

# **SINGAPORE'S ELECTRONICS INDUSTRY - FACING CHALLENGES, BUT FIRST MOVER ADVANTAGES**

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## **S U M M A R Y**

The electronics industry is a key economic engine for Singapore, accounting for 43% of domestic exports in 2003, 40% of total manufacturing output, and providing employment to about a quarter of the total manufacturing labor force. The sector played a central role in Singapore's phenomenal economic growth in the 1980s and 1990s, but the sharp downturn in global electronics demand in 2001-2002 raised concerns that Singapore had become overly dependent on electronic exports as a source of growth.

Two main trends have marked the sector since the mid-1990s: the fragmentation of electronics production across East Asia together with the acceleration of Singapore's loss of competitiveness in lower-end assembly operations, as overall wages in Singapore have risen. The majority of consumer electronics and basic IT assembly operations have moved to lower wage countries, most notably Indonesia, Malaysia, and China, and the sector's relative importance as a source of exports has declined since 1998. In 2003, electronics exports accounted for 53% of non-oil domestic exports, compared to 69% in 1998. The restructuring of Singapore's electronics industry is also reflected in Singapore's share of U.S. electronics imports, which fell sharply from around 13% in early 1997 to stabilize at around 6% since 2000. Total investment, while still strong, fell nearly 10% in 2003, but accounted for over half total manufacturing investment.

Singapore remains a major center for electronics production, now focused in more capital-intensive segments like semiconductors and disk-drive production and in R&D and product development. While making concerted efforts to diversify sources of manufacturing growth, officials continue to see the electronics industry as an important source of economic growth. Indeed, a key mission of Singapore's investment promotion agency, the Economic Development Board (EDB), remains "to develop Singapore into a world-class electronics and precision engineering hub for manufacturing solutions and high value-added components".

The electronics sector in Singapore includes subsidiaries of large multinational firms (EDB's efforts over the past 30 years have attracted nearly every player in the electronics industry to Singapore), a number of large home-grown firms (Chartered Semiconductor, Creative Technology, Venture Corp.) as well as a range of competitive small-cap firms supplying components to the major producers. Many of these nimble smaller suppliers have followed their MNC clients as they have moved operations overseas. As part of its strategy of securing new investment in the sector, EDB has taken equity stakes in most large semiconductor wafer fabrication projects in Singapore. The government also maintains large stakes in Chartered and in Singapore Test and Assembly Services (STATS).

While Singapore holds few inherent long-term advantages as a production center over China or other lower-cost East Asian locations, it does retain a large installed production base, a host of first-mover advantages, and proactive government policies. Many analysts therefore believe Singapore is well-positioned to remain an important center for the electronics industry. At the

same time, they expect the share of electronics output in total GDP and total employment to decline, as Singapore-based facilities become more focused on R&D and product development, with a core of high-end manufacturing.

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*Note: This report is available at the Embassy's Internet site, <http://singapore.usembassy.gov/>*

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### **Growth of the Electronics Industry**

The electronics industry in Singapore was an emerging industry in the late 1960s, with foreign companies coming to Singapore to set up assembly plants for products such as transistors and low-end consumer electronics. The industry led Singapore on a growth path and provided employment to almost one-third of the labor force. Early investors included National Semiconductor, Texas Instrument, Hewlett Packard, Philips, Matsushita and STMicroelectronics, all attracted mainly by Singapore's low production costs.

From the early 1980s to the early 1990s, Singapore became a key manufacturing base for original equipment manufacturers (OEMs) as production costs increased in the OEMs' home base. The Singapore Government encouraged the sector's development through investments in state-owned enterprises like Chartered Semiconductor, NatSteel Electronics. A host of smaller private-sector Singapore firms emerged, many as suppliers to the MNCs, but others as innovators themselves (Creative Technology and its soundcards). In the 1990s, several large contract assemblers grew, including Venture and NatSteel Broadway. By the mid-1990s, electronics was contributing over half the economy's manufacturing output, up from 23.6% in 1985 and 10.7% in 1975.

