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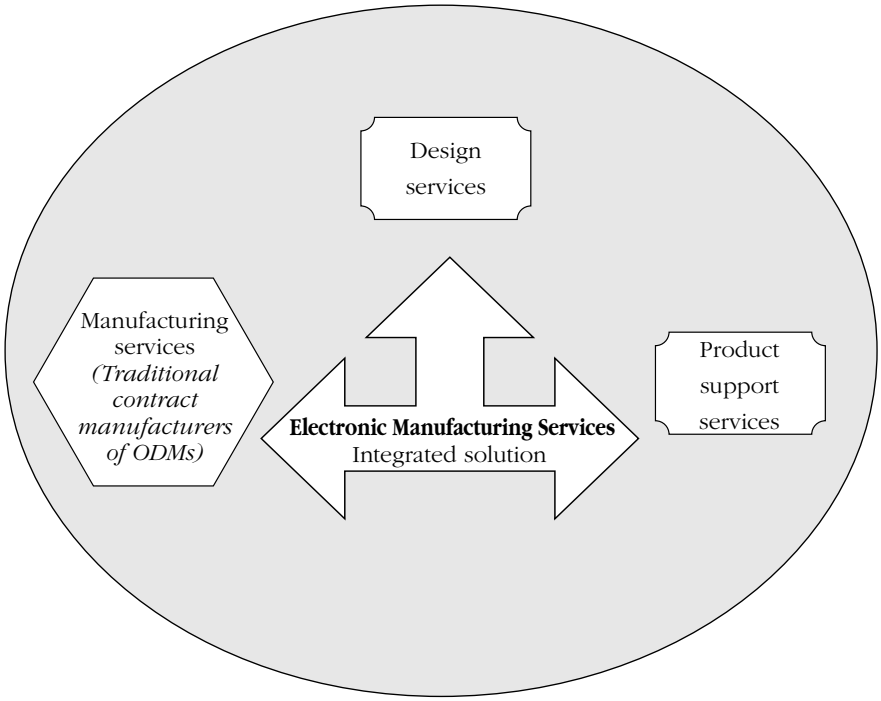
INTRODUCTION

Traditionally, ODMs of electronics products were companies that designed, manufactured, marketed and provided customer support for their products. They often were vertically integrated and invested significantly in manufacturing assets and facilities around the world. EMS providers emerged as ODMs began to outsource some of their labour-intensive manufacturing functions to obtain additional capacity during periods of high demand. Early EMS providers were essentially subcontractors, providing production capacity on a transactional basis. However, with significant advances in manufacturing process technology, EMS providers developed additional capabilities and were able to provide engineering services which improve product quality and reduce ODMs' costs. Furthermore, as the capabilities of EMS companies expanded, an increasing number of ODMs were adopted and became dependent upon EMS outsourcing strategies.

In recent years, major ODMs such as IBM, Cisco Systems, Dell, Nortel, Nokia and Ericsson have adopted plans to outsource everything from production to after-sales services and even new product developments to EMS providers. EMS companies have become the beneficiaries of this trend and have grown to become the global giants in recent years. In 1996, Solectron Corporation was the only EMS company with more than US$3 billion in sales. It grew quickly to US$6 billion in sales and ranked third after America Online, Inc. and Dell Computer Corporation according to the Infotech 100 Plus Survey published by Business Week Magazine in June 1999. Among the top 50 EMS companies in 1998, 3 companies passed the US$3 billion revenue benchmark.

EMS companies do not have their own brand names. Instead, they add value by focusing on combining production and services such as design and after-sales support and running production lines in a highly efficient way. According to a report published by Custer Consulting Group, an EMS industry research firm, approximately 17 per cent. of all electronics production globally passed through the hands of CEMs in 1998. Within a decade, the industry is expected to account for 50 per cent. or more of all electronics production.

The following diagram describes the difference in services offered by EMS companies and traditional contractors of ODMs.



A number of international EMS providers have further expanded their range of services to include advanced manufacturing, packaging and distribution and overall supply-chain management. In addition, many ODMs are reducing the number of vendors from which outsourced services are purchased, and are partnering with EMS providers that can provide a total service solution on a national or global basis, in order to further lower costs and increase supplier accountability.

