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

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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 $V_{DS}$

[Graph showing the active current for various $V_{DS}$ values]

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SRAM Cell Operation

- A traditional resistive load SRAM cell was constructed as shown on the left.
- The input voltage, $V_{\text{in}}$, is applied at drain of $T_1$ and the output voltage, $V_{\text{out}}$, 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


5. J. Evans, Modeling Radiant Thin Ferroelectric Film Transistors, Radiant Technologies Inc, 2011.


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