**TABLE: ECONOMIC CONTRIBUTION BY ELECTRONICS INDUSTRY**

	<u>Real GDP Growth %</u>	<u>Electronics Output as % of Total Output</u>	<u>Manufacturing % Employment in Electronics</u>
1988	11.1	38.7	34.8
1990	7.3	39.1	34.9
1995	8.8	51.4	34.3
1996	7.0	50.8	34.9
1997	8.5	50.5	33.8
1998	-0.9	50.1	31.7
1999	6.4	52.1	21.2
2000	9.4	51.3	29.7
2001	-2.4	45.0	28.4
2002	2.2	42.2	26.7
2003	0.8 (est.)	40.0	27.1 (est.)

## Electronics A Driver of Growth

The electronics sector remains the most important pillar of Singapore's manufacturing base. In 2003, it accounted for an estimated 40% of Singapore's total manufacturing output, way ahead of the three other leading manufacturing sectors: chemicals (26%), engineering (14.8%) and biomedical sciences (7-8%). But the sector's relative importance as a source of exports has declined since 1998, due in part to the cyclical downturn in the industry as well as increased non-electronics exports, particularly pharmaceuticals. In 2003, electronics exports accounted for 43% of domestic exports and 53% of non-oil domestic exports; chemicals represented 17% and 21%, respectively. This contrasts with 1998, when electronics domestic exports peaked at 60% of total domestic exports, and 69% of total non-oil domestic exports. The table below offers a comparative view of electronics exports between 2000-2003.

**TABLE: DOMESTIC EXPORTS OF ELECTRONICS**

	<u>2000</u>	<u>2001</u>	<u>2002</u>	<u>2003</u>
Total (S\$ million)	74.4	59.0	57.0	113.5
Percentage change (%)	11.8	-14.5	1.9	15.1
 (S\$ million)				
Integrated Circuits	20.0	13.4	12.0	16.0
Parts of Personal Computers (PCs)	13.1	11.7	11.7	10.9
Disk Drives	16.0	14.6	15.8	16.7
PCs	3.7	2.7	1.7	1.2
Telecom Equipment	3.2	2.1	2.1	2.1
Others	18.5	14.4	13.8	13.1
 (% Share of Domestic Electronics Exports)				
Integrated Circuits	26.9	22.8	21.1	28.0
Parts of Personal Computers (PCs)	17.6	19.8	20.5	19.1
Disk Drives	21.5	24.8	27.6	29.2
PCs	4.9	4.6	2.9	2.2
Telecom Equipment	4.3	3.6	3.7	3.8
Others	24.8	24.4	24.2	22.9

*Note: US\$1 equivalent to S\$1.73(2000), S\$1.85(2001), 1.74(2002), S\$1.70 (2003)*

Investment in the electronics sector totaled US\$4.2 billion in 2003, or 56% of the total amount committed by both foreign and local companies. The stock of foreign direct investment (FDI) in the sector reached US\$20 billion in 2000, accounting for 50% of manufacturing FDI. The electronics sector has also dominated expenditure on R&D, accounting for nearly 30% of the total amount of US\$1.8 billion in 2001, while the up-and-coming biomedical sector took up a mere 9% of the total.

In 2003, the industry employed 85,000 persons, down from 88,500 in 2002, or about 26.7% of total manufacturing employment. This is far ahead of the next largest employer, the transport equipment sector, which represented 13.3% of manufacturing employment.

## Dependence A Vulnerability

The downside of the dependence on electronics for such a large share of output and exports was brought home in 2001, when Singapore suffered a sharp economic recession. The 2001-2002 downturn in global electronics demand (global sales of semiconductors plunged 34% in 2001) saw Singapore's domestic exports of electronics down 20% to S\$59 million (US\$32 billion at then current exchange rates) in 2001 (the U.S. absorbs 20% of Singapore's electronics shipments). Shipments were down in all segments of the electronics industry. Exports of electronics fell further in 2002, to S\$57 billion (US\$32 billion at end-2002 exchange rates), or 25% below their level in 2000 and 10% below the 1997 level.