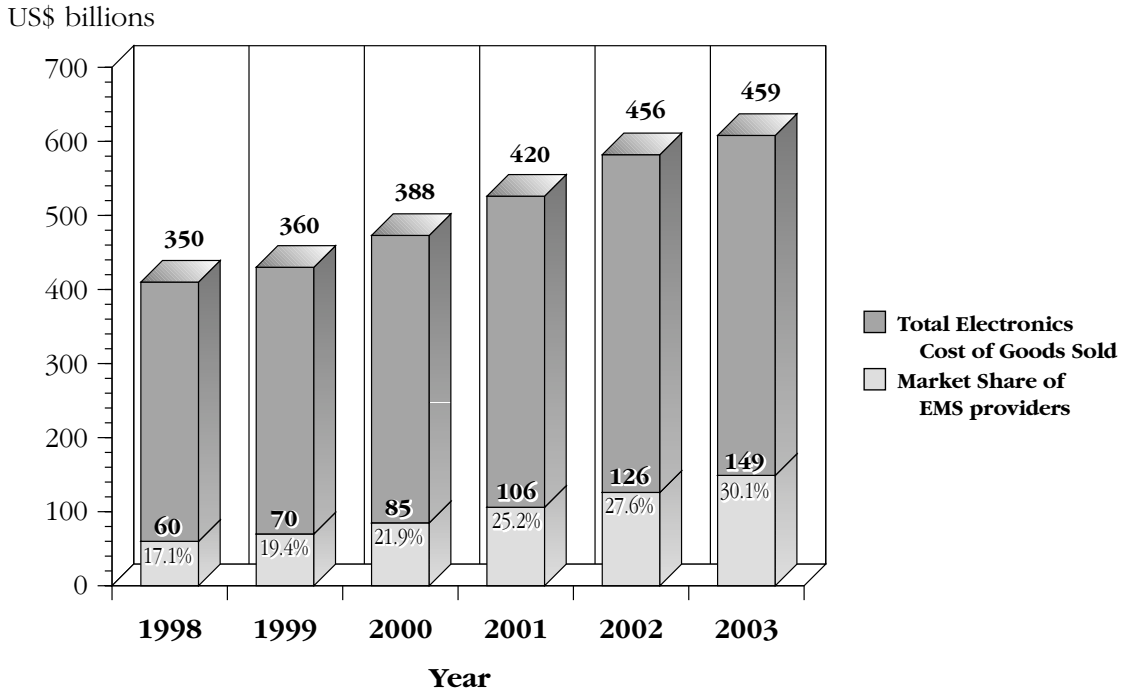
THE EMS INDUSTRY

Overviews and market trends

The world's EMS market continues to grow rapidly resulting from the global outsourcing trend. Revenues generated by the EMS industry are relatively concentrated among the computing and communications sectors. By using EMS providers, ODMs are able to focus on their core competencies, including product development and sales and marketing, whilst leveraging on manufacturing efficiency and capital investment of EMS providers.

According to a report published by the Custer Consulting Group, an EMS industry research firm, the global EMS industry revenue is forecasted to grow at a compound annual growth rate of approximately 20 per cent., from approximately US$60.0 billion in 1998 to approximately US$149.4 billion in 2003. It is further estimated that the percentage of total cost of goods sold in the electronics industry which is outsourced for manufacturing by EMS providers will increase from approximately 17.1 per cent. in 1998 to approximately 30.1 per cent. by 2003.

The following graph illustrates the estimated value of outsourcing by ODMs against the gross value of electronics cost of goods sold:



Source: Custer Consulting's estimate (PWB Outlook, June 2000)

The Directors have observed the following aspects which enable EMS providers to enhance the competitive position of ODMs.

Reducing time-to-market

Electronics products are experiencing increasingly shorter product life cycles, requiring ODMs to continually reduce the time required to bring new products to market. ODMs can significantly improve product development cycles and enhance time-to-market by benefiting from the expertise and infrastructure of EMS providers.

Improving supply-chain management

ODMs who manufacture internally are faced with greater complexities in planning, procurement and inventory management due to frequent design changes, short product life cycles and product demand fluctuations. ODMs can address these complexities by outsourcing to EMS providers who possess sophisticated supply-chain management capabilities and can leverage significant component procurement advantages to lower production costs.

