Testing Flash Memory with the Model 4200-SCS

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Flash Memory

Floating gate non–volatile memory: programmed and erased by charge tunneling or hot electron injection

Two main technologies

- Nor
- Nand

Two main sets of tests for each technology

- Characterization
- Lifetime

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NOR vs. NAND

Parameter	NAND	NOR
Nonvolatile	yes	yes
Random Access	No	yes
Write Cycles	10^6	10^6
Read Time	25μS	70nS
Write Time/Voltage	300μS < 20V	1-10μS < 13V
Erase Time/Voltage	900μS - 5mS < |20 |V	10-100mS -13 to -10V

*Source: *Prospect of Emerging Nonvolatile Memories*, Hongsik Jeong & Kinam Kim, Materials Research Society Symposium Proceedings, Vol. 830, p 366

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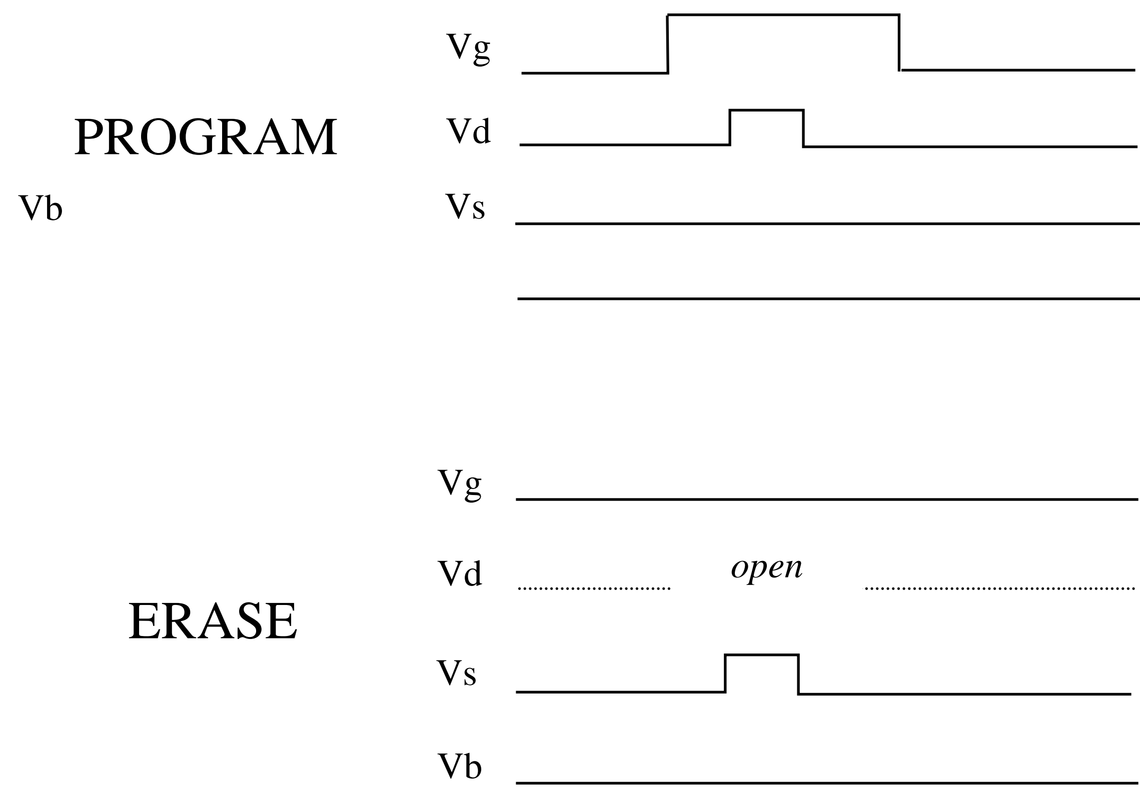
Typical NOR program/erase cycle