### Electronics Trade (Percent Share)

	<u>CY 2001</u>	<u>CY 2002</u>	<u>CY 2003</u>
Electronics Exports:			
As a percentage of Total Exports	52.6	52.1	49.7
To U.S. as percentage of Total Exports	11.6	10.9	9.7
To U.S. as percentage of NODX	26.2	24.7	21.5
To U.S. as percentage of Electronics Exports	22.1	20.9	19.6
Electronics NODX as percentage of NODX	61.0	57.9	52.9

*Source: IE Singapore*

## Challenges

Several trends pose challenges for Singapore's status as a preferred electronics production center. One is the quickening pace of technological change and price compression within the electronics industry. Companies need deep pockets to stay ahead of the pack technologically, yet fierce competition has compressed margins, leading firms to zealously cut costs while making it even harder for weaker firms to fund needed R&D. These developments have hit some Singapore firms, such as Chartered Semiconductor (see section on Integrated Circuits/Semiconductors). Other Singapore firms, such as Venture Corp and Creative Technology, have done better.

The imperative to lower costs has encouraged another trend -- the fragmentation of production in the electronics industry, both geographically and towards a model based largely on contract manufacturing. Looking to cut costs, major MNCs now outsource most of their production and even design work to contract manufacturers, whose own production is generally concentrated in low cost locations. Singapore has both benefited and suffered from this trend. Several large contract manufacturers are Singapore-based, although only one, Venture Corp., has any assembly operations in the country. Several other local contract manufacturers have been bought by larger foreign competitors since 2000.

Fragmentation and the emphasis on contract manufacturing have accelerated decisions by some MNCs in Singapore to cease assembly operations in the country, a development reinforced by another trend, Singapore's loss of competitiveness in labor-intensive assembly operations. Over the 20 years, wage levels in Singapore have risen close to developed country levels: average monthly income increased from S\$568 (US\$265.27) in 1980 to S\$3,114 (US\$1,806.26) in 2000. The loss of competitiveness first came in such areas as printed circuit board assembly and consumer electronics, and more recently in PCs, peripherals, and telecom equipment. MNCs transferred production facilities out of Singapore, especially to Indonesia, Malaysia, and China; Siemens, Philips, Panasonic, Sanyo, Fujitsu, Western Digital and Maxtor are a few examples. With the scaling down of production facilities in Singapore, operations in Singapore are largely focused on management, R&D activities, and some high-end, capital intensive production processes.

Efforts to cut costs, including a search for lower wage levels, have provided considerable lift to China's rapid rise as a production base for electronics MNCs. This trend, which has taken a major bite out of Singapore's share of the global electronics pie, is likely to continue. Singapore officials believe that China poses a major competitive challenge at all levels of the industry, including high-tech wafer fabrication as well as R&D, design, and other areas where Singapore had long assumed it would remain well-positioned to compete. For example, 2002-2003 saw several MNCs, including Honeywell, announcing plans to transfer management and/or support functions to China.

Aside from trends within the electronics industry, Singapore faces other challenges, both external and internal. Political instability and concerns about terrorism have resulted in a less attractive investment climate in some ASEAN countries. For example, Sony's decision to close its production facilities in Indonesia also affects Singapore, given production patterns whereby many products pass through Singapore before final shipment.

Internally, although many lower-skilled jobs have been lost, the electronics sector in Singapore faces a shortage of skilled workers. As of late 2003, over 3,500 jobs were on offer in the electronics sector, but many Singaporeans have been reluctant to take shift work in the industry. As a result, many production line workers are foreign (mainly Malaysian). A survey by the Infocomm Development Authority suggests Singapore will need about 10,000 skilled IT workers per year to sustain growth in the electronics sector, but will have to look abroad to find many of individuals.