Accessing advanced manufacturing capabilities and process technologies

Electronic products and electronics manufacturing technology have become increasingly sophisticated and complex, making it difficult for many ODMs to maintain the necessary technological expertise and focus required to efficiently manufacture products internally. By working closely with EMS providers, ODMs can gain access to manufacturing expertise and capabilities in the areas of advanced process, interconnect and test technologies.

Improving access to global markets

ODMs are generally increasing their international activities in an effort to expand sales through access to foreign markets. EMS providers with production facilities located in different parts of the world are able to offer ODMs global manufacturing solutions, enabling ODMs to meet local content requirements and distribute products efficiently around the world at lower costs.

ELECTRONIC INTERCONNECT MARKET

Interconnect products which include plain PCBs, PCB assembly, backplanes and backplane assembly, are essentially the backbone of any electronic products. PCB assembly services hold the biggest share of EMS providers' business. In the US, sales of PCB assembly services among the top 50 CEMs amounted to approximately US$16.3 billion in 1998. Electronic interconnect products are customised for specific electronic applications and are sold to ODMs and CEMs in volumes that range from several units for prototypes and small quantities for pre-production to large quantities for volume production. However, the proliferation of electronics and the emergence of new technologies have significantly broadened this market and reduced the amplitude of interconnect industry cycles in the 1990s. Electronic interconnects such as rigid PCBs, flexible circuits and backplanes are now used in a wide variety of industries and products, including data communications, telecommunications, workstations, servers, personal computers, computer peripherals, industrial automation, instrumentation, medical equipment, transportation and military and aerospace.

Historically, electronics ODMs used independent PCB manufacturers as offload capacity for their internal facilities. During economic downturns, independent facilities lost production orders as ODMs produced a greater percentage of demand internally. As electronic products become smaller and more complex, the manufacture of interconnect products requires increasingly sophisticated engineering and manufacturing expertise and substantial capital investment. These advanced manufacturing processes and technology requirements have caused ODMs to rely more heavily on independent manufacturers and reduce dependence on their internal fabrication and assembly facilities.

Latest trends in electronic interconnect market

The Directors consider the following trends important in understanding the electronic interconnect industry:

Industry consolidation

The Directors believe that the industry will continue to consolidate due to the substantial capital investment in advanced production facilities, engineering and manufacturing expertise and technologies required to make increasingly sophisticated electronic interconnect products. The increased investment requirement for state-of-the-art production facilities has accelerated consolidation in the electronic interconnect industry and resulted in the exit of smaller companies. As a result, the Directors believe that companies with lesser financial and technical resources are likely to exit the industry and larger interconnect companies with sufficient resources will continue to gain market share.

Increasing demand for one-stop solution

To avoid delays and costs during the production cycle, ODMs are increasingly turning to suppliers capable of producing electronic interconnect products from development, design, quick-turn prototyping and pre-production through volume production and backplane assembly. The accelerated need of time-to-market and time-to-volume from ODMs have resulted in increased collaboration with qualified suppliers capable of providing a broad and integrated supply. To meet their rapidly changing electronic interconnect requirements, many ODMs have moved to limit their vendor base to a smaller number of technically qualified suppliers capable of providing both quick-turn prototyping and pre-production quantities as well as cost-competitive volume production.

New and emerging markets

The markets for electronic products are growing as a result of new product introductions, technological changes, demands for a wider variety of electronic product features, and increasingly powerful and less expensive electronic components. New markets have emerged in the fields of computing, data communications/telecommunications and multimedia. Moreover, existing industries have significantly expanded applications in areas such as computer networking and peripherals, digital and mobile communications, video-on-demand, the Internet/world wide web, instrumentation and industrial controls. The Directors believe that these new and emerging electronic product markets and applications have also contributed to the reduction in the amplitude of the electronic interconnect industry cycles.

