Class 19: Memories-EEPROMs and FLASH

Topics:
1. DA2/DP Issues
2. Types of Non-Volatile Memories
3. EEPROMs / Flash
4. EEPROMs
5. FLASH
6. Baising
7. Embedded FLASH Chip
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Types of Non-Volatile Memories

ROM
- read only memory
- fusible-link ROM

EPROM (a.k.a. UV PROMS)
- electrically (erasable) programmable read only memory
- UV shown through quartz window to erase

EEPROM (E²)
- electrically erasable programmable read only memory

FLASH
- EEPROM-like, but entire array erasable at once

SONOS
- Silicon Oxide Nitride Oxide Semiconductor
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EEPROMs / Flash (Martin c.11)

Realized by using a floating gate transistor, in a double poly process

Advantages:
• user can readily change memory stored, as opposed to ROM
• flexible in terms of configurations

Disadvantages
• expensive process due to extra masks (dnwell, hvnwell, hvpwell, fpoly, etc.)
• design issues (programming, erasing, reading)
Program:
- Individual cell selected using pass transistor
- Source and BL low; PG put at high voltage (12V)
- Electrons transferred from SD region to floating gate, thus shifting Vt

Erase:
- Individual cell selected using pass transistor
- WL and BL high (12V); PG low (0V); SL floating
- Electrons transferred from floating gate to D, thus shifting Vt

Read:
- WL and PG held at VDD
- If PG has stored charge, the gate is below the Vt and no current flows
- If PG has no charge, the gate is above the Vt and current flows
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FLASH

Program:
- SL 0V; BL VDD; WL put at high voltage (12V)
- Current flow from S to D, injected to floating gate, thus shifting V
- HCI type programming

Erase:
- SL VDD; WL negative voltage; BL floating
- Electrons transferred from floating gate to source, thus shifting Vt

Read:
- SL 0V; WL VDD; BL 1V
  - If PG has stored charge, the gate is below the Vt and no current flows
  - If PG has no charge, the gate is above the Vt and current flows
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Baising

<table>
<thead>
<tr>
<th></th>
<th>WL</th>
<th>BL</th>
<th>SL</th>
<th>Body</th>
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<tr>
<td>PGM-HCI</td>
<td>MV</td>
<td>MV</td>
<td>GND</td>
<td>GND</td>
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<tr>
<td>PGM-FN (channel)</td>
<td>HV</td>
<td>float/gnd</td>
<td>float/gnd</td>
<td>GND</td>
</tr>
<tr>
<td>RD</td>
<td>VDD</td>
<td>SA</td>
<td>GND</td>
<td>GND</td>
</tr>
<tr>
<td>EE-FN1 (source)</td>
<td>GND</td>
<td>float</td>
<td>HV</td>
<td>float</td>
</tr>
<tr>
<td>EE-FN2 (channel)</td>
<td>NV</td>
<td>float/gnd</td>
<td>float/gnd</td>
<td>GND</td>
</tr>
</tbody>
</table>

Programming:

FN: Fowler-Nordheim tunneling
- electrons tunnel through tox potential barrier
- traps in tox cause electronic charge to remain in oxide
- 12V Vgs, 0V drain and source, 10^7 V/m
- low current
- good process control over tox needed

HCI: Hot Carrier Injection
- energetic electrons surmount tox potential barrier
- creation of “hot holes” which effect interface
- gate very high voltage, drain at high voltage
- 0.6um process, 12V Vgs, 6V Vds with a 5V part
- high current needed
- tox control not as critical