### **Government's Response and Role**

The Government has responded to these varied challenges by recognizing that Singapore cannot compete in low-cost assembly operations and working to reinforce Singapore's attractiveness as a center for high-end manufacturing and R&D. Officials see semiconductor manufacturing, the manufacturing of semiconductor production equipment, disk drive production, and the assembly of leading-edge products like LCD and plasma displays as priority areas where Singapore can retain its competitive position. The "Background: Industry Profile" section examines these and other industry segments in greater detail.

Singapore's investment promotion agency, the Economic Development Board (EDB), works aggressively to encourage existing industry players to reinvest in Singapore and to attract new foreign investment. Besides business-friendly regulatory and labor policies and a range of investment incentives, Singapore also provides special incentives directed at high-tech firms, such as the Initiatives in New Technology, Research Incentive Scheme and Technopreneur Investment Incentive. EDB also acts as a co-investor, taking stakes in high-profile new ventures, as it has with several of the wafer fabrication plants, including the new United Microelectronics' 12-inch wafer fab.

Officials place special emphasis on attracting electronics MNCs to set up R&D operations in Singapore, with proactive policies to attract expatriate talent and robust protections for intellectual property rights, enhanced further by the US-Singapore Free Trade Agreement. In 2001, according to the Agency for Science, Technology and Research, public R&D expenditure in the electrical and electronic sector reached US\$185.5 million, accounting for 35% of total R&D expenditure in this sector. Nevertheless, total private sector spending on R&D remains low.

The Government has taken measures to reduce labor costs, such as by lowering the mandatory pension contribution rate; average monthly wage levels in the sector have fallen slightly since 2000. In collaboration with Government educational institutions, EDB has also initiated efforts to improve the supply of skilled manpower for the electronics sector. For example, in 2000, EDB launched a training program in conjunction with the two main Singapore universities to train engineers specializing in digital signal processing for multimedia and info-communication. Incentives are given to companies to encourage development of manpower skills under the Initiatives in New Technology incentive. In 2003, the Government established the Workforce Development Agency to boost workforce training programs.

## Outlook

The near term outlook for Singapore's electronics sector is bright. Demand is robust, and the sector is once again the economy's star performer, with exports up 5.1% year-on-year in 2003, reversing two consecutive years of declines. Most analysts offer strong growth forecasts for 2004, seeing potentially huge semiconductor demand within Asia itself (especially China) driving growth in the medium term. Longer term, many analysts are cautiously optimistic Singapore will be able to retain, and even enhance, its position as a leading electronics production center. While acknowledging the competitive challenges faced by the industry in Singapore, they see the country retaining a number of significant advantages, including an important "first mover" advantage.

Industry players say that like Singapore's past success, its future success depends on a combination of forward-thinking Government planning, the economic performance of the United States and Japan, regional stability in the ASEAN countries, economic progress of China and just plain luck. The Government's aggressively pro-business environment and excellent infrastructure for manufacturing, logistics, and transportation, will continue to be an advantage in areas where labor costs or proximity to customers are not central.

Most analysts do not see China's emergence as a key global electronics production base derailing Singapore's own position in the industry, even if it does pose challenges in some specific segments. They note that there is little evidence to suggest global electronics firms will concentrate all – or even most – production in China; indeed, industry trends suggest the opposite, i.e., a rationalization of production among several locations. The reasons are largely economic, but occasionally other factors may play a role. For example, political tensions between China and Taiwan, and the 1999 major earthquake in Taiwan influenced Taiwanese UMC and TSMC to expand in Singapore rather than in Taiwan or China. Recent trade data supports the view that China is, as the World Bank recently stated, "energizing intra-regional production networks and trade", propelling a vast expansion of imports from East Asia, including electronics. Singapore's domestic exports of electronics to China rose 53% y/y in the second half of 2003, compared to 14% y/y in H1 2003, driven by robust demand for disk drives, semiconductors, and parts of PCs. Most analysts forecast this strong demand to continue.

Key foreign investors appear committed to remaining in Singapore, expanding cutting edge operations at the same time they transfer lower-end operations abroad. HP is an example. The firm stated in January 2004 that it plans to increase investments in new manufacturing operations in Singapore, while simultaneously moving production of more lower-end items out of Singapore.