Greater demand for complex electronic products

Advanced communications equipment, as well as computer chips and microprocessors, require interconnect systems that operate at high speed and high frequencies with minimal signal loss and distortion. Furthermore, electronics ODMs are designing more compact and portable high performance products. The complexity of these new products requires higher performance, smaller size, greater circuitry and component density, and increased reliability. These requirements necessitate greater sophistication in PCB manufacturing and process technologies, including advanced materials, more layers, narrower line widths and spacing, smaller vias to connect internal circuitry, and more precise positioning of traces and pads to accommodate a greater density of SMT components. The trend towards increasingly sophisticated products also requires greater engineering support and investment in manufacturing and process technology for suppliers to produce high quality electronic interconnect products on-time, in volume, and at acceptable cost.

Shorter product life cycles for electronic products

Rapid changes in technology have significantly shortened the life cycle of complex electronic products and placed increased pressure on ODMs to develop new products as quickly as possible. The time-to-market considerations of ODMs have increased emphasis on the engineering and quick-turn production of small unit volumes of electronic interconnects in the prototype development stage. In addition, the success of first-to-market products has heightened the emphasis on volume manufacturing expertise and technologically advanced manufacturing infrastructure.

Printed circuits

Printed circuits are the basic platforms used in interconnect microprocessors, ICs and other components essential for the functioning of electronic products. Printed circuits consist of a pattern of electrical traces etched from copper laminated on an insulated base that is typically composed of rigid fibreglass or thin flexible circuits.

The PCB manufacturing process consists of photographically imprinting circuit patterns on to substrate materials (typically fibreglass or film), which are then permanently incorporated into the PCB through a screen or photo printing process. To meet the increasing requirements of ODMs and CEMs, PCB manufacturers have developed more complex multilayer designs with SMT, BGA and other attachment technologies, narrower widths and separations of copper traces, advanced materials, and smaller vias and through-holes to connect internal circuitry.

PCBs are produced in various sizes and specifications, including flexible printed circuits, single and double-sided rigid PCBs, multilayer PCBs and backplanes.

Flexible printed circuits

Flexible printed circuits due to their mechanical flexure and three-dimensional shape accommodate packaging contours and motions in a manner that traditional two-dimensional rigid PCBs cannot. The applications of flexible printed circuits include notebook computers, portable communication devices such as cellular phones, pagers, printers, scanners and data storage devices such as compact disk players, cameras and camcorders.

Rigid PCBs

Rigid PCBs are widely used given their lower complexity compared to flexible PCBs, and high-volume nature compared to flexible circuits. They can be found in a wide array of products, ranging from personal computers and communications equipment to consumer electronics such as cellular phones, personal digital assistants and DVD players. Rigid PCBs include (1) single-sided and double-sided PCBs and (2) multilayer PCBs.

Single-sided and double-sided PCBs. Single-sided and double-sided PCBs are the most common boards used and are typically the lowest-cost solutions suitable for the consumer market (for example, radios, VCRs, etc.).

Multilayer PCBs. Multilayer PCBs have many functional advantages, including the ability to accommodate a higher packaging density, improve power and ground distribution, low weight, and permit the use of higher-speed circuitry. Due to such advantages, multilayer boards have become the standard for numerous high-technology applications. Multilayer boards are employed in electronic products which require high-speed and high-frequency interconnect solutions, including communications, computing and instrumentation. Since these products require specialised manufacturing techniques and expertise, multilayer production typically delivers higher margins as well as reduced competition from low-labour-cost fabricators who typically focus on high-volume low-mix products.

Backplanes

Backplanes are generally larger and thicker printed circuits on which connectors are mounted to the interconnect printed circuits, ICs and other electronic components. A system assembly includes the backplane, power supply, fan card, cables and system chassis.

DEVELOPMENT PROCESS OF PCBS

PCB design and production process

The development of PCBs usually progresses in four stages, namely: (1) initial design and simulation; (2) schematic capture and layout design; (3) quick-turn prototyping and pre-production; and (4) volume production.

Initial design and simulation

Initial design is performed by the ODMs which encompasses the processes of idea formation, conceptual analysis, engineering design (including specifications and features), functional simulation and simulation of the processed layout of a PCB.

At present, in terms of sales volume, PCBs with 1 to 6 layers capture approximately 80 per cent. of the market share and are widely used. Higher layers PCBs are often used in high-tech equipment such as complex telecommunications and network equipment. Considerably few equipment use PCBs with more than 20 layers except some advanced applications such as equipment used in aerospace and defence industries.

