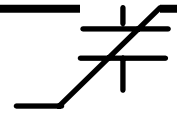

Static FRAM: A Novel Ferroelectric Memory

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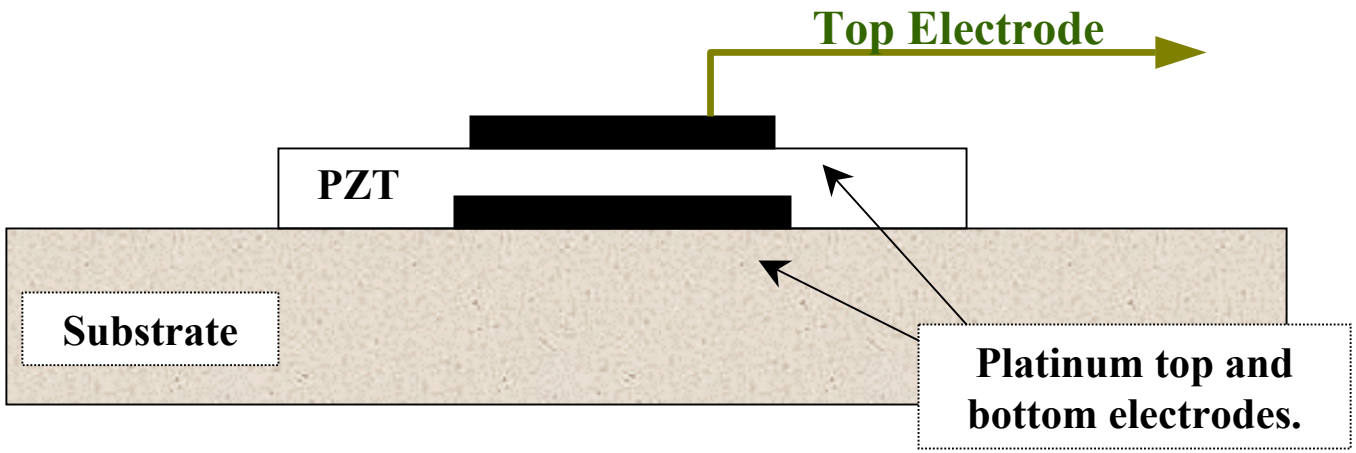
Presented by Michelle Bell
Radiant Technologies, Inc.
November 5, 2002