And Singapore continues to successfully attract new investors, such as programmable chip producer Xilinx.

Singapore's private sector has also adapted reasonably well to changes in the industry, including by moving production offshore to lower-cost countries. More adaptable local firms that supply electronics MNCs have followed their MNC customers to China, or have teamed up with Chinese companies. While large government-linked firms like Chartered Semiconductor or Stats have initially been less nimble than their private sector counterparts, they too are moving to better secure their position in the industry, including. Chartered concluded a production and technology tie-up with IBM, while Stats announced plans to acquire ChipPac, a larger US-based competitor, for US\$1.6 billion, and thereby become the world's third largest chip test and packaging firm.

The Government also believes that Singapore's aggressive policy to conclude free trade agreements (FTAs) with key foreign markets (including the US) gives Singapore an added advantage vis-à-vis its competitors, although most electronics items are already traded duty-free among major producing and consuming countries, thanks to the WTO Information Technology Agreement (ITA). In the end, Singapore still have advantages over many of its regional neighbors in terms of relative stability, good government, excellent logistics, and a critical mass. These advantages should continue to serve Singapore well.

## BACKGROUND: INDUSTRY PROFILE

<u>Segment</u>	<u>Share of Output (Percent)*</u>	
	<u>Electronics</u>	<u>Total Manufacturing</u>
ICs/Semiconductors	28.0	12.0
Data Storage	26.0	11.0
PCs/Office Automation	12.0	5.0
Modules & Components	5.0	2.0

*\* 2002 data (latest available)*

## Integrated Circuits/Semiconductors

The semiconductor sector, the most important segment for the local electronics industry, accounted for nearly 30% of the total electronics output of US\$62.2 billion in 2003; exports of integrated circuits represented 14% of total non-oil domestic exports. The three key areas of the semiconductor industry - wafer fabs, assembly and test centers, and integrated circuit (IC) design centers - comprised mainly foreign MNCs, with some large local companies as well. At present, there are 12 wafer fabs, 19 assembly and test centers and 32 ICs design centers in Singapore. Leading semiconductor investors include Taiwan Semiconductor Manufacturing Company (TSMC), United Microelectronics Corporation (UMC) and indigenous Chartered Semiconductor, and others such as STMicroelectronics, Matsushita, and Infineon. Singapore's Economic Development Board (EDB) is a strategic investor in most of the fabs. In the IC assembly and test sector, Singapore has attracted Advanced Micro Devices, Agere Systems, Linear Technology, among other international companies, and locally-spawned ST Assembly Test Services (Stats), Infiniti, and United Test and Assembly. Major IC design companies operating in Singapore are Infineon Technologies, Broadcom, NEC Semiconductors, and Marvell.

After the sharp contraction in global semiconductor demand in 2001-2002, the semiconductor industry in Singapore is again, as of early 2004, enjoying a strong upsurge in demand, which plants running at capacity. Yet some analysts question Singapore's long-term competitiveness in the sector. They note that Singapore offers few unique advantages for wafer fabrication or assembly/test services, and see competition heating up from firms in China, even if few Chinese

fabs are at the cutting edge of technology. But Singapore does not only face competition from China: In 2003, it lost out to Dresden, Germany, for a US\$4 billion wafer fab investment by AMD, reportedly thanks to generous financial incentives from the German government.

Analysts comment that Singapore is working hard towards developing high-level capabilities in product innovation and design, but local industry has yet to catch up with the speed of innovation in industry leaders. Problems at majority state-owned Chartered Semiconductor have highlighted this issue. Between 2001 and 2002, Chartered lost US\$800 million (a further loss is expected in 2003) as utilization rates hovered at low levels; many analysts see Chartered's competitive position as weak. Chartered, which has five operating fabs in Singapore (two of which are joint ventures) and one planned fab, has fallen significantly behind market leaders TSMC and UMC in product development, but in an effort to counter this announced a production and technology transfer arrangement with IBM in late 2002 under which it will make certain chips for IBM. Chartered also announced another tie-up in 2002, this time China's Semiconductor Manufacturing International, under which Chartered will transfer certain technology to SMIC, in exchange for access to SMIC's production capacity. Chartered also closed its oldest fab, selling the manufacturing equipment to another China-based firm, CSMC Technologies.