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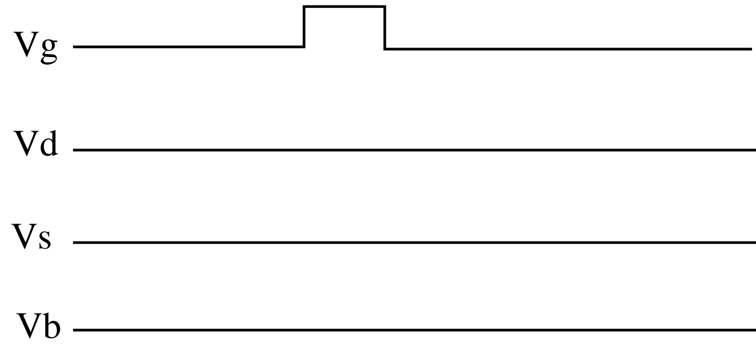
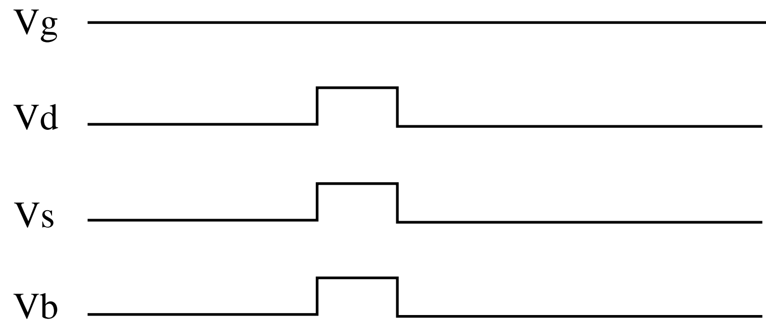
Typical NAND program/erase cycle

PROGRAM



ERASE



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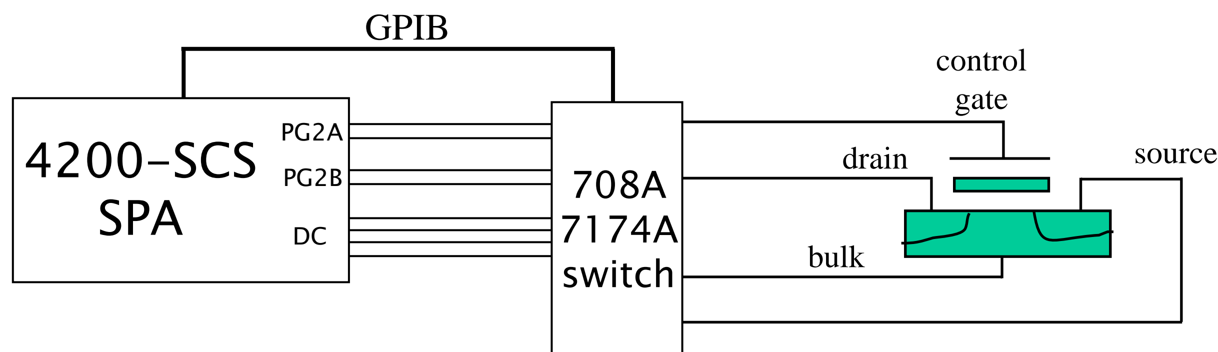
Proposed NAND Flash test setup



- Allows easy switching between Pulse and DC tests
- PG2 channels can be used as DC bias during program/erase – minimizing switching
- Pattern generation/multi-segment pulse capabilities of PG2 allow for program/erase cycle to be setup as one pattern and repeated n times for lifetime testing

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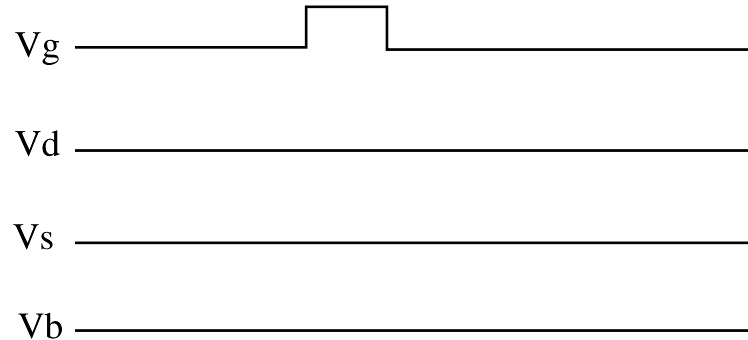
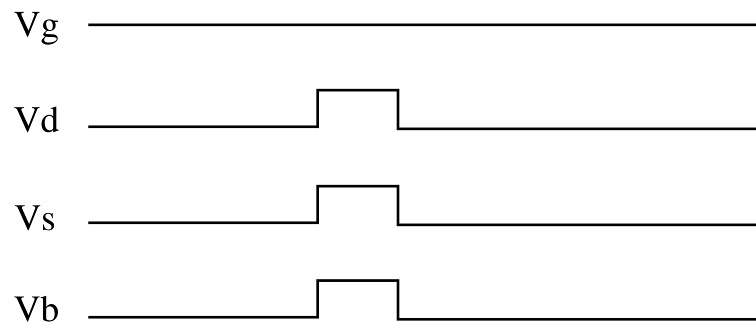
NAND program/erase cycle performance

