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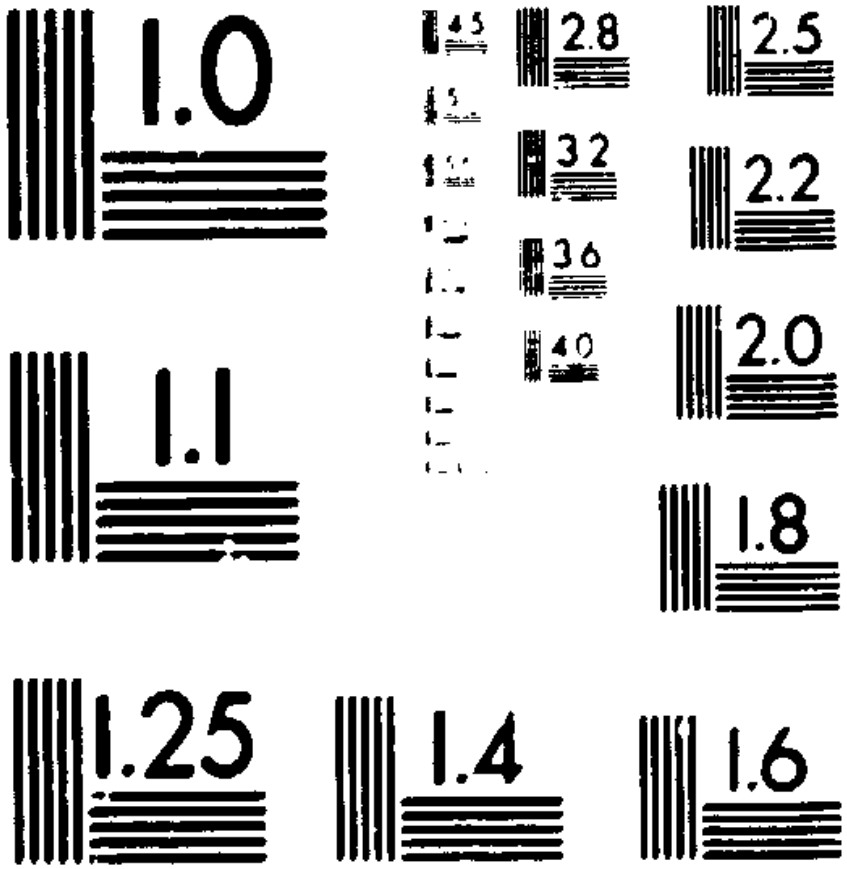

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UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

STATE-OF-THE-ART SERIES ON MICROELECTRONICS
No. 3: REPUBLIC OF KOREA *

Prepared for the Technology Programme

by

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EXPLANATORY NOTES

Abbreviations

CMOS	Complementary Metal-Oxide Semiconductor
CRT	Cathode Ray Tubes
DRAM	Dynamic Random Access Memory
ESS	Electronic Switching Systems
IC	Integrated Circuits
LED	Light Emitted Diode
MOS	Metal Oxide Semiconductor
PBX	Private Branch Exchange
PCB	Printed Circuit Boards
ROM	Ready Only Memories
VLSI	Very Large Scale Integration

Organizations

EIAK	Electronic Industry Association of Korea
ESPRIT	European Strategic Programme on Research in Information Technology
IBRD	World Bank/International Bank for Reconstruction and Development
KAIST	Korea Advanced Institute of Science and Technology
KETRI	Korea Electrotechnical and Telecommunications Research Institute
KIET	Korea Institute of Electronics Technology
KTA	Korea Telecommunications Authority
MOST	Ministry of Science and Technology

CONTENTS

S U M M A R Y

Microelectronics industry is growing very rapidly in the Republic of Korea at an annual rate of over 30 per cent in the last decade. Its share of the electronics products in the world increased from 1.3 per cent in 1977 to 1.8 per cent in 1982. The microelectronics industry is being promoted with the highest priority since 1983. A large share of national R and D is allocated to the microelectronics industry.

All major corporate groups are committed to the industry. They are actively pursuing production as well as R and D activities. There are three national laboratories for the microelectronics technology in the country. The national laboratories and the corporate groups have technical arrangements with the overseas research laboratories and corporations. Majority of the advanced equipment is imported mainly from USA and Japan and some from Europe.

