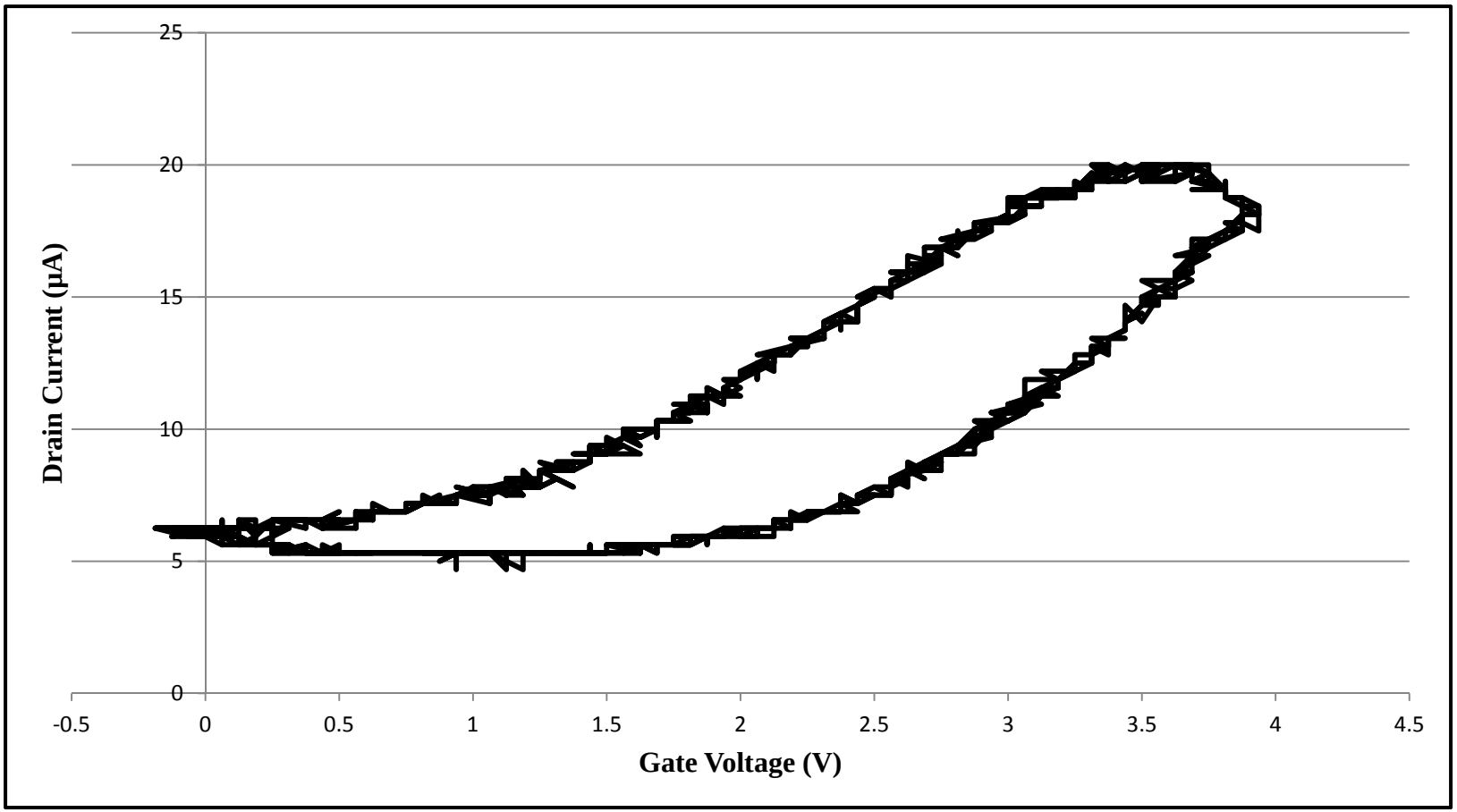


- A traditional resistive load SRAM cell was constructed as shown on the left
- The input voltage, V_{in}, is applied at drain of T_1 and the output voltage , V_{out}, is read at drain of T_2
- A couple different configurations were investigated
  - FeFETs for T_1 and T_2
  - Various resistance values with FeFETs for T_1 and T_2