Summary

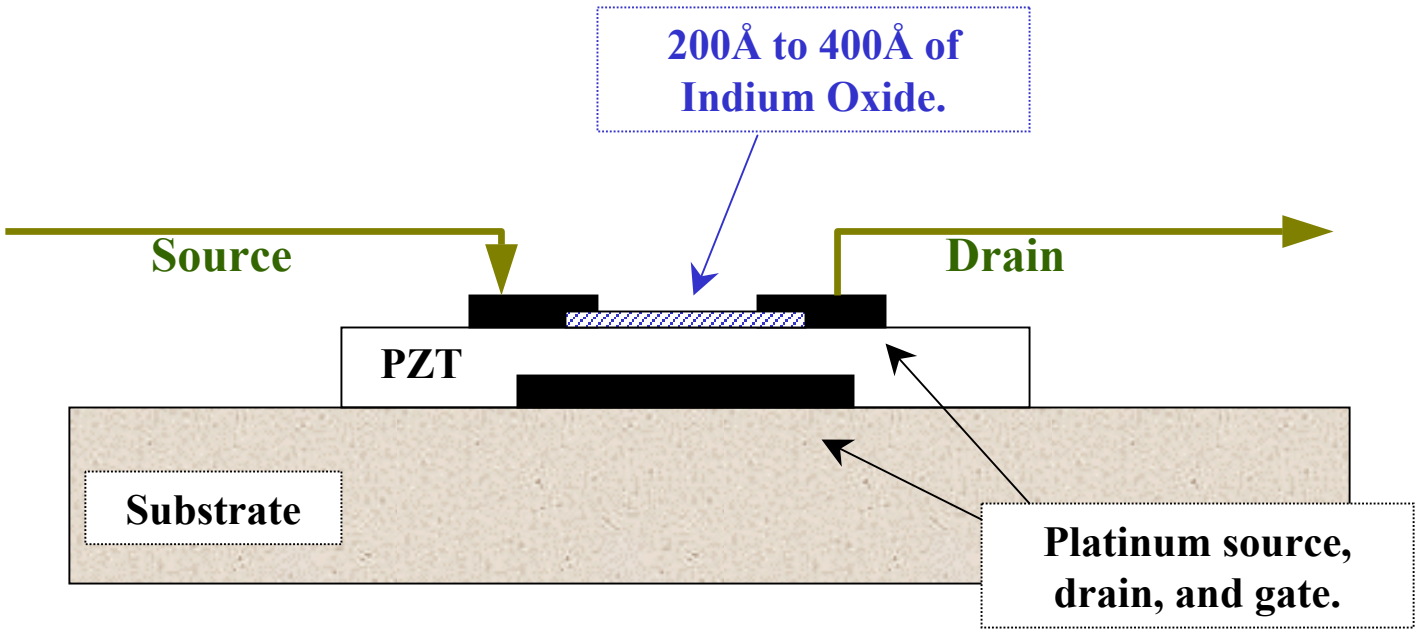
- There are efforts today to make non-volatile transistors by inserting a ferroelectric film into the gate of a MOSFET.
- It is much simpler to build Thin Film Transistors (TFTs) using thin ferroelectric films as the gate material and semiconducting oxides as the channel.
- Radiant has built and tested such devices.
- This presentation will disclose the device structure, operation, and application to memories.

Standard Capacitor Cross Section



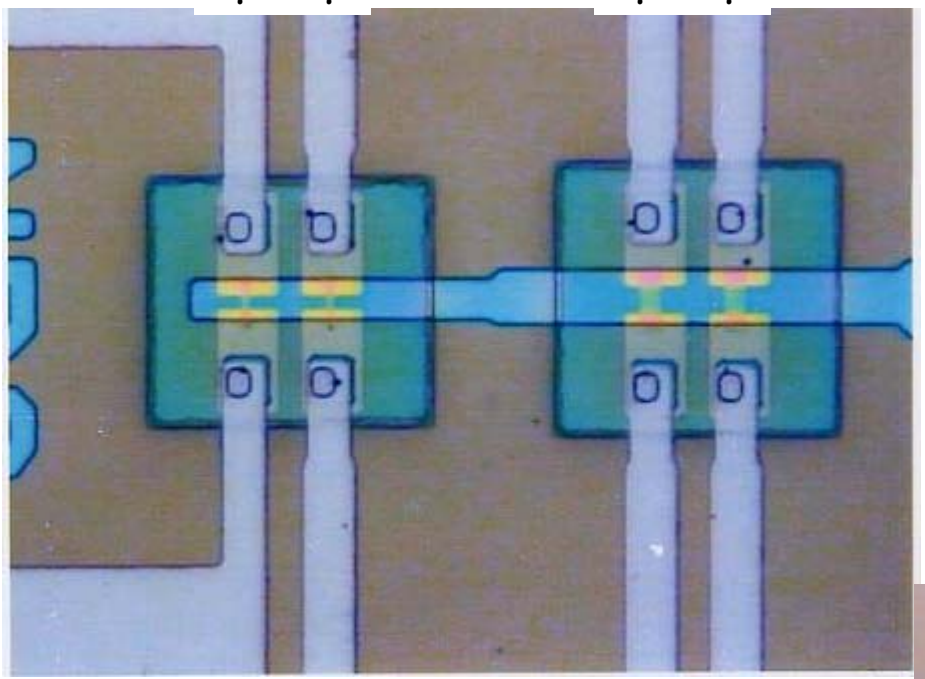
- A simple ferroelectric capacitor has a thin ferroelectric film sandwiched between two electrodes.
- The substrate is usually silicon but can be anything that can take the temperature.
- Radiant has built capacitors on stainless steel!

