Flash Memory Market Trends

Flash memories are expanding into promising new areas of demand, including digital TVs and handheld PCs, and are the driving force in the strong cellular phone market. The next area of development is expected to be NAND memories.

Introduction

Since 1993, when FUJITSU concluded a cooperative business agreement for flash memories with AMD, we have been the leading company in the flash memory market. This article provides a brief analysis of market trends in the quickly growing flash memory market.

Overview

Buoyed by powerful demand from cellular telephone manufacturers, the flash memory market has grown at an astonishing pace. This growth trend is still strong, and with the emergence of promising new areas of demand such as digital TVs and handheld PCs, more growth is expected in the future.

Market Trends

The primary driving force behind the sustained rapid growth of the flash memory market has been the cellular telephone market. In addition, the multifunction cellular phone is now building demand for higher memory capacities.

Figure 1 (see p. 4) shows trends in the size and composition of the semiconductor market. The proportion of the overall semiconductor market represented by flash memories has grown from 2% in 1998 and earlier, to 3% in 1999, and 5.2% in 2000, and is expected to reach 6.4% by 2002.

Figure 2 (see p. 4) shows the growth of the semiconductor market in financial terms. The market in 1999 was $4,560.5 million, but in 2000, the value jumped 133.2% to $10,635.6 million. By 2003, the market is projected to reach $15,229.0 million. The causes of the rapid growth between 1999 and 2000 were the strong growth of the cellular telephone market, digital consumer electronics, the emergence of new markets, such as networks, and a shift to high-capacity memories combined with a shortage of supply that led to higher prices.

Figure 3 (see p. 5) shows trends in market composition by geographic region, illustrating that Japan's market is continuing to show strong growth. We at FUJITSU believe this is due to demand for memory in digital still cameras and digital consumer electronic products, such as DVDs and games, as well as to the growth of i-mode phones (wireless web phones).
Figure 1. Semiconductor Market Size*  

Figure 2. Flash Memory Market Size*  

*WSTS (World Semiconductor Trade Statistics)
Europe also shows strong growth, reflecting the rapid growth of cellular phones, as well as the startup of the set-top box market. More than half of all cellular phones use the European Global System for Mobile Communication (GSM) specifications and, with two of the top three cellular phone manufacturers in the world, the region is expected to continue to show stable growth.

The North American market accounted for more than one third of the market in 1997, but since that time, its share has slowly dwindled. This is due to 25% cellular phone usage (half the level of Japan), as well as the lack of much demand for high-end models with additional functions. Network growth remains strong, however, and there are recent signs of a reversal of this trend.

The market share of the Asian region is falling, not because the market itself is contracting, but because of higher growth in other regions. If China and India achieve cellular phone usage rates comparable to Japan, the growth in this region will be tremendous.

**Market Forecast by Memory Type**

Flash memories come in two basic types: NOR and NAND memories, with NOR memories accounting for 90% of the present market. NOR memories store programs, and NAND memories store data. With the growing popularity of digital consumer electronics, the ratio of NAND memories is expected to increase. NAND memories are used in products such as Digital Still Cameras (DSC), Digital Video Cameras (DVC), and silicon audio devices, for which demand is expected to grow very rapidly.

The size of built-in memory in DSC and DVC products is unlikely to grow because built-in memory alone cannot keep pace with the increased capacity requirements of high-end models, and such products are expected to continue to use external recording media. There is also a trend toward using memory cards for cellular phones. Both situations contribute to a scenario for significant growth in the NAND market. In 1999, the NAND market was 12.6% of the total revenue, but FUJITSU expects this share to grow to 19.9% by 2005.

Figure 4 (see p. 7) shows the market composition by NOR- and NAND-type memories. Figure 5 (see p. 7) shows a comparison of growth rates. On a bit-unit basis, the growth of the NAND memory is clearly higher, but on a revenue basis, there is virtually no difference. This is because the NAND memory is likely to experience greater drops in price.
Market Segment Trends

One characteristic of flash memories is their potential for use in a broader range of applications than other memory devices. The list includes cellular phones, as well as handheld PCs, auto navigation equipment, digital still cameras, printers, and personal computers. It seems that there are few products that do not have a flash memory. Here we will discuss trends in cellular phone applications, which represent a large proportion of the market.

Background

The growth in production of flash memories for cellular phones is due both to the growth of the cellular phone market itself and to the addition of more functions to the average phone. In Japan, in particular, the popularity of Internet-capable phones and color displays has grown, leading to demand for greater flash memory capacity.

Table 1 shows the development of the average built-in memory capacity in cellular telephones of each standard.

Current Japanese Market

In Japan, 32 M-bit was the most common capacity for cellular phones in early 2000. But by the latter half of the year, most phones used 32 to 64 M-bit flash memories. By the start of 2001, 48 M-bit was considered the minimum requirement. High-end Wideband Code Division Multiple Access (W-CDMA) phones now require 128 M-bit of memory. Only a few manufacturers can produce NOR memories larger than 64 M-bit, and as yet, there are no 128 M-bit low-voltage memories on the market.

NOR-type 128 M-bit memories are expensive and in short supply, and it is often necessary to use two 64 M-bit memories or partially substitute with NAND memories. In either case, the size requirement is greater than for a single 128 M-bit NOR chip. If a NAND memory is used, the solution will likely require two Multi-Chip Packages (MCP) including NOR + SRAM and NAND + FCRAM combinations.