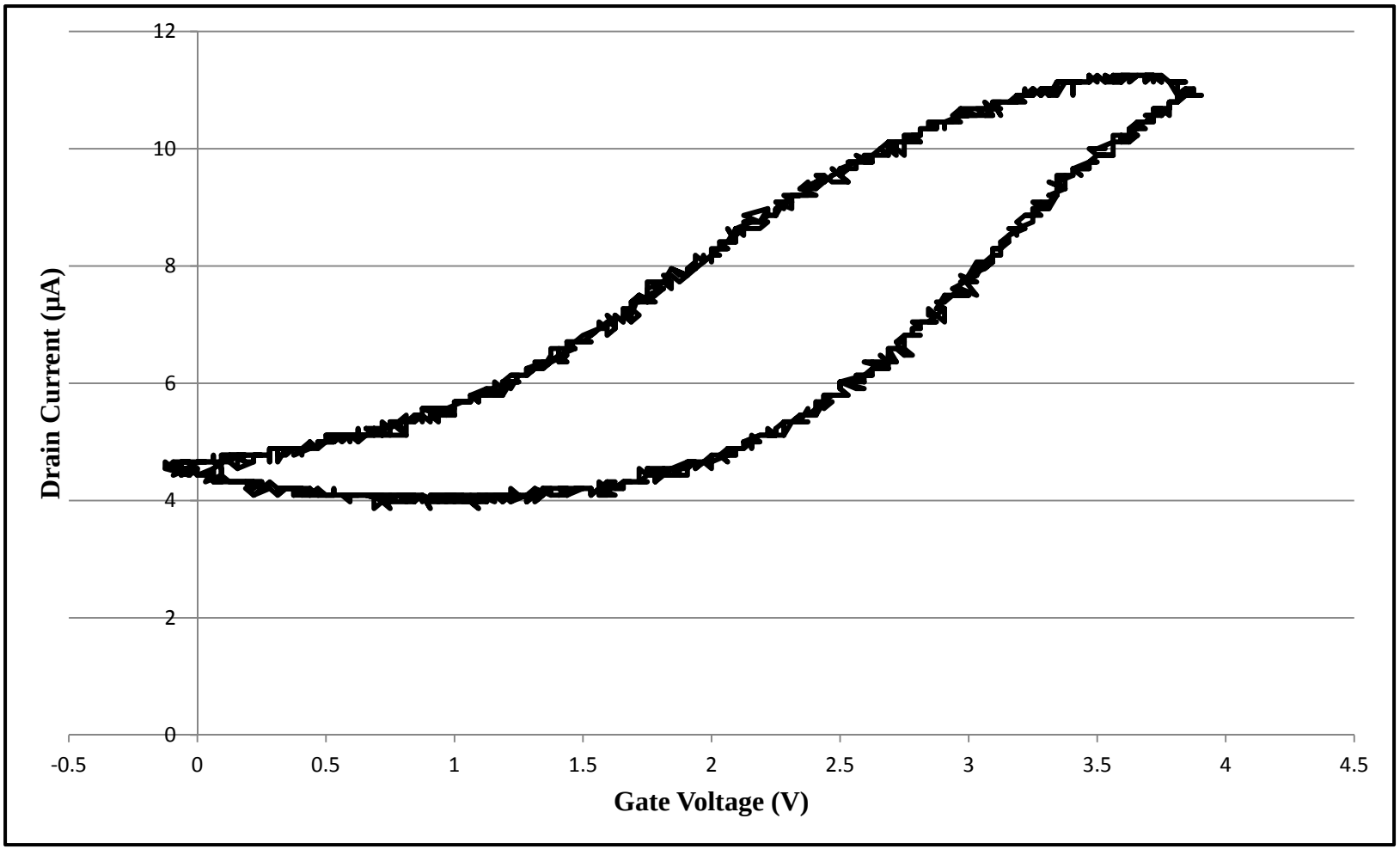
ND1 SRAM I-V Characteristics at a Load Resistance of 51 kΩ