Simulation of proposed locations of holes and conductors (the "layout") provides information regarding potential layout problems to the initial design engineer and creates revised design guidelines for the schematic capture and layout design technicians. Due to the increasing number of high-speed devices being used on PCBs, physical layout guidelines must be tailored for each particular design to resolve problems regarding circuit timing, signal-integrity and electromagnetic interference. These problems, if not resolved at the initial stage of layout design, can result in low manufacturing yields and inconsistent product performance that can increase time and cost to market for ODMs.

Schematic capture and layout design

Schematic capture involves the input of an electronic schematic diagram into a high-performance computer workstation that generates a list of electronic components and interconnects required to design a PCB. Layout design is accomplished using specialised CAD software programs. Computer-generated data describe the layout which, along with manufacturing information, may be transmitted electronically from the designer to the manufacturer. When transmitting data to its internal manufacturing division, specialised CAM software is used prior to sending the data to ensure "design-for manufacturability" and "design-for testability" and to help speed up the quick-turn prototyping process. Historically, layout design was the step in the PCB production process least likely to be outsourced by ODMs. As PCB related "design-for manufacturability" becomes more complex, more ODMs are relying on outside sources for these services.

Quick-turn prototyping and pre-production

Quick-turn prototyping is characterised by shorter than standard lead time requirements, typically one to ten days, and involves production of a small quantity, usually fewer than 50 pieces of PCBs. Prototype evaluation is critical to product development and frequently requires several alterations before a design can be finalised. Due to the time critical factor, most prototypes are manufactured on a quick-turn basis. Consequently, high quality and timely delivery are generally the most important factors for the quick-turn prototyping market.

Pre-production runs involve the manufacture of limited quantities of PCBs during the transition from prototyping to volume production. Pre-production may require quick-turn delivery because of the overall time-to-market pressures and shorter product life cycles or as a temporary solution in the event of volume production delay. Accordingly, high quality and timely delivery continue to be the factors most important to the ODMs or CEMs, notwithstanding the price factor which is also considered significant. Many ODMs take advantage of a PCB manufacturer's quick-turn capability, even when circuit design or volume production is done in-house or by other PCB manufacturers.

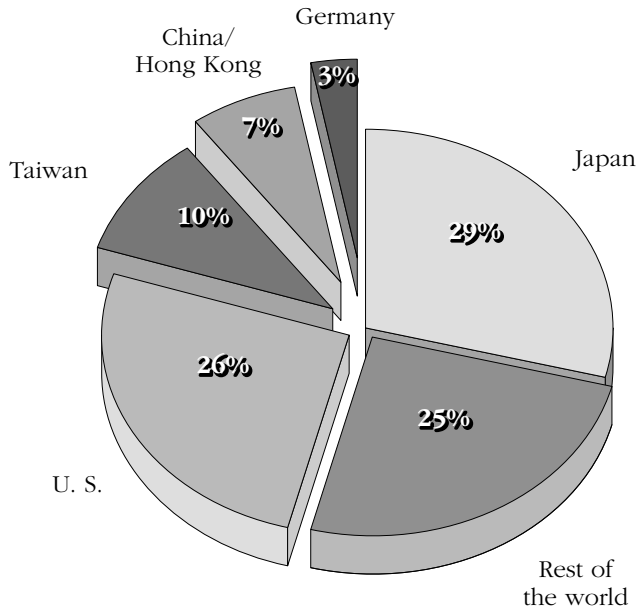
Volume production

Volume production is characterised by longer lead time and increased emphasis on lower cost as the product moves to full-scale commercial production. At this stage of production, price, quality, on-time delivery and process capability are the factors most important to the ODM or CEM. As product life cycles grow shorter, the ability to meet shorter lead time requirements becomes an increasingly significant competitive factor.

THE GLOBAL PCB MARKET

World production of PCBs amounted to approximately US$36.2 billion in 1999, according to statistics in the Report on the World Market for Printed Circuit Boards and Substrate Materials published by the IPC Technology Market Research Council ("TMRC") in June 2000. TMRC is an industry forum for the active exchange of information and data regarding the PCB industry. According to the report, global rigid PCB production for 1999 was approximately US$32.8 billion, and flexible circuit production was approximately US$3.4 billion. Japan was ranked first in the global rigid PCB production, followed by the US, Taiwan, China/Hong Kong and Germany.