PROGRAM



Vg pulse capabilities
- ±10V
- min rise/fall = 100ns
- min pulse width = 100ns

ERASE



Vd, Vs, Vb pulse capabilities
- ±20V
- min rise/fall = 100ns
- min pulse width = 250ns

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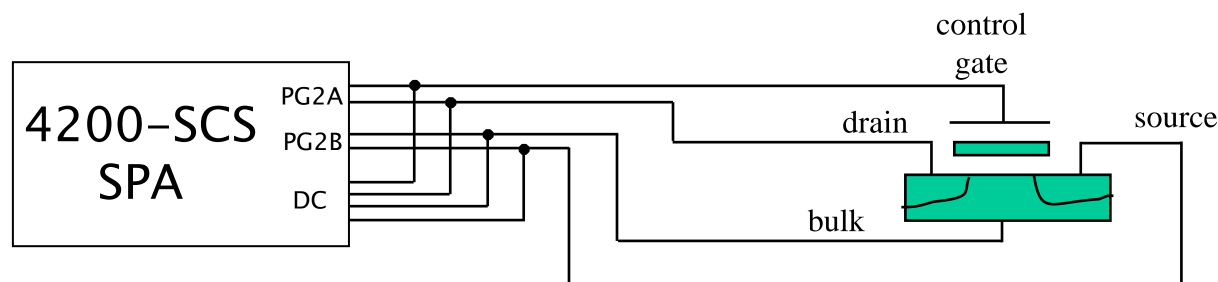
Alternate NAND Flash test setup



- Pulse and DC have output relays – open DC relays when Pulsing, open Pulse output relays when DC testing
- PG2 channels can be used as DC bias during program/erase
- Easy connect, less flexibility
- Pattern generation/multi-segment pulse capabilities of PG2 allow for program/erase cycle to be setup as one pattern and repeated n times for lifetime testing

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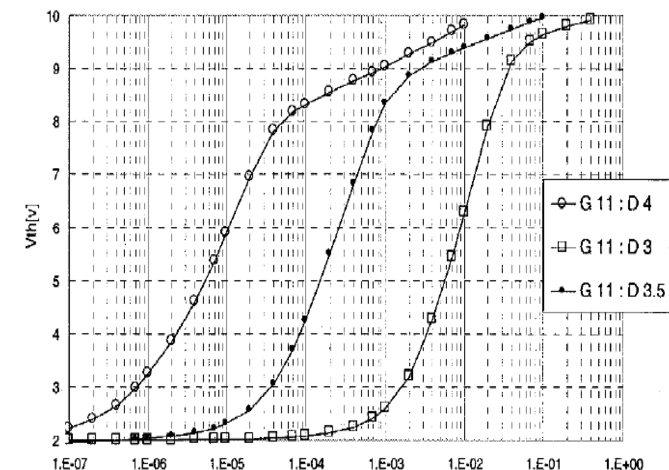
NAND Flash performance testing

Sample tests:

- Program characterization
  - Sweep program width, measure Vth between each program cycle, graph Vth vs. Program PW
  - Sweep program voltage, measure Vth between each program cycle, graph Vth vs. Program voltage
- Erase Characterization: similar to Program tests
- Disturb Test
  - Tbd for NAND