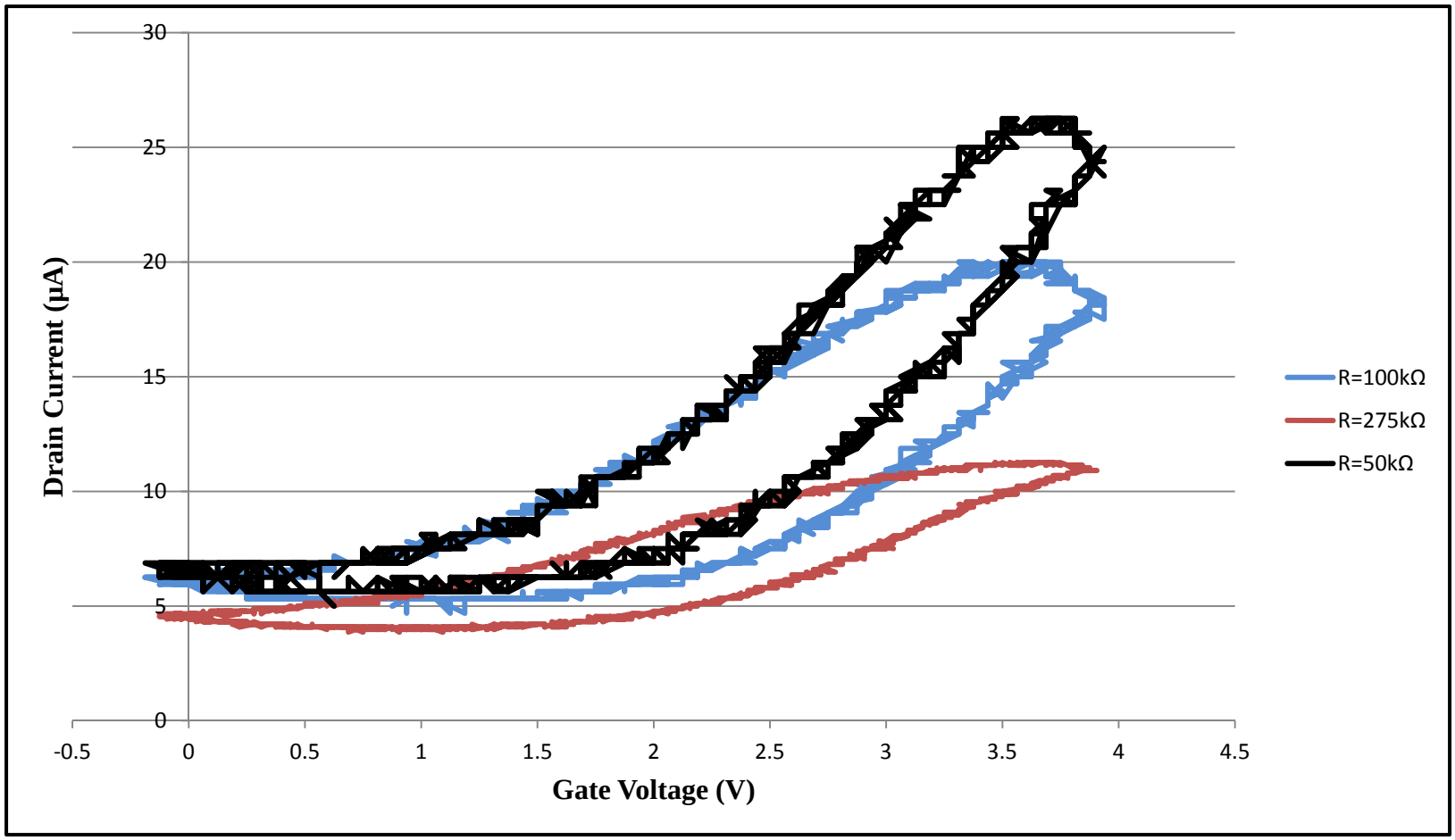
ND1 SRAM I-V Characteristics at a Load Resistance of 105 kΩ



ND1 SRAM I-V Characteristics at a Load Resistance of 275 kΩ



ND1 SRAM I-V Comparison Chart



Conclusion

- I-V characteristics for FeFET different than that of MOSFET
  - Ferroelectric layer features hysteresis trend whereas MOSFET behaves same for both increasing and decreasing V_{GS}
  - FeFET I-V characteristics doesn't show dependence on V_{DS}

- A Transistor with different channel length and width as well as various resistance and input voltages give different results
  - As resistance values increased, the magnitude of the drain current decreased

References

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