The following chart illustrates the share of global rigid PCB production by region for the year 1999:



Source: IPC

In 1999, multilayer PCBs accounted for approximately 42 per cent. of all types of laminate consumed based on gross production area, while paper-based laminate accounted for approximately 36 per cent. Single-and double-sided glass and composite-based laminate accounted for the remaining 22 per cent. World consumption of laminate for rigid PCBs is estimated at approximately 230 million square metres.

Fabricating a complex PCB must meet stringent quality control standards and adhere to strict electrical performance characteristics. These requirements include tight etching and lamination tolerances, and are especially critical for boards with ten or more layers.

There are eight distinct market segments for PCBs:

Market segments	**Examples of applications**
Automotive	engine and drive performance, convenience and safety, entertainment and other applications for diagnostic display and security
Business/retail	copy machines, cash registers, "point-of-sale" terminals, teaching machines, business calculators, gas pumps and taxi meters

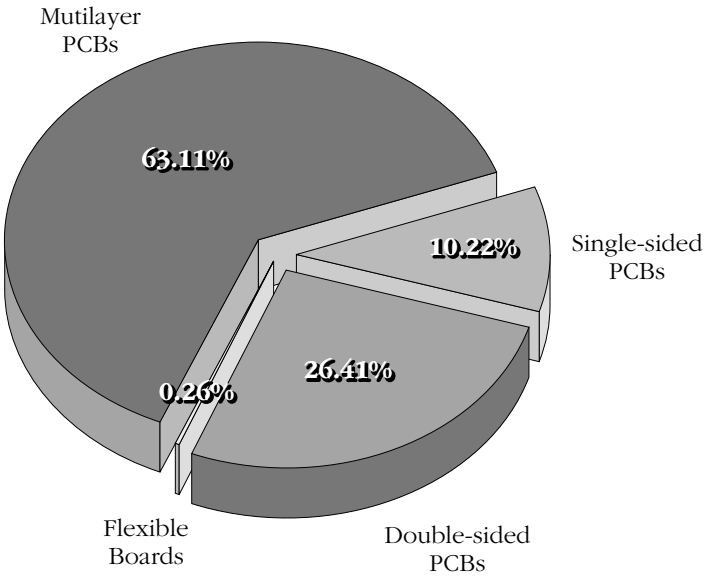
Communications	mobile radio, portable communication, pagers, data transmissions, microwave relay, telecommunications and telephone switching equipment and navigation instruments
Computer	mainframe computers, mini-computers, broad level processors, add-on memories, input devices, output devices, terminals and printers
Consumer electronics	watches, clocks, portable calculators, musical instruments, electronic games, large appliances, microwave ovens, pinball/arcade games, television/home entertainment, smoke and intrusion detection systems and video records
Government and defence	radars, guidance and control systems, communication and navigation, defence/aerospace electronic warfare, ground support instrumentation, sonar ordinance, missiles and satellite related systems
Industrial electronics	machine and process control, production test measurement, material handling, machining equipment, pollution, energy and safety equipment, numerical control power controllers, sensors and weighing equipment
Instrumentation	test and measurement equipment, medical instruments, medical testers, analytical nuclear, lasers, scientific instruments and implant devices

THE PRC'S PCB MARKET

Ten years ago, the PRC manufactured PCBs which were mainly used in domestic home appliances. In recent years, the rapid development of IT in the PRC generated an increased demand for electronics products, especially with a population of 1.3 billion people who are just starting to purchase electronic and computer products such as personal computers, cellular phones, cameras and audio/video electronic appliances. The PRC's PCB industry has grown rapidly in the past three years and has become one of the most promising industries in China. In view of the complicated technical processes involved and increasingly stringent environmental requirements, PCB manufacturers in Europe and the US have already formulated plans to make investments in countries with cheaper labour such as the PRC and other southeast Asian countries, through acquisition of, or merger with, established PCB manufacturers in those countries. At the same time, existing purchasers have also started to procure from the PRC. It is expected that the manufacturing of PCBs in the PRC will experience substantial changes in terms of both quality and quantity in the next few years.