Transistor Cross Section

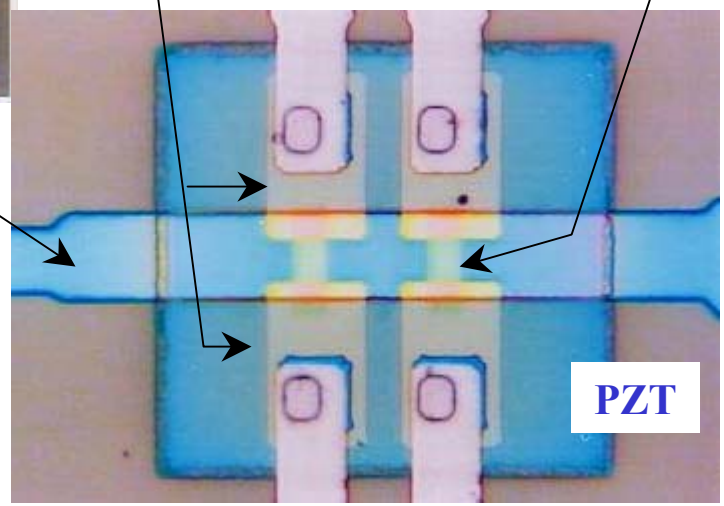


- The TFFT (Thin Ferroelectric Film Transistor) is a ferroelectric capacitor where the top electrode is replaced by a conducting oxide. -->> Simple! <<--

Photo Op!



3500Å of 20/80 PZT with 200Å of Indium Oxide semiconductor.

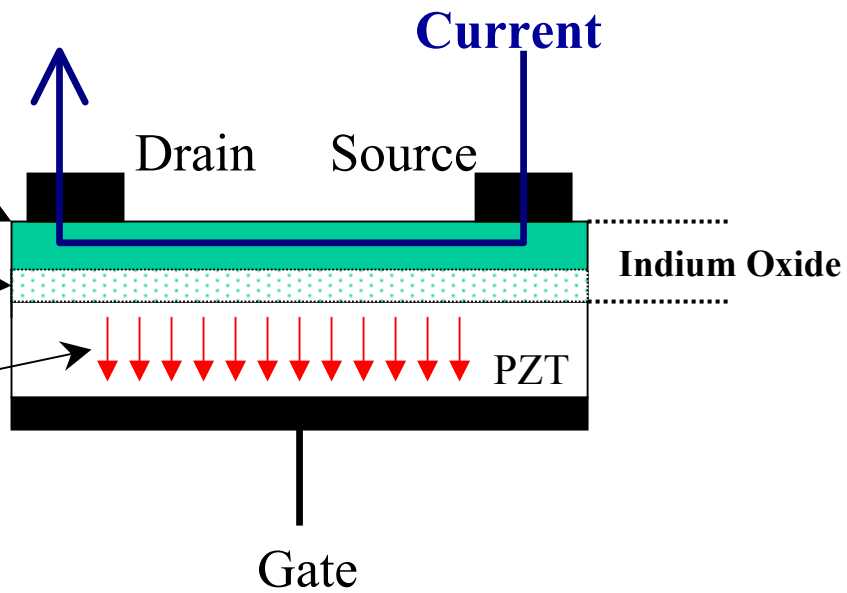


The transistors are fully integrated with passivation and metal interconnect.