The microelectronics industry is oriented towards export. Increasingly the Republic of Korea is developing microelectronics products rather than simple manufacture of imported designs. This requires the country to have design capability for internationally competitive products. Raw materials and infrastructure for microelectronics development are improving, but the country, like many other advanced developing countries, needs further improvement in both areas. The majority of the raw materials is imported. So are numerous computers and equipment as the country is lacking the supporting industries for microelectronics industry.

Needs/opportunities for co-operation are identified in the following areas: IC Design Centre with CAD, joint large-scale R and D programmes, training centres for managers and engineers, regional computer networks, pilot plant for wafer production for custom chips, consultancy and systems study.

The information industry is considered one of the strategic at present. The fifth five-year plan (1982-1986) emphasizes information industry and machinery industry. Foreign capital can be invested in the country with automatic approval under the foreign capital investment act for most of the high technology areas. Applications for technology acquisition will be approved automatically unless the Government requests clarification within 20 days. The Ministry of Commerce and Industry has formulated long-term promotion plans for microelectronics and computer industries.

1. Introduction

Microelectronics industry is very rapidly growing in the Republic of Korea. Its share of the electronics products in the world increased from 1.3% in 1977 to 1.8% in 1982[9]. The annual growth rate was over 30% in the last decade, and it is expected to go up even higher in the coming decade. Lately, the microelectronics technology attracts even greater attention throughout the country including industry, Government and educational institutions. In this report, microelectronics means semiconductors, its applications, and computers. Information technology includes telecommunications, information processing, control applications and other related areas in addition to the microelectronics technology. "Korea" may be used instead of Republic of Korea for readability in this report.

All major corporate groups are investing heavily in the microelectronics industry. The investment ranges from the R&D activity to manufacturing facilities. The Samsung Group and the Gold Star Group have been active in the microelectronics industry since 1970s. Recently, two other major groups, Hyundai and Daewoo, decided to get into the industry. In addition to the large corporations, many small companies are actively pursuing microelectronics technology.

The Government is also actively promoting the microelectronics industry and technology through the ministries. They promote more liberal overseas interface, the computerization of the administration, expansion of the education systems, and expansion of the R&D activities.

The Government's role in the microelectronics industry is to coordinate environmental work for industry and technology promotion. It sets frameworks for the education system and the national research laboratories. The schools mainly engage in education with some research activities. The national research laboratories, with funding from the Government and the private industry, engage on research and development. Often, the private industry participates on the R&D projects at the national laboratories. Most of the large corporations carry out also R and D activities at their own research laboratories .

Both the national laboratories and the corporate groups have technical arrangements with the overseas research laboratories and corporations. The majority of the advanced equipment and the technical assistance is imported mainly from USA and Japan and some from Europe.

Microelectronics is oriented towards export. Increasingly, we are developing microelectronics products rather than simple manufacturing of the imported design. This forces the Republic of Korea to have the design capability of internationally competitive products. Raw materials and infrastructure for microelectronics development are improving. but the country needs further improvement in both areas like many other advanced developing countries. The majority of the raw materials is imported. So are numerous computers and equipment as the country is lacking in the support industries for microelectronics technology.

The Republic of Korea has a well structured educational system, and produces sufficient manpower at nearly all levels ranging from technical high schools to graduate schools. But, there are problems usual for the advanced

developing countries due to the rapid growth. Contrary to the availability of graduates there is a great shortage of manpower in the middle managerial level and in experienced engineers. This gap is difficult to fill. Retraining poses another problem. The private sector cannot accommodate extensive retraining programs due to its rapid growth.

There could be international co-operation in various areas. Examples are design centers, joint R&D programs, and training centers. EEC started the program, ESPRIT for advancement of information technology, Asia could have similar programs[4]. Cooperation may pose a substantial problem as Asia never really had as good co-operation as Europe.