Other fabs in Singapore involve foreign investors, and have had not the same problems, and overall, most analysts expect Singapore will retain its position as a key semiconductor manufacturing and development center in the near term, leveraging its first mover advantages, strong IPR protection, proactive government policies, and investors' desire to over-concentrate production in a single economy.

Indeed, foreign investment continues to flow into the semiconductor sector. In late 2002, UMC International (UMCi), co-invested by UMC, Infineon and EDB started production of advanced 12-inch wafers. Systems on Silicon Manufacturing Co. (SSMC), a \$1.2 billion joint venture between Philips Electronics, Taiwan Semiconductor Manufacturing Co. and EDB to manufacture 0.15-0.25 micron wafers, announced in late 2003 a major expansion of its facility. And STMicroelectronics announced it would invest as much as US\$250 million to double the company's output at its six-inch wafer fab in Singapore.

Investment is also going into R&D. For example, Agilent Technologies set up a US\$92 million research facility in semiconductor wafer fabrication, IC design, and photonics, while Infineon announced plans to inject US\$50 million to boost R&D and product design capabilities at its Singapore facility. Motorola also has an important Singapore design center.

## Storage

Singapore accounts for nearly a third of the global hard disk drive (HDD) output, with output of US\$8.8 billion in 2002. That share is a decline from the early 1990s, when shipments of disk drives from Singapore for 45-50% of the global shipment of HDD units, according to a study by U.S.-based Information Storage Industry Center. The decline was due both to industry consolidation and rising wage costs in Singapore, as major producers such as Seagate, Conner, Maxtor and Western Digital relocated low-end production from Singapore to Malaysia, Thailand and China, while others, such as Syquest and Integral Peripherals, exited from Singapore altogether. In an effort to keep HDD producers in Singapore, the Singapore Government worked to move production up the value chain, funding collaborative R&D efforts, such as the Data Storage Institute, and providing direct financial incentives for firms to do their own R&D work in Singapore.

This strategy has been largely successful, and Singapore continues to host high-end HDD operations, such as disk media and optical storage production, drive design and R&D activities. For example, in February 2004, Seagate announced it will produce its latest 2.5 inch drives in Singapore. Singapore's niche in the high-end HDD segment, which is projected to grow by 25-30% by 2006, given strong HDD demand from new consumer electronics applications, looks

stable. Exports of disk drives accounted for nearly 15% of Singapore's total non-oil domestic exports in 2003.

### **Electronics Modules & Components**

Output of electronics modules and components totaled US\$1.7 billion in 2002. Printed circuit boards (PCBs) production and PCB assembly have shifted from low-end to high-end production, with output today concentrated in multi-layered boards and multi-layered flex-rigid boards. About 40 companies are involved in production and 35 companies in assembly. Major players are Hitachi Chemical, Gul Technologies, 3M, Venture Corp, MFS Technology, and Sanmina-SCI. The passive components segment, dominated by Matsushita (Panasonic), Murata, EPCOS (formerly Siemens Matsushita Components), and others, continues to be driven by new technologies in the telecommunications sector. Current efforts to attract new investment have concentrated in flat panel display technology. For example, Toshiba and Matsushita jointly set up an LCD plant in the Advanced Display Park in 2002.

EDB has identified photonics as another new growth area in the shift towards higher value-added activities. Venture capital firm 3i recently announced a US\$30 million investment in locally-owned Denselight Semiconductors, which manufactures a wide range of indium-phosphide based photonic integrated circuits.