Theory of Operation

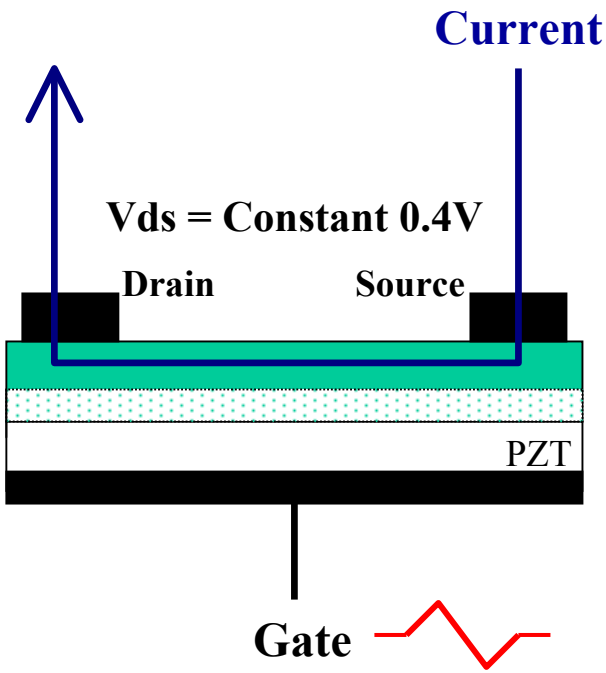
The TFFT is a JFET, not a MOSFET!

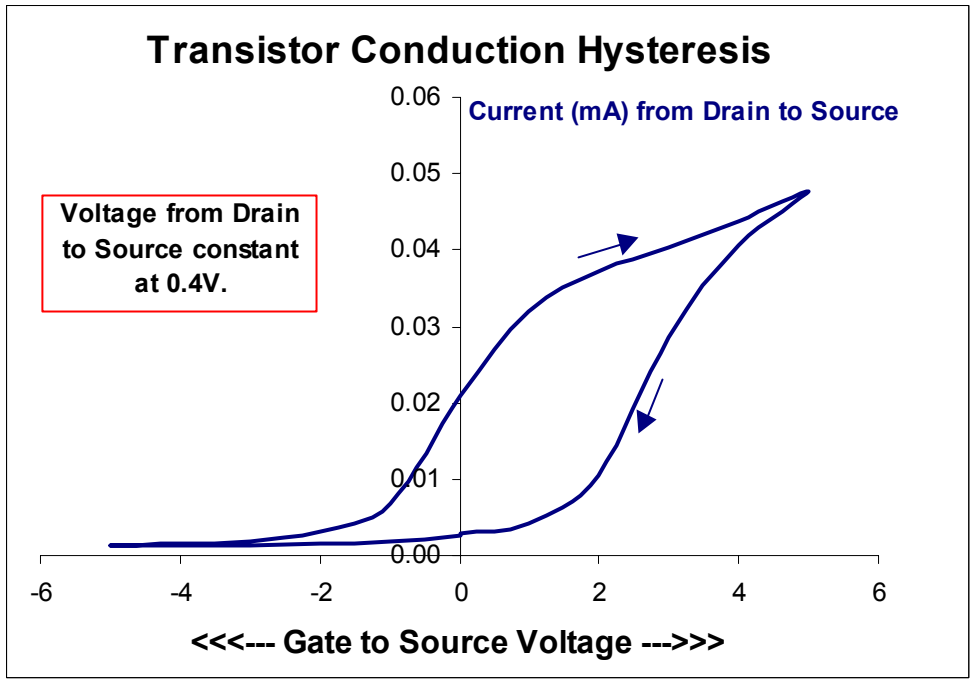
- Conductive Region of Indium Oxide.
- Non-conductive region of Indium Oxide. (Depletion Region)
- The non-conductive region grows or shrinks according to the polarization!