Vth vs. Program pulse width



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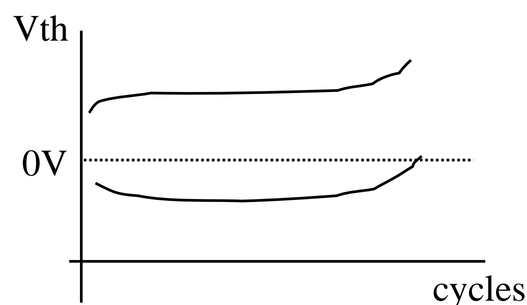
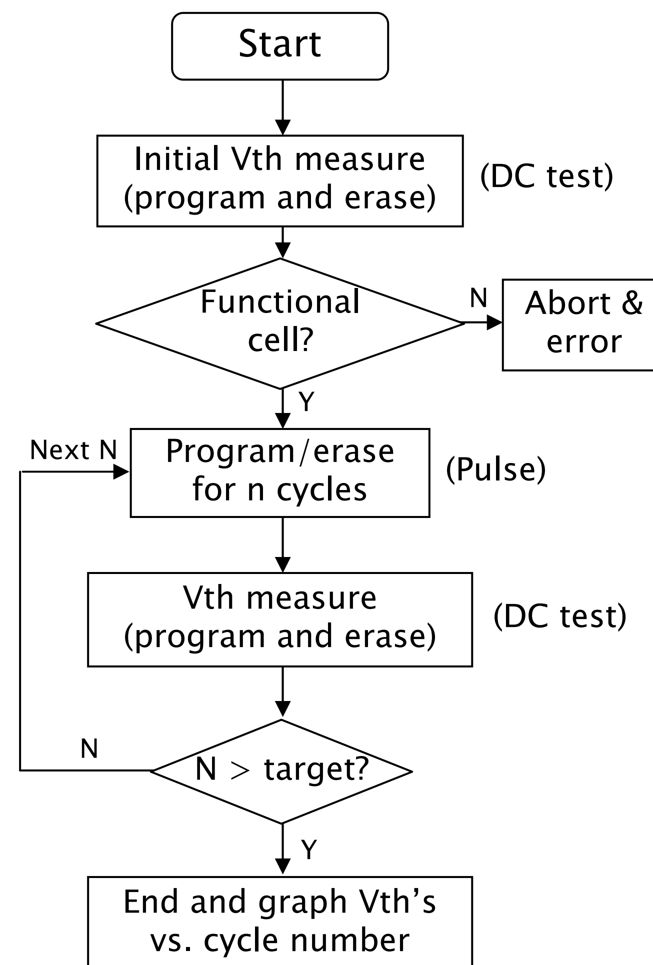
NAND Flash endurance testing

- Stress–Measure
- Stress: series of program/erase cycles
  - Each program/erase cycle is the same
  - User control of cycle specifics (pulse widths, voltages, pulse delays and synchronization
- Measure: test Vth at specific cycle points
  - User controllable: i.e. 3 measures per decade
- Graph Vth vs cycle number (log scale)





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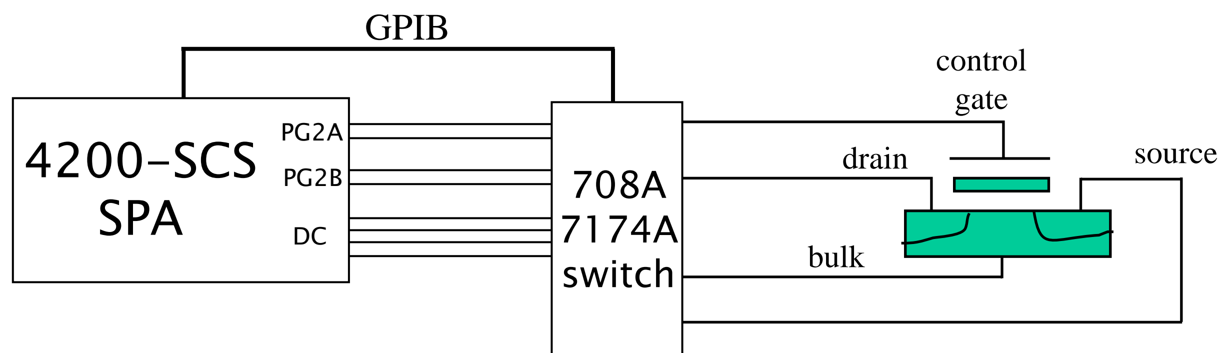
Proposed NOR Flash test setup



- Allows easy switching between Pulse and DC tests
- Solid-state relay on output of PG2 for lifetime testing (open drain on erase)
- PG2 channels can be used as DC bias during program/erase – minimizing switching
- Pattern generation/multi-segment pulse capabilities of PG2 allow for program/erase cycle to be setup as one pattern and repeated n times for lifetime testing (segment can control solid-state output relay)