<table>
<thead>
<tr>
<th>Table 1. Average Built-In Cellular Phone Memory Capacity (by standard)</th>
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<tr>
<td>PDC</td>
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<td>GSM</td>
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<td>cdmaOne</td>
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FUJITSU Estimates

<table>
<thead>
<tr>
<th>Table 2. Average Built-In Cellular Phone Memory Capacity</th>
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<tr>
<td>Asian GSM</td>
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<td>TDMA</td>
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FUJITSU Estimates
**European Market**

Europe, like Japan, is witnessing the coming of the Internet-capable cellular phone, but at a far slower rate of growth and with far fewer content providers than in Japan. A sudden shift to high-capacity phone models, such as happened in Japan, therefore, seems unlikely in Europe. The average built-in memory capacity of Personal Digital Cellular (PDC) and GSM phones was three-to-one in late 2000, and the PDC phone still requires 2.3 times as much memory in 2001.

**North American and Asian Markets**

In North America and Asia, demand for high-performance cellular phones is virtually nonexistent. Low-capacity models predominate, the Time Division Multiple Access (TDMA) phones in North America and GSM phones in Asia, and any shift toward high memory capacities in these regions is expected to be gradual.

Table 2 (see p. 6) shows the development of average memory capacity in the Asian GSM and TDMA phones.
Delivery Volume Forecasts for Cellular Phones

Next we will look at trends in delivery volumes, both the optimistic and pessimistic scenarios. Table 3 (see p. 9) shows volume forecasts for the cellular phone market. The best-case estimate is based on the following assumptions:

- Stimulation of replacement demand by the transition to W-CDMA/cdma2000 phones
- Growth of Internet-capable phones and anticipation of models with built-in Java
- Higher usage in China, India, and Latin America
- Aggressive production planning by terminal manufacturers

At the same time, the worst-case estimate is based on the following points of view:

- Cellular phone inventories are starting to build up
- High costs of next-generation phone frequency licenses in Europe are placing pressure on carrier profitability
- Unit phone costs will rise in the transition to W-CDMA/cdma2000 (from almost free to the $200 level)
- Usage rates are already high in Japan and some parts of Europe
- In Asia and other regions where cellular phones are just starting to catch on, cellular phones are not free or almost free, restricting the speed of growth
- Future trends in China, India, and Latin America are still unknown

The dampening of the global economy as a result of the U.S. economic slowdown

In the first half of 2000, the optimistic outlook predominated, but pessimistic voices began to increase by the second half of 2000. And by the first half of 2001, it became the majority point of view. Completion of the infrastructure for the next generation of cellular phones is now expected to take longer than initially estimated, and many believe that the rate of growth of demand in Asian markets will not reach initial expectations. FUJITSU predicts that deliveries in 2001 will be 485 million units, a much more conservative figure than the optimists had predicted.

Besides cellular phones, other applications expected to grow include automotive navigation, digital television, digital cameras, and handheld PCs. The forecasts for these markets have a substantial effect on the estimated growth of the flash memory market. Digital television and handheld PCs, in particular, are markets of the future and involve many unknown factors. FUJITSU expects these products to show strong growth, but not to surpass the level of the cellular phone.

Figure 6 (see p. 10) shows the market trend for each type of application. As the graph shows, FUJITSU believes that the relative share of cellular phone applications, including PHS, pagers, and cordless phones, will continue to grow. Conversely, it could be said that we are taking a conservative view of the future growth in the market for digital consumer electronics products.

“...applications expected to grow include automotive navigation, digital television, digital cameras, and handheld PCs.”
Future Developments

Industry experts agree that the flash memory market will continue its rapid growth in terms of volume and bit capacity. As mentioned earlier, the cellular phone and digital consumer electronics segments are expanding and increasing demand for higher memory capacity. The sources of flash memory demand can be described as follows:

- Shift to higher capacity
- Strong growth in applications, particularly for cellular phones
- Emergence of new market segments
- Use of composite memory

In financial terms, growth may be slowed by increased supply competition and falling prices due to multi-level cell technology design. This technology is restricted, however, in that it cannot be used in applications with low-voltage systems, preventing any steep drop in prices. We therefore agree with the WSTS forecast that growth rates will gradually slow, but that healthy growth will be maintained. In particular, we foresee continued stable growth for NOR memories. Because NAND memories are more like commodities, we expect the price drop to be steeper with strong growth in bit volume, but no more than gradual growth in financial terms.

We at FUJITSU will continue to take on the challenge of further technological innovation and to maintain a strategic relationship with our customers in order to maintain our position as a leader in the continued growth of the flash memory market.

Table 3. Estimated Cellular Phone Market Growth

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
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<tr>
<td>FUJITSU Forecast</td>
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<td>12.10%</td>
<td>19.16%</td>
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<tr>
<td>Optimistic Estimate</td>
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<td>72,000</td>
<td>90,000</td>
<td>103,000</td>
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<td></td>
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<td>35.80%</td>
<td>30.91%</td>
<td>25.00%</td>
</tr>
<tr>
<td>Pessimistic Estimate</td>
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<td>48,000</td>
<td>50,500</td>
<td>54,000</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>8.64%</td>
<td>9.09%</td>
<td>5.21%</td>
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</tbody>
</table>

FUJITSU Estimates
Figure 6. Market Growth by Application (FUJITSU estimates)