J. Evans, R. Suizu, and L Boyer, Applied Surface Science, 117/118 (1997) pp413-417

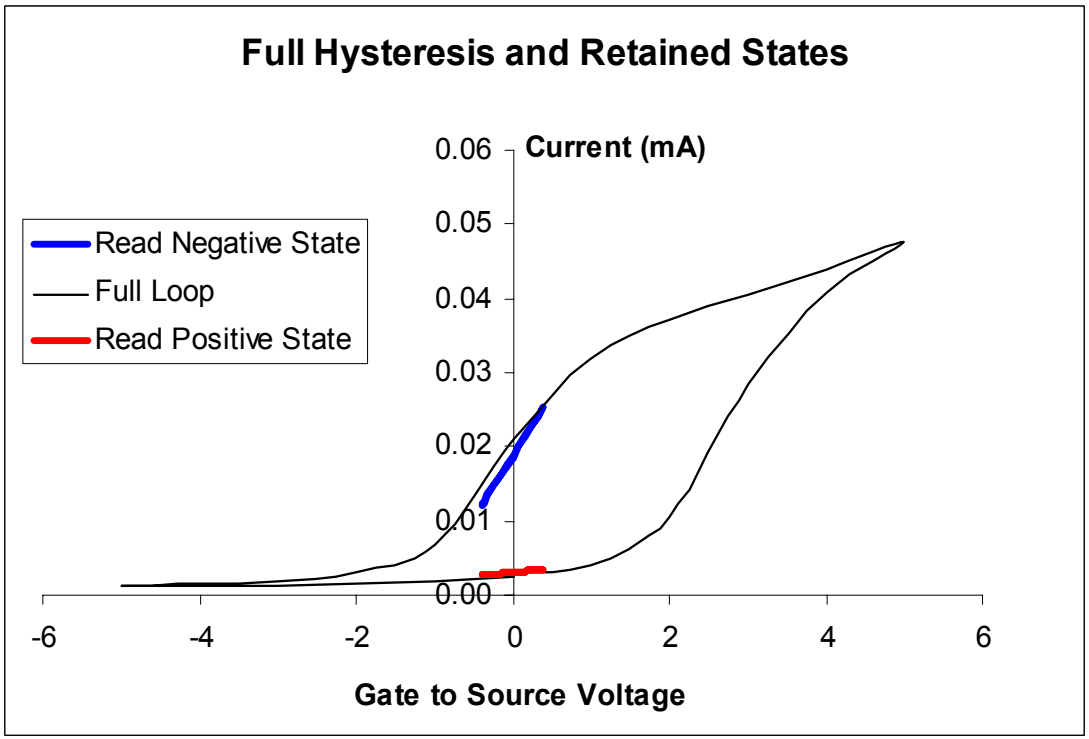
Transistor Hysteresis





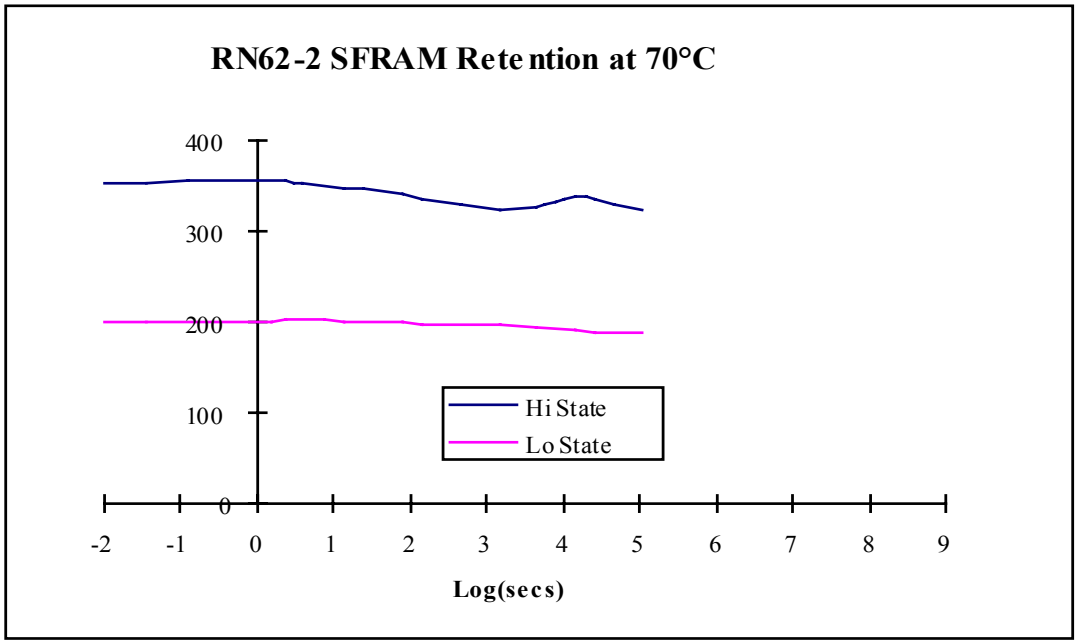
- The TFFT hysteresis is centered on zero gate volts, giving it current memory.