### **Consumer Electronics/Computers/Peripherals**

Singapore's move from low-wage assembly operations has been most pronounced in the consumer electronics/telecom equipment segment of the electronics industry. Collectively, the value-added for these segments has been declining, but still represents over 10% of total manufacturing, compared with 12.4% for semiconductors or 5.5% for data storage. Yet even though the bulk of consumer electronics assembly operations had already moved offshore, exports of consumer electronics and computer printers have expanded slightly, represented only 4.1% of Singapore's total non-oil domestic exports in 2003, compared with 3.2% in 2000. Motorola, Philips, Ericsson, NEC, Nokia, Siemens, Hewlett-Packard, 3COM, and Allied Telesyn are the major players in this segment. Hewlett-Packard alone accounted for 9% of Singapore's non-oil domestic exports in 2002.

While low-end operations have gone abroad, these segments continue to attract investment at the high end, in cutting edge technologies. For example, Toshiba-Matsushita's joint venture, AFPD Pte. Ltd. broke ground in 2001 for a US\$1.0 billion LCD manufacturing plant. In 2003, Matsushita announced major investments in facilities to produce DVD recorders and image sensors for digital cameras, while in early 2004 HP indicated its intention to transfer production of a top-of-the-line type of computer server from the U.S. to Singapore. As it has in other electronics segments, the Singapore Government has seen some success in encouraging investments in R&D and design work in the consumer electronics, computers, and telecom equipment segments Singapore. For example, in 2003 NEC and Philips announced new investments in R&D facilities in Singapore focused on biometrics and digital televisions, respectively. In addition, Toshiba announced it will transfer the development and design of its color televisions from Japan to Singapore.

Small and medium-sized local enterprises have grown in this segment to become contract manufacturers, building up their R&D and supply chain management capabilities in the process. Examples include Nera Telecommunications, Astralink Technology, Innomedia, Group Sense Technology and Innomedia.

## **Contract Manufacturing/Electronics Manufacturing Services**

The outsourcing policies of IBM, Hewlett Packard and Seagate in the late 1980s and 1990s benefited many local contract manufacturing (CM) firms, some of which have moved ahead to become original design manufacturers (ODM) and electronics services manufacturing companies (EMS), beating competition from lower-cost CMs from China. Venture Corporation is the best example, and one of the few CMs in Singapore which have remained independent. Venture is among the world's top 12 EMS, involved in designing, making and delivering products for big brands such as Motorola, Cisco and Hewlett-Packard. Other established Singapore CMs include Beyonics, Flairis Technology and GES International.

Most of the other Singapore CMs were acquired by foreign firms during the post-2000 global electronics slump. Examples include NatSteel Electronics, NatSteel Broadway, JIT Holdings and Li Xin Industries. The buyers were CM giants like Solectron, Celestica, Flextronics, the latter nominally-headquartered in Singapore.

Local entrepreneurial efforts from EMS companies, like Venture Corp which has increased its product line to more than 2,500 products from 1,000 products just two years back, continue to put Singapore on the world map for contract manufacturing. But, local CMs have also relocated low-end manufacturing to China to keep ahead of competition and to stay close to their customers, including the MNCs who have also moved to China.

## **Precision Modules/Components & Machinery/Systems**

Precision modules, components, machinery and systems for the electronics is an important contributor to the manufacturing sector, accounting for 11% or nearly US\$10 billion of total output in 2003. The presence of semiconductor and HDD giants have contributed to the growth of this sector, giving rise to local manufacturers such as Singapore-listed firms Seksun, Beyonics, MMI Holdings, MI Technology, Brilliant Manufacturing and Gul Technologies. Many of these firms have become competitive world-class manufacturers. For example, Brilliant Manufacturing is one of the largest producers in the world of aluminum base plates for HDDs. Foreign investors SKF, Tyco, Molex, Nypro, GE-Fanuc and many others also set up in Singapore to join in the supply chain. Many of these firms have established off-shore factories to cut costs or have followed their MNC clients to new production centers like China, becoming foreign investors in their own right. As in other segments, production in Singapore is increasingly centered on only high-end products.