The spread of Social Network Service (SNS) and cloud computing lead to dramatic change of our life style and business style. The data volume of digital media contents has become larger scale. In order to process the large data smoothly, high performance memories are required. On the other hand, low power consumption is a key factor for long battery life. FCRAM (Fast Cycle RAM) has challenged to deliver best balance between performance and power consumption for dedicated applications.

Mobile FCRAM is a high density and low power pseudo SRAM for mobile applications. The FCRAM appeared in 2000 as an alternative memory of low power SRAM which had been used for mobile phones, and at the time the Mobile FCRAM density was the industry's largest for RAM memories used in the mobile phones. It had contributed to the dramatic market expansion.

Consumer FCRAM is a Low Power SDRAM and suitable for digital TVs and digital video cameras that require high-speed data transfer for display and video processing. The FCRAM features low power consumption, high data bandwidth, high temperature of 125°C operation, and is optimized for SiP (System in Package). Recently market for digital media applications with enriched functions such as High Definition video and 3-D video is spreading rapidly, and the FCRAM is well positioned for that video processing applications.

Not only offering FCRAM products as a pure memory solution, Fujitsu also able to customize FCRAM core-based DRAM, and a SiP solution which containing ASIC/ASSP and FCRAM. Beyond FCRAM, Fujitsu Semiconductors offers a wide range of products to satisfy various requirements and applications.

For more information, please visit: http://www.fujitsu.com/global/services/microelectronics/product/memory/fcram/

* FCRAM is a trademark of Fujitsu Semiconductor Limited.
Consumer FCRAM (Low Power SDRAM)

Consumer FCRAM is a Low Power SDRAM suitable for digital consumer electronics that require high-speed processing of large-scale digital data such as video data or computer graphics data, limited power budget. Fujitsu provides Consumer FCRAM products in wafer form allowing FCRAM and SoC to be combined in a single package also known as SiP solution.

FCRAM Features

- Consumer FCRAM with 64-bit I/O features high data bandwidth, low power consumption and the world’s first 125°C operating temperature for standard DRAMs.
- High Temperature Operation up to 125°C
  - Maximum operating temperature of standard DDR3 is 85°C while that of Consumer FCRAM is 125°C. The extended temperature range allows FCRAM to be used in a SiP together with other high power rating SoC.
- High Data Bandwidth
  - With 64-bit I/O and operating at 216MHz frequency, an FCRAM delivers 3.46GByte/s data bandwidth for I/O interface due to no termination resistors and optional 1.2V I/O voltage.
- Low Power Consumption
  - Lower operating frequency doesn’t need termination resistors. FCRAM can reduce power consumption for I/O interface due to no heat through costly addition of heat-sink.

Feature Comparison between FCRAM and Standard DRAMs

FCRAM with 64-bit I/O operating at 200MHz enables high data bandwidth comparable to that of a DDR3 SDRAM at 800MHz. Lower operating frequency doesn’t need termination resistors. FCRAM can reduce power consumption for I/O interface due to no termination resistors and optional 1.2V I/O voltage.

<table>
<thead>
<tr>
<th>Memory Type</th>
<th>DDR3</th>
<th>DDR2</th>
<th>LPDDR2</th>
<th>LPDDR</th>
<th>FCRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus I/O</td>
<td>x16</td>
<td>x8</td>
<td>x8</td>
<td>x4</td>
<td></td>
</tr>
<tr>
<td>Core Voltage</td>
<td>1.8V</td>
<td>1.8V</td>
<td>1.8V</td>
<td>1.2V</td>
<td></td>
</tr>
<tr>
<td>I/O Voltage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max Operating Temperature</td>
<td>85°C/105°C</td>
<td>85°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADD/CMD Input</td>
<td>SDR</td>
<td>SDR</td>
<td>SDR</td>
<td>SDR</td>
<td></td>
</tr>
<tr>
<td>Operating Frequency (Data Transfer Rate)</td>
<td>800MHz (1066Mbps)</td>
<td>400MHz (800Mbps)</td>
<td>333MHz (666Mbps)</td>
<td>266MHz (533Mbps)</td>
<td>200MHz (400Mbps)</td>
</tr>
<tr>
<td>Data Bandwidth</td>
<td>3.2GByte/s</td>
<td>1.6GByte/s</td>
<td>4GByte/s</td>
<td>4GByte/s</td>
<td>3.2GByte/s</td>
</tr>
<tr>
<td>Dqs on RAM</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>I/O Interface</td>
<td>SSTL</td>
<td>CMOS</td>
<td>CMOS</td>
<td>CMOS</td>
<td></td>
</tr>
<tr>
<td>Termination</td>
<td>ODT (On Die Termination)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