2. Government Technology Strategy

The Government's role is to coordinate the environment for the industry. The primary thrust for the promotion comes from the private sector. The information industry is considered as one of the strategic Industries in the country at present. This is the major change of the Government policy. The light industry was emphasized until 1960 s when the Republic of Korea decided to build up the heavy industry. The early 1980s marked another change in strategy towards the information industry as indeed also occurred in many developed and developing countries. The fourth five-year national plan (1977-1981) emphasized heavy industries, such as heavy machinery, ship building, electric power, and refinery. The fifth five-year plan(1982-1986) emphasized information industry and machinery industry. Foreign capital can be invested in the country with automatic approval under the foreign capital inducement act for most of the high technology areas. Applications for technology acquisition will be approved automatically unless the Government requests clarification within 20 days.

Ministry of Commerce and Industry delivered the report of the Long Term Promotion Plan of Electronics Industry in 1983[6]. The report which was published by Electronic Industry Association of Korea(EIAK) describes the current status and future expectation, and the master plan for the promotion. The long term promotion plan for semiconductor industry for 1982-1986 was delivered in 1982[15]. A similar report for computer industry has just been released[16].

The Ministry of Education has strongly promoted education programs on microelectronics technology ranging from secondary schools to universities. There are electronics engineering, and computer science departments in many universities and junior colleges. In addition, there are many technical high schools with electronics and computer science majors. Major enhancements on curricula and facility are being carried out now. Various loans such as IBRD loans are generously allocated to the microelectronics technology education.

The Ministry of Science and Technology (MOST) set up the Korea Institute of Science and Technology for general R&D activities, and Korea Advanced Institute of Science for graduate studies in science and technology in 1960s and 1970s. They were merged to form Korea Advanced Institute of Science and Technology(KAIST) in 1981. Many specialized R&D laboratories were span off in the mid-1970s. Two relevant laboratories to the microelectronics technology are Korea Electrotechnical and Telecommunications Research Institute(KETRI) and Korea Institute of Electronics Technology(KIET).

MOST started the national projects in various areas of science and technology in 1981. The overall funding is twenty-three million dollars with 2,263 engineers in 1982. The figures are forty-two million dollars with 3,232 engineers in 1983. Over thirty percent of them are in the microelectronics technology. MOST plans to increase the investment to science and technology from 1.09% of GNP in 1982 to 2% in 1986. Through the national projects, MOST emphasizes very large scale integrated circuit(VLSI) design, the national design center for VLSI, and the next generation computers for the next several years[17].

Korea Telecommunication Authority under Ministry of Communications funds R&D activities on the microelectronics technology centered around telecommunications. Recently, Korea Telecommunication Authority decided to allocate three percent of its annual sale to the R&D fund, which amounts to around seventy-five million dollars in 1984. Korea Electric Power Corporation has a similar policy. The main R&D activities in the telecommunication technology are advanced telephone switching systems, optical fiber transmission systems and integrated services data network[12].

The Government plans to establish the Committee for Technology Promotion at the ministers' level to coordinate efforts on promotion of technology in general[17].

3. Main Subsectors of Microelectronics Industry

The private sector has two associations; Korea Information Industry Association, and Electronics Industry Association for Korea[6]. The majority of companies have memberships on relevant associations.

Electronics Industries Association of Korea in conjunction with the Ministry of Commerce and Industry classifies the electronics products by

(1) Consumer Equipment,

(2) Industrial Equipment, and

(3) Components and Parts.

The statistics of production, export, and import are shown in Table 1 [8]. Table 2 shows comparison with USA, Europe, and Japan.

The electronics industries are also classified by the investment sources as follows;

(1) Domestic

100% owned by Korean

(2) Joint-Venture

Jointly owned by Korean and foreigners

(3) Foreign

100% owned by foreigners

Amount of production and export by the investment sources are shown in Table 3.

The detailed classification of electronics products is as follows;

(1) Consumer Products

1.1 Amplifier

Tuner, Receiver, Music center, Equalizer, Record player, Speaker

1.2 Recorder

Tape recorder, Video tape recorder

1.3 Radio

Radio, Clock radio, Car radio, Headphone radio

1.4 Color Television

1.5 Black & White Television

1.6 Electronic Watch

Digital wrist watch, Analog wrist watch, Wall clock,

Desk clock

1.7 Others

Video game, Electronic toy

(2) Industrial Products

2.1 Computer

Calculator, Computer, Peripheral, Monitor, Display terminal

2.2 Measurement Equipment

Monitor Television, Television Camera, Electronic Measuring

Instrument, Alarm Device

2.3 Wire Telecommunication Equipment

Telephone, Telephone recorder, Switching system,

Carrier telephone system, Telegraph equipment,

Teleprinter, Interphone, Intercom, Facsimile

2.4 Wireless Telecommunication Equipment

Citizen band(CB) transceivers, Walkie-talkie,

Transmitters, Receivers

2.5 Others

Vending machine, Cash register

(3) Components and Parts

3.1 Electronic Tube

Black & white cathode ray tubes (CRT),

Color cathode ray tubes (CRT)