Memory Effect



- Reads executed at 0.4V do not disturb states written at ±5V.

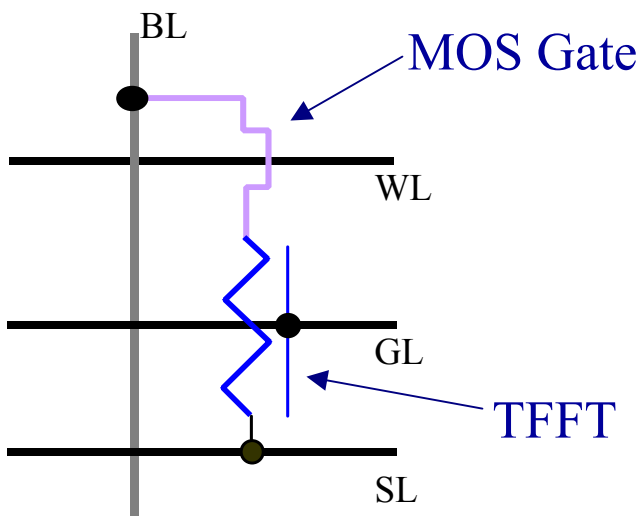
Retention at 70ºC



- TFFTs also show no fatigue and no imprint.

Memory Cell

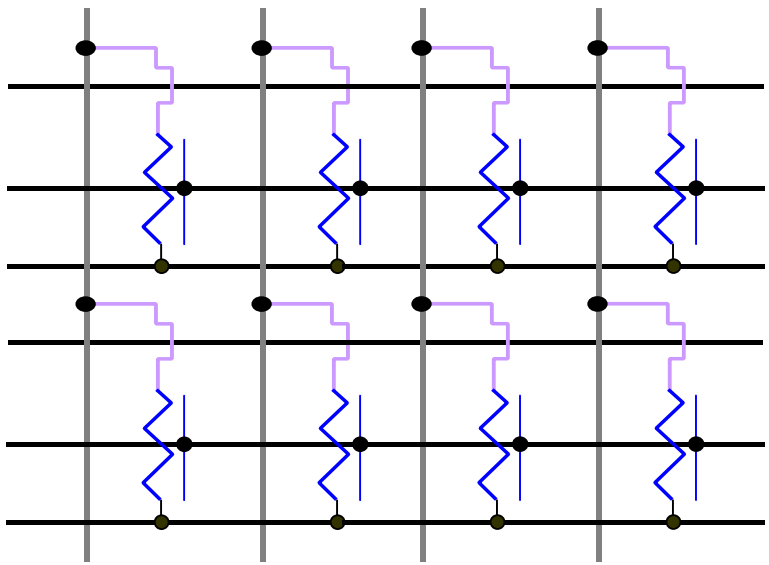
The memory cell has a pass transistor and four control lines. The pass gate is required to prevent disturbs.



Cell areas approaching $6\mu^2$ are possible with 0.5u CMOS technology.

TFFT Memories -> SFRAM

- SFRAM memories operate totally asynchronously with 100% SRAM control line compatibility.
  - Chip select can be tied low and reads can ripple through.
  - 2x faster than FRAM
  - Extremely low power consumption during read operations.
  - Smaller cell.



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Conclusion

- A Thin Film Transistor (TFT) can be fabricated by placing a semiconducting oxide channel on top of a thin ferroelectric film capacitor.
- The transistors have excellent characteristics and are easier to fabricate than MFSFETs (Metal Ferroelectric Semiconductor Field Effect Transistors).
- Memories fabricated with the TFFTs can exceed existing FRAMs in density and speed.
- The most important aspect of the SFRAM is the incredibly low power at which they can be operated.