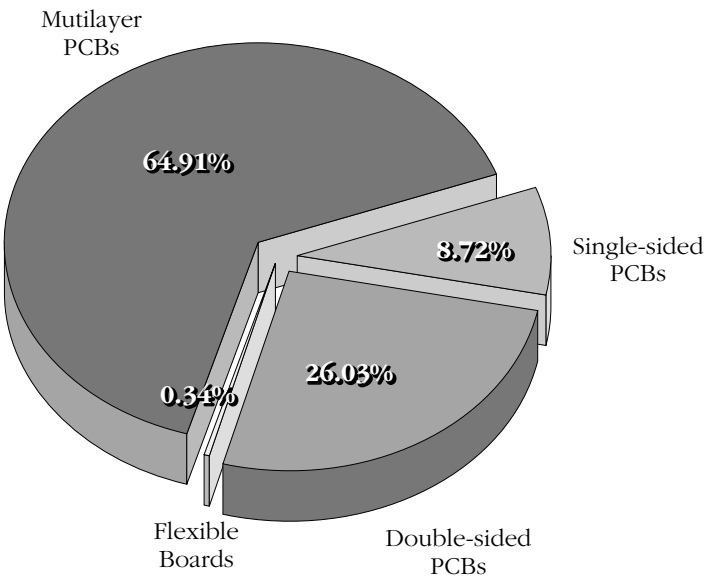
The following pie charts illustrate the breakdown of the PRC's PCB output value in terms of different types of PCBs for the years 1998 and 1999 respectively:

1998



Source: CPCA

1999



Source: CPCA

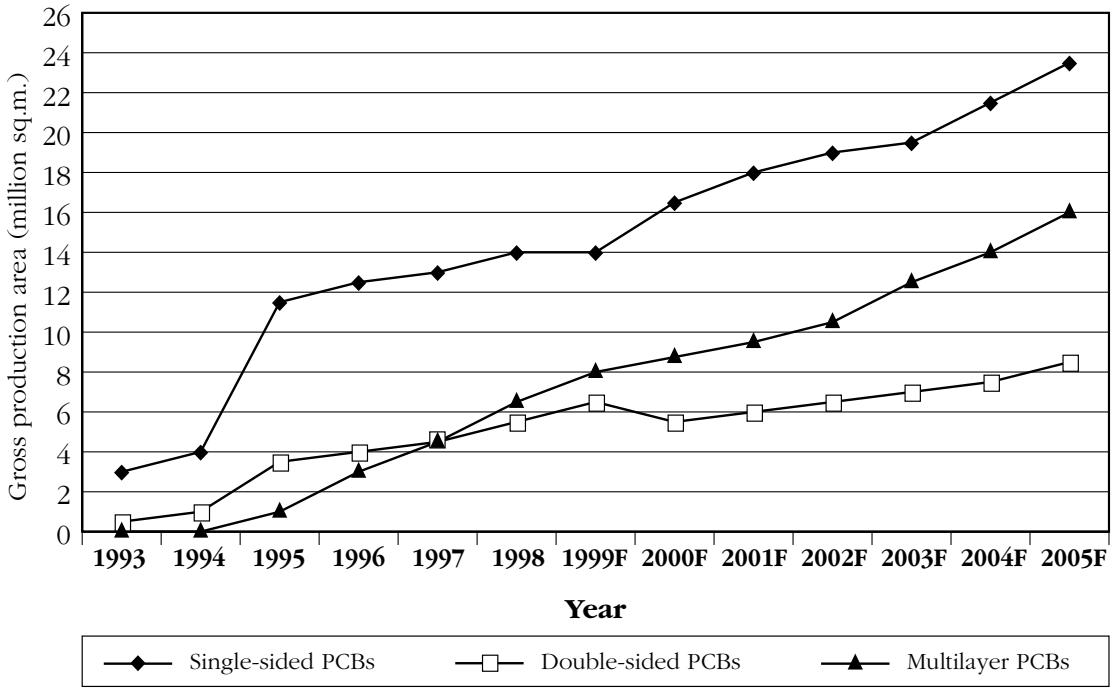
Growth of PRC electronics market

In 1998, the total output value of China's electronics manufacturing reached approximately RMB547.7 billion, while the total sales turnover of the electronics market was approximately RMB320 billion. According to CPCA, the product output value for electronic components is expected to reach RMB5 billion, and the PRC will become a world leader in the electronics industry by 2010. The average growth rate of the electronics industry is around 15 per cent. to 20 per cent. The investment-type electronics market is still dominated by the communications and computer industries. According to the analysis of the Ministry of Electronics Industry, the communications equipment with an annual growth rate of approximately 8 per cent., occupies a global market share of 8 to 9 per cent., and the computers and related accessories industry, with an annual growth rate of approximately 40 per cent., occupies the largest global market share. Since PCBs are the backbone of most electronic components, the future growth rate of China's PCBs industry is expected to keep pace with the growth of electronic manufacturing industries.

Growth of the PRC's PCB market

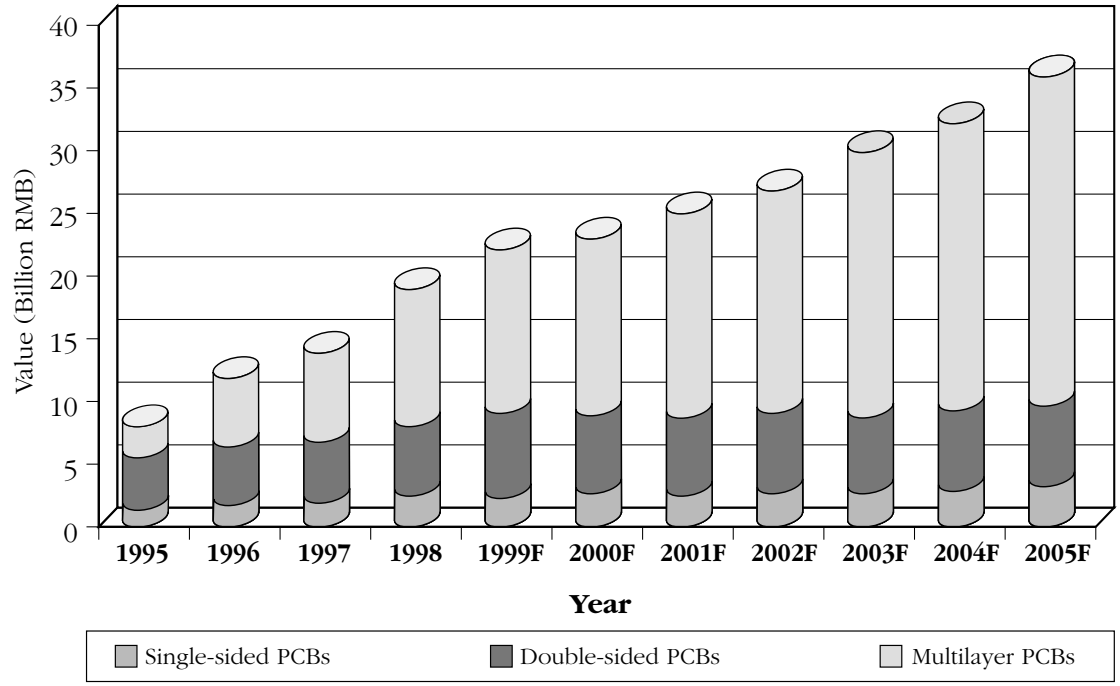
According to a survey of CPCA, China's PCB production output (excluding Taiwan and Hong Kong) was approximately 5 million square metres with total sales of less than RMB5 billion at the end of the 1980s. In 1998, the number surged to more than 26.7 million square metres for gross production volume while total sales climbed to approximately RMB19.13 billion, representing an approximately 434 per cent. growth in output volume and an approximately 283 per cent. growth in output value. It is estimated that the aggregate production for PCBs in the PRC may reach RMB22.5 billion and RMB36.2 billion in the years 2000 and 2005 respectively.

The following chart illustrates the historical and forecasted gross production area of PCBs in the PRC from 1993 to 2005:



Note: F denotes forecasted figures
Source: CPCA

The following chart illustrates the historical and forecasted value of PCB production output in the PRC from 1995 to 2005:



Note: F denotes forecasted figures
Source: CPCA