FCRAM Product Lineup

- 512Mbit FCRAM
  - Organization: 2Mword x 64bit x 4bank
  - Interface: Low Power DDR
  - Supply Voltage: Core Voltage: 1.8V, I/O Voltage: 1.8V
  - Clock Frequency: 216MHz (Tj: 125°C)
  - Data Bandwidth: 3.46GByte/s (Tj: 105°C)
  - Junction Temperature: -10°C to +125°C

- 1Gb FCRAM
  - Organization: 4Mword x 64bit x 4bank
  - Interface: Low Power DDR
  - Supply Voltage: Core Voltage: 1.2V, I/O Voltage: 1.8V
  - Clock Frequency: 216MHz (Tj: 125°C)
  - Data Bandwidth: 3.46GByte/s (Tj: 125°C)
  - Junction Temperature: -10°C to +125°C

Benefits of 125°C-Rated FCRAM

Consumer FCRAM supports operating temperatures up to 125°C allowing FCRAM to be used in SiP with a high power rated SoC. In case of SiP with standard DRAM, constrained by the lower temperature rating of conventional memory, limits its performance and hence applications. By extending the operating temperature up to 125°C, SiP with 125°C-rated FCRAM can be used for high performance consumer electronics such as digital television and camcorders.

- **125°C-Rated FCRAM is the Only Solution**
  - Resolves thermal design issue and eliminates worry of overheating, high power and high performance SiP become feasible.
  - Reduced cost and necessity of heat sink or heat spreader.

Case Study of SiP Thermal Design

125°C-rated Consumer FCRAM resolves thermal design issues on SiP below shown.

- Figure (a): With an SoC of high power consumption, the SiP temperature can rise to 125°C, however standard DDR3 can only operate up to 85°C so this configuration is limited only up to 85°C.
- Figure (b): SiP can operate at 125°C by dissipating excess heat through costly addition of heat-sink.
- Figure (c): SiP operates up to 125°C without heat-sink by using 125°C-rated FCRAM.

FCRAM Support Policy

While standard DRAMs are increasing their memory density for PC and smart phone, FCRAM provides the optimal memory density and data bandwidth for digital consumer applications.

- **SiP Solutions**
  - Optimized design for high performance SiP
  - SiP solutions possible with ASIC/ASSP and FCRAM
- **Wide I/O memory**
  - Continue development of x64-bit products
  - x512-bit products are under study
  - Reviewing three-dimensional stack technology such as CoC (Chip on Chip) suited for wide I/O
- **Custom FCRAM**
  - Customization of DRAMs that are optimal for customer applications

FCRAM Target Area

- x512 FCRAM
- x64 FCRAM
- RDRA & LPDDR3
- DDR2 & LPDDR2
- DDR4 & LPDDR4
- JEDEC TSV-wide I/O

* Temperatures shown in () of DDR3, FCRAM, and SoC indicate maximum operating temperature as examples.

* Please contact our sales department for information on the latest roadmap.
SiP stands for "System in Package", a technology and a product containing different semiconductor devices, such as memory devices and SoC (System on Chip) in a single package. Two cases of memory system configuration mounted on PCB are shown below.

Advantages of SiP

SiP resolves the following issues on miniaturization, low design risk with short TAT, and cost reduction.

- **Miniaturization**
  By minimizing mounting area on PCB, customer’s products can be smaller and more compact.

- **Low Design Risk and Short TAT**
  Since PCB design and evaluation for high-speed DRAM interface is not necessary, engineering resources and design risk can be reduced. Design time can be shortened.

- **Cost Reduction**
  Smaller PCB size cost less. In addition, components cost can be reduced since termination resistors are eliminated.

<table>
<thead>
<tr>
<th>Factor</th>
<th>On-board DRAM+SoC</th>
<th>FCRAM+SoC (SiP)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PCB Size</strong></td>
<td>Worse (Larger)</td>
<td>Better (Smaller)</td>
</tr>
<tr>
<td><strong>PCB Design</strong></td>
<td>Worse (More difficult)</td>
<td>Better (Easier)</td>
</tr>
<tr>
<td><strong>Passive Component Cost</strong></td>
<td>Worse (Higher)</td>
<td>Better (Lower)</td>
</tr>
</tbody>
</table>

Density | Configuration | Voltage | Access Time | Burst Mode Frequency | Burst Mode Access Time |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>128Mbit</td>
<td>88x16</td>
<td>1.8V</td>
<td>95ns</td>
<td>33MHz</td>
<td>9ns</td>
</tr>
</tbody>
</table>

FCRAM products meet the environmental regulation and all new products are approved as "Green Products". FCRAM low power feature contributes to the reduction of CO2 emission.