3.2 Integrated Circuit(IC)

Metal oxide silicon, Bipolar, Hybrid

3.3 Semiconductor

Transisters, Diodes, Light emitted diode(LED),

Thermistors, Varistors

3.4 Others

Capacitors, Varicons, Printed circuit boards(PCB),

Switches, Keyboards, Relays, Resisters

Production, export and import of each item are shown in Tables 4, 5, and 6[9]. It is expected to increase the industrial products significantly in the next ten years. Consumer products are 42 per cent of the total electronic products in 1981. They are expected to decrease to 36% in 1991. The industrial products are expected to increase 13% in 1981 to 31% in 1991. The components and parts are expected to decrease 45% in 1981 to 33% in 1991.

Software products are not classified in the electronics products yet. Common software products in Korea may be classified as follows;

(1) System software

(2) Application software

(3) Word processing software

(4) Video game software.

4. National R&D Activities

The majority of national R and D activities are carried out by the national research laboratories with the governmental funding through the Ministry of Science and Technology(MOST), and public corporations[13]. Minor funding comes from other ministries, public associations, and private companies. Private companies often share the national R&D activities with the national laboratories. There are three national laboratories in the microelectronics technology as follows;

(1) Korea Institute of Electronics Technology(KIET)

(2) Korea Electrotechnical and Telecommunications Research Institute(KETRI)

(3) Korea Advanced Institute of Science and Technology(KAIST)

They all belong to Ministry of Science and Technology(MOST). KIET and KAIST are mainly funded by MOST. KETRI, on the other hand, is funded by Korea Telecommunications Authority(KTA).

KIET and KETRI span off from KAIST in 1978. The former specializes in semiconductor and computer technologies, and the latter specializes in telecommunications. KAIST has graduate schools and research departments in addition to Software Development Center which handles data processing and time sharing services.

KIET was funded by the International Bank of Reconstruction and Development(IBRD or World Bank) with twenty-nine million dollars in 1979. This funding was matched by the government funding. The primary mission of KIET is the microelectronics technology centered around integrated circuits from design to fabrication. It has a full scale wafer fabrication facility for both metal oxide semiconductor(MOS)

and bipolar integrated circuits. In addition, it carries on computer development activities. Yearly funding is around fifteen million dollars with over 200 technical staff. It has produced the video tape recorder chips, 8-bit computer on a chip, 32K and 64K read only memories(ROM). The last ones were produced in quantity. The processing was done with 4 or 5 micrometer technology. The computers developed at KIET are microcomputers and the supermicrocomputers with capability of minicomputers[1]. It is currently engaged in development of mainframe computers in addition to advanced computers. KIET has the computer aided design systems for integrated circuits, a mask fabrication facility and a utility facility for high quality hydrogen. The Microelectronics Technology National Project and the Computer National Project has been carried out since 1982[14]. Some of projects are carried out with domestic manufacturers. KIET is starting the national design center for intograted circuits and the next generation computer project in 1984.

Korea Electrotechnical and Telecommunications Research Institute(KETRI) is funded by Korea Telecommunications Authority(KTA) with around twenty-five million dollars per year, and has over 650 technical staff. The primary mission of KETRI is to carry on R&D activities for public telecommunication networks. There are three major R&D areas as follows;

(1) Development of advanced electronic switching systems,

(2) Development of fiber optics networks, and

(3) Development of information networks such as integrated services data networks[12].

All areas span over five years.

Korea Advanced Institute of Science and Technology(KAIST) has six divisions. One of them is the Electronics Division. It has two academic departments for postgraduate studies; Electrical Sciences, and Computer Science, and two research departments; Control, and Data Communications. The academic departments have 25 professors, 70 students in the doctoral programs, and 250 students in the masters programs. They carry on various research activities covering many areas of microelectronics technologies.

