Embedded Flash – Driving Down the “Memory” Lane

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Outline

- SST Overview
- Automotive Semiconductor Market
- Automotive Semiconductor Growth Drivers
- Embedded Flash Usage in Automotive Microcontrollers
- Embedded Flash Requirements
- Embedded Flash Landscape
SST’s History

1989
SST Founded

1995
Went Public

2003
Annual Revenue $450M

2010
SST focuses on licensing for embedded Products. NOR Flash business absorbed by Microchip

2010
SST was Acquired by Microchip and became a wholly owned subsidiary

2013
SST Acquired Novocell, an OTP Company
Automotive Semiconductor Market

- Semiconductor content in cars
  - Luxury car: over $1000
  - Mid-range car: over $350
- MCU and Analog are the most dominant components
- Modern cars can have up to 80 ECUs (Electronic Control Units) on boards

*Source: IHS
Automotive Semiconductor Growth Drivers

- Growing global automotive market – BRIC countries
- Government requirements for safety and emissions
- Consumer need/want for increased safety, efficiency, infotainment, comfort & luxury
- Trend toward high-efficiency HEV and EV

Automotive Semiconductor Market is poised to grow at a CAGR of 9% for next five years*

*Source: STRATEGYANALYTICS
High Entry Barrier for Semiconductor Suppliers Due to:

- High degree of regulatory scrutiny and safety requirements
- Stringent zero-defect qualification processes
- Thorough understanding of failure mechanism
- Extensive design-in timeframes
- Long product life cycles
Automotive Market – Applications

- **Powertrain**
  - Engine and Transmission Controls, Starter, Alternator

- **Safety**
  - ABS, ESC, Suspension, Airbags, Power Steering, Tire Pressure, Brakes, ADAS, Traffic-Aware Cruise Control

- **Body and Convenience**
  - Light, Heating, AC, Door, Seat Controls

- **Infotainment**
  - Navigation, Multimedia Controls
Embedded Flash Advantages

- Embedded – Secure
- Fast communication between Memory and Logic
- Custom embedded Flash can be optimized for each application
- Lower BOM, and fewer components at the system level
Automotive Market Key Requirements and Usage for Embedded Flash

- **Low Failure Rate:**
  - 0 ppm (0.1 ppb) over ~15 years of lifetime

- **Data Retention**
  - ~15 years

- **Operating Temperature:**
  - -40°C to up to 150°C ambient (various grades)

- **Fast Code Execution:**
  - Random read access: 10 ns – 20 ns

- **High Endurance:**
  - 500K for data array and 1K for code array

- **High Density:**
  - 2 MB to 16 MB
## Embedded Flash Landscape

### Key drivers

<table>
<thead>
<tr>
<th>Technology</th>
<th>SST &amp; licensees and 100+ users</th>
<th>FSL</th>
<th>Infineon</th>
<th>ST Micro/FSL</th>
<th>Renesas, CY, Spansion,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low VCC, fast read capability</td>
<td>Yes</td>
<td>-</td>
<td>Need Vread &gt; 2V (SGOX – scaling challenges)</td>
<td>Need Vread &gt; 2V (to avoid over-erase)</td>
<td>-</td>
</tr>
</tbody>
</table>

### P/E

<table>
<thead>
<tr>
<th>Technology</th>
<th>SSI/FN to EG 100K-1M</th>
<th>SSI/FN to CG 10K-100K</th>
<th>SSI/FN to Channel, 10K-100K</th>
<th>CHEI/FN to channel 100K</th>
<th>FN/FN, HEI/FN, SSI/HHI, 1K-30K</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-0 VT window</td>
<td>&gt;10V</td>
<td>~3V</td>
<td>~6V</td>
<td>~3-4V</td>
<td>~4V</td>
</tr>
</tbody>
</table>

### Scaling, R&D

<table>
<thead>
<tr>
<th>Technology</th>
<th>28 nm</th>
<th>28 nm</th>
<th>28nm</th>
<th>40nm</th>
<th>28 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5T Poly FG &amp; EG</td>
<td>1.5T TFS</td>
<td>1.5T Poly FG</td>
<td>1T Poly FG</td>
<td>1.5T (1T,2T) ONO</td>
<td></td>
</tr>
</tbody>
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Flash Memory Summit 2015
Santa Clara, CA
# “Emerging” Memories

<table>
<thead>
<tr>
<th>Origin</th>
<th>Players</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCRAM</td>
<td>1960 – first patent filed&lt;br&gt;Samsung, Micron, Intel, STM&lt;br&gt;Foundries, Research Institutes, Others</td>
</tr>
<tr>
<td>MRAM</td>
<td>1988 – Magneto-resistive effects with thin films discovered&lt;br&gt;Samsung (Bought Grandis)&lt;br&gt;Hynix, Toshiba,&lt;br&gt;Everspin – Motorola,&lt;br&gt;Renesas – abandoned&lt;br&gt;Foundries, Research Institutes, Others&lt;br&gt;STT, Crocus, Avalanche</td>
</tr>
<tr>
<td>ReRAM</td>
<td>2000 (Various types)&lt;br&gt;Sandisk/Toshiba - Collaboration&lt;br&gt;Panasonic, Sharp, STM, Samsung, Hynix&lt;br&gt;Sony, Adesto (CBRAM)&lt;br&gt;Rambus (Bought Unity Semiconductor), Crossbar&lt;br&gt;Foundries, Research Institutes, Others</td>
</tr>
<tr>
<td>FeRAM</td>
<td>1952 – first work published, development began in 80s&lt;br&gt;Ramtron (Acquired by Cypress), TI, Fujitsu, Hynix, Samsung, Seiko-Epson</td>
</tr>
</tbody>
</table>
Note on Emerging Memories

- Embedded MRAM, ReRAM, CBRAM, FeRAM etc.
  - These technologies are promising, but we are not there yet
  - Automotive OEMs need several years of high-volume production data before a new technology can be used in automotive, due to failure rate and quality concerns
Automotive semiconductors are a growth engine of the semiconductor industry.

MCUs are a critical component in automotive ECUs, and embedded Flash is a key component in those MCUs.

Floating-gate-based embedded Flash is the most widely deployed non-volatile memory in automotive MCUs.

Emerging Memories are not yet ready for automotive applications.