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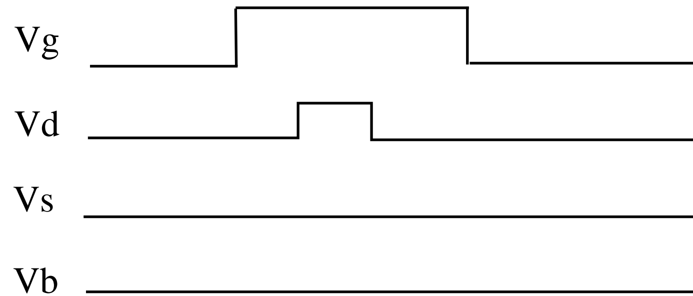
Typical NOR program/erase cycle

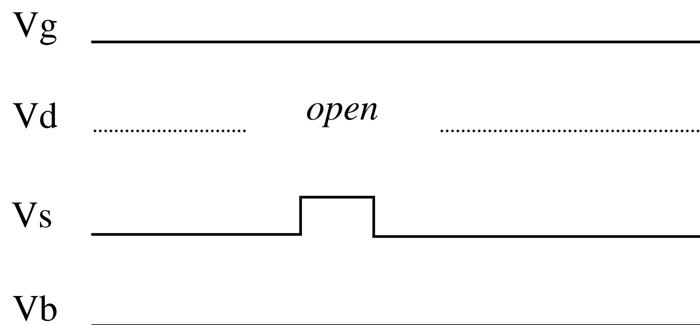
PROGRAM



Vg pulse capabilities
- ±10V
- min rise/fall = 100ns
- min pulse width = 100ns

Vd pulse capabilities
- ±20V
- min rise/fall = 100ns
- min pulse width = 250ns

ERASE



Vs pulse capabilities
- ±20V
- min rise/fall = 100ns
- min pulse width = 250ns

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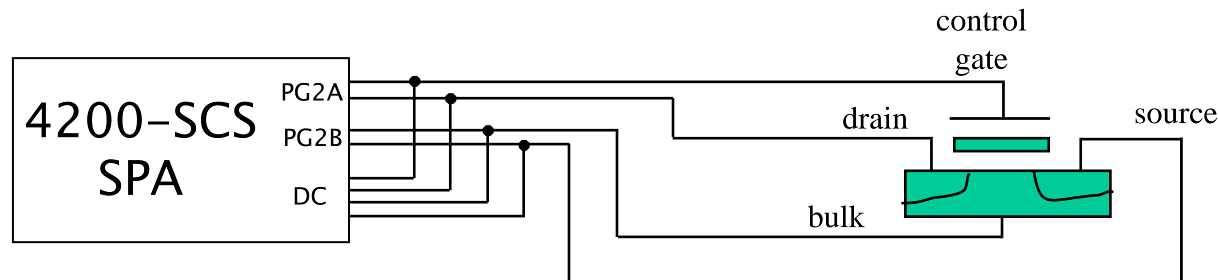
Alternate Proposed NOR Flash test setup



- Pulse and DC have output relays – open DC relays when Pulsing, open Pulse output (mechanical) relays when DC testing
- Solid-state relay on output of PG2 for lifetime testing (open drain on erase)
- PG2 channels can be used as DC bias during program/erase
- Easy connect, less flexibility
- Pattern generation/multi-segment pulse capabilities of PG2 allow for program/erase cycle to be setup as one pattern and repeated n times for lifetime testing

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NOR Flash performance testing

Sample tests:

- Program characterization
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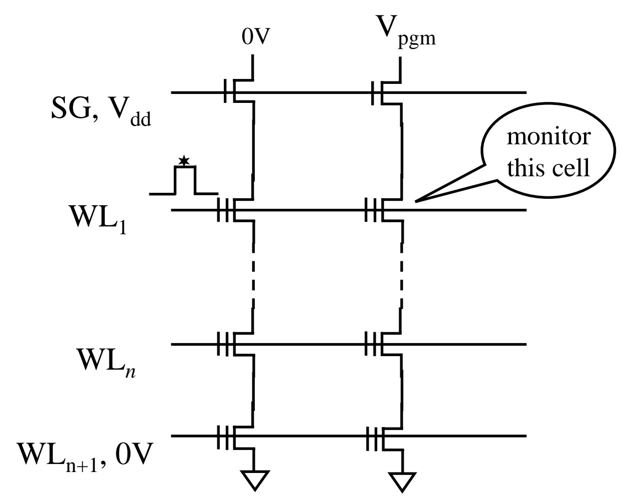
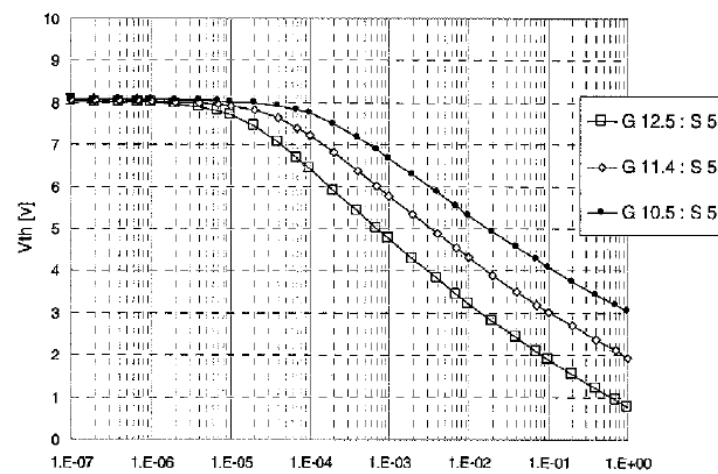
  - Sweep program voltage, measure Vth between each program cycle, graph Vth vs. Program voltage
- Erase Characterization: similar to Program tests
- Disturb Test



Vth vs. Erase Pulse Width



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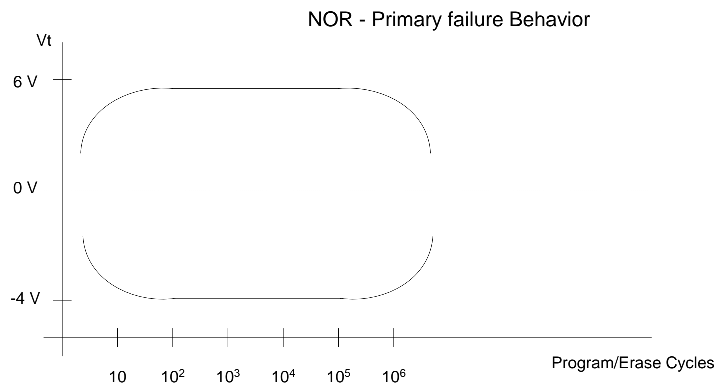

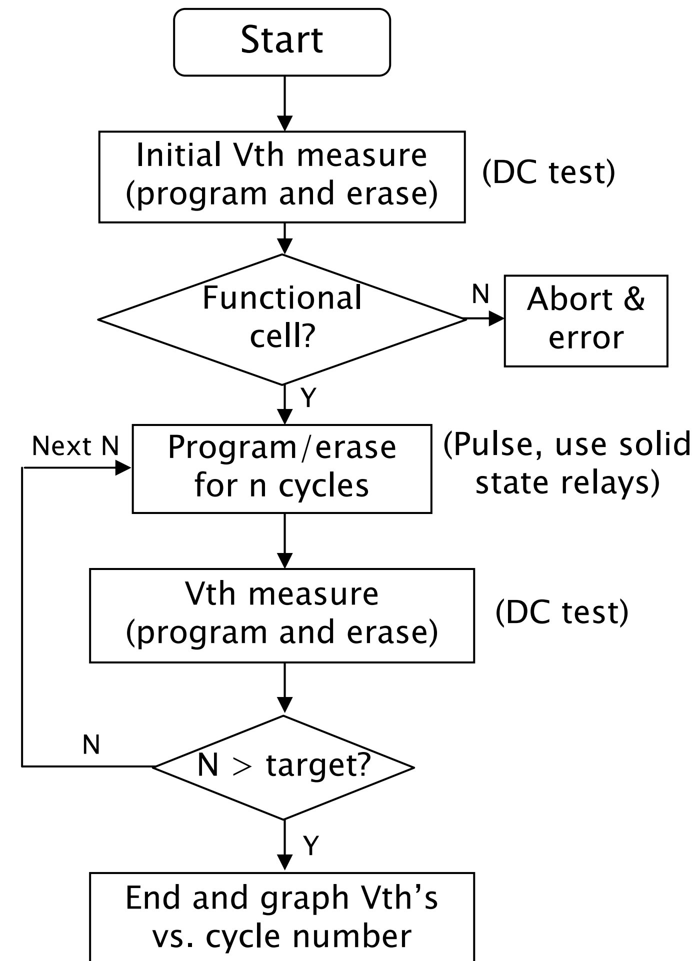

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END

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