Many other universities also have graduate programs with some research activities. Their funding is very limited compared with KAIST, and comes from Ministry of Education, Korea Science Foundation, and the private sector. Two of the universities, Seoul National University and Kyungbuk National University, have limited wafer fabrication facilities. The former is now setting up a computer aided design system. Limited computing facility is available at the universities. Limited numbers of professors and graduate students participate in the national R&D activities.

The private sector participates in various national R&D projects carried out at the national laboratories in addition to ever increasing internal R&D activities. Examples are video tape recorder chips, 8-bit microcomputer chips, home computers and personal computers at KIET, and electronic switching systems at KETRI. Many large corporations are spending over ten million dollars on the R&D activities. Some of them spend as much as twenty percent of their gross sales on the R&D activities. Many of them have their own research laboratories with several hundred engineers each.

Cooperation among domestic organizations is carried out in various ways, but regional cooperation between Korean and the Asian countries is very limited except in Japan. There are many areas where the regional co-operation is possible or even desirable. Examples are as follows;

(1) design center for very large scale integrated circuits

(2) development of electronic switching systems

(3) regional computer networks

(4) multilingual computer development

(5) integrated circuit pilot plant.

5. Technology Acquisition Approaches

Microelectronics technology is mainly supplied from USA and Japan, and Europe in much less degree. There are several ways to acquire the technology. They are as follows;

(1) Joint venture

(2) Comprehensive technology acquisition

(3) Procurement of specific technologies

(4) Overseas branch activity.

The Republic of Korea is changing the technology acquisition policy from the positive system to the negative system starting in the summer of 1984. A company can acquire technologies automatically by submission of an application form unless the Government decides to request further information.

The joint venture is increasingly common in the country. Most of joint ventures are in telecommunication industry, in particular, electronic switching systems since they were not developed locally until recently. So far, all but one cases of the switching systems were arranged with the joint venture. Other areas such as the computer and semiconductor industries are seeing more joint ventures.

The comprehensive technology acquisition as contrasted to the procurement of specific technologies are common in all areas of the microelectronics technology. All necessary technologies to produce a product are transferred to the Republic of Korea in the case of comprehensive technology acquisition. This is common especially among new products to the country. The problem with this approach is that design knowhow cannot really be acquired. In many cases, the Republic of Korea has gone through repeated

technology acquisitions on the same product of different generations or at different companies.

The third approach, the procurement of specific technologies is the area in which the country has some technology build-up. The procurement of specific technologies requires Korean companies to be responsible for integration of the acquired technologies to their systems, i.e., technology insertion. This approach is increasingly common nowadays. Typical examples are the integrated circuit technologies from VLSI Technology Inc. to KIET, and a Japanese company to Samsung Semiconductor and Telecommunications.

The fourth approach, the overseas branch activity, goes one step beyond the third approach. Increasingly, many companies, especially among microelectronics firms, are setting up marketing analysis offices, design centers and pilot plants in USA and other developed countries. By now, all major corporations have the overseas activities and are expanding them rapidly. Some of them are moving their entire design activity to USA. This trend will be accelerated for a while.

As stated in the previous chapter, the country also concentrates on building up the local technologies. Examples are semiconductor design, computer development, electronic switching systems and computer tomography at the national research laboratories.

The majority of technology acquisitions is carried out with domestic funds. But, some of technology acquisitions are carried out through overseas loans

such as the World Bank, the Asian Development Bank and the EXIM Bank.

In some cases such as the electronics switching systems, the company to acquire the technology is regulated by the government. Some technologies are decided to be pooled at the national research laboratories. Por example, the technology must be transferred to the laboratories in addition to a company who contracted the technology acquisition with an overseas company. This is the case of the electronic switching system at KETRI.

6. Technology and Equipment Procurement

As stated in the previous chapter, most of technology and equipment supplies are from USA and Japan.

6.1 Semiconductor

There are seven major organizations to be mentioned as follows;

(a) Korea Institute of Electronics Technology (KIET)

(b) Samsung Semiconductor & Telecommunications Co.

(c) Gold Star Semiconductor

(d) Korea Electronics Co.

(e) Hyundai Electronics Co.

(f) Daewoo Telecommunications Co.

(g) Anam Industry Co.

All but Anam Industry are aiming at 2 to 3 micro device production technology. Many have projection aligners, and some are considering direct steppers. Anam specializes on IC packaging, and automates some of its processes.

Technology acquisition of each organization is as follows;

(a) KIET

KIET has major technology acquisition from VLSI Technology Inc. on 32K read only memory(ROM) production with 4.5 micrometer silicon gate n-junction metal oxide silicon(NMOS) process technology, and NMOS and complementary metal oxide silicon(CMOS) design technologies on the basis of computer aided design training.

(b) Samsung Semiconductor & Telecommunications

Samsung obtained silicon gate CMOS process technology from a Japanese firm, various device technologies including linear, NMOS and CMOS from ITT, and 64K dynamic random access memory(DRAM) fabrication technology from a USA firm.

(c) Gold Star Semiconductor Co.

Gold Star is getting fabrication and design technolcgies on advanced memories, hybrid IC's for telecommunications from AT&T, and fabrication and design technologies on 8-bit microprocessors from Zilog.

(d) Korea Electronics Co.

Korea Electronics obtained the audio and video devices fabrication and training for design, process, and assembly from Toshiba.

(e) Hyundai Electronics Co.

Hyundai Group decided to get into the microelectronics industry in 1983, and is designing NMOS and CMOS devices. Fabrication facilities are under construction in both Korea and USA. It is known the company is also negotiating joint ventures.

(f) Daewoo Telecommunications Co.

Daewoo Group took over the microelectronics operation from Taihan Group in 1983, and is negotiating with Northern Telecomm on semiconductor devices.

(g) Anam Industry Co.

Anam Industry is one of the largest IC packaging companies in the world. Its automation facilities are acquired from Japan and USA.

6.2 Telecommunications

There are two major areas of technology acquisitions. They are electronic switching systems(ESS) and private branch exchanges(PBX). All technology acquisitions are comprehensive covering from fabrication to maintenance. All technology acquisitions in major telecommunication products are regulated by the government and KTA due to compatibility to the existing public telephone network. Some of technology transfer involves joint ventures, too. The list is as follows;

(a) Gold Star Semiconductor and AT&T

ESS and PBX

(b) Gold Star Tele-Electric and Siemens

Electro Mechanical Switching System

(c) Gold Star Telecommunications and NEC

PBX

(d) Samsung Semiconductor & Telecommunications and ITT

ESS

(e) Samsung Semiconductor & Telecommunications and Rolm

PBX

(f) Oriental Precision Co. and Ericsson

ESS and PBX

(g) Daewoo Telecommunications and Northern Telecomm

PBX

6.3 Computers

Technology acquisition is less comprehensive and regulated in the computer industry than the telecommunication industry. There are also many more computer manufactures than telecommunication manufactures.

Several companies have arrangements with Japanese makers such as Hitachi and NEC, and with USA makers such as AT&T, Digital Equipment, Honeywell, Prime, Hewlett Packard, and Mohawk Data Systems. Most of the arrangements with the U.S. firms mentioned here are joint ventures. We have been seeing rapid increase in the joint ventures since 1983. Fujitsu, IBM, and Sperry have 100% owned local firms in Korea. There are many more companies with minor arrangement on technology acquisitions with frequent export arrangement. The manufacturing arrangement for export is rapidly increasing among computer terminals, and personal, and home computers.

There are also arrangements on technology acquisitions on computer aided design systems, robots, monitoring and control systems.

6.4 Regional Resources

There are very extensive procurements from Japan, but almost none from other areas in Asia. Technology transfer to Asian countries from the Republic of Korea has not been active except in some minor cases.

7. Microelectronics Applications

Main fields of applications of microelectronics equipment can be classified similarly as the previous chapters. The basic characteristics have been consumer products for export and industrial products for domestic usage. For example, televisions and audio products are exported world wide. Computers and telecommunication equipment are used domestically. This trend is changing now. Export of integrated circuits is growing rapidly. So are the computer terminals and personal computers.

7.1 Integrated Circuits

Samsung has over 50% of the wafer fabrication in Korea, and intends to double the production capacity within two years. It exports 60% of the products mainly to the Hong Kong area, Japan and the USA. The products cover broad range of applications from consumer products to industrial products. A notable example is the digital watch ICs which dominate the market in the area of Hong Kong.

Korea Electronics mainly produces discrete components with nearly half exported to USA and Japan. It is also expected to double its production capacity soon. Gold Star produces IC's for its telecommunication products until its expected major expansion in a year or two.

Anam Industry and Motorola Korea specialize on IC packaging. The former is one of the largest companies for the IC packaging in the world.

7.2 Telecommunications

There are several areas of applications such as

(1) electronic switching systems

local installation

(2) private exchange systems

local installation

(3) terminals such as facsimile, telephone, and modem

Both domestic consumption and export

(4) optical fibers

both domestic consumption and possible export later.

7.3 Computers

Application areas of computers are mainly local information processing including office automation applications. So is the majority of software developed. Majority of computer terminals produced locally are exported to USA. Personal computers are following the same path now.

7.4 Consumer Products

Consumer products are oriented toward export rather than domestic consumption. Examples are televisions, audio products, microwave ovens and video tape recorders. This trend is expected to continue. The industry trend is toward more value added products.

7.5 Others

Control applications have not been actively developed in the Republic of Korea. Most of such products are imported mainly from Japan and the USA. There are hardly any export activities since local manufacturing has not been active so far. Major commitment on development and manufacturing of the control systems is expected in the near future.

8. Raw Materials and Infrastructure

Raw materials for microelectronics industry are not readily available in the Republic of Korea. Some of such materials are described below.

(1) Silicon

Silicon ingot for four inch wafers has been developed and being tested for mass production now. Currently, all silicon ingots are imported from USA.

(2) Chemical

No fine grade chemical products are produced locally for integrated circuits.

(3) Metal

No metal products for the 99.99% grade and above are available in the country.

(4) Printed Circuit Board(PCB)

Eight companies produce double layer PCB in quantity and multi-layer PCB in limited quantity.

(5) Special Glass

Special glass for black and white television tube is produced in quantity at two companies. Special glass for color television tube has been developed and will be produced in quantity soon.

(6) Plastics

Resin is produced in quantity, but epoxy resin is imported 100%.

(7) Fine Ceramics

One company produces various kinds of fine ceramics and is expected to export in large quantity soon. But, the imported fine ceramics still dominate the domestic market.

Infrastructure for microelectronics development has been improving in many areas such as raw materials and parts. The industry is rather vertically integrated within a company compared with USA and Japan. Subcontracting to subsidiaries is not well developed. Subcontracting to other companies is not working as well as in USA and Europe. Thus, dependency on the developed countries such as USA and Japan tends to be extensive.

9. Manpower

The manpower statistics in electronics industry is described in the EIAK reports[6,7]. The total number of employees in the industry is 153, 411 in 1982 with 44 per cent male and 56 per cent female. The numbers of employees for the domestic companies, the joint-venture companies, and the foreign companies in the Republic of Korea for 1982 are as follows:

	Total Employees	Percentage
Domestic	87,451	57%
Joint-Venture	38,996	25%
Foreign	27,164	18%

The numbers of employees by functions is shown in Table 6.

The country is producing reasonable numbers of fresh graduates despite the rapid growth in the microelectronics industry, however, there is a lack of experienced personnel in management and engineering due to the rapid expansion.

Training can be classified into three areas;

(1) Educational Institutes

(2) Research Institutes

(3) Overseas

Educational institutes includes technical high schools, technical junior colleges, universities and graduate schools. Both the high schools and the junior colleges produce sufficient graduates. Quality of instruction needs enhancement especially in the junior colleges. The universities also produce sufficient graduates, but the graduates from the qualified universities are

hard to get as most of them go to graduate schools within the country or overseas. Facility and instruction are out of date in many cases since this area is advancing very rapidly. Many college graduates go to graduate schools, and many universities offer graduate programs leading to masters and doctors programs. Their facility and instruction are not adequate except at a few institutions.

Postgraduate training at in-house institutes and the national institutes are improving, but not adequate yet. There is a model institution, KAIST, which offers a good graduate training leading to the masters and doctors degrees, and many workshops. But, the training cost per student is much higher than that of other universities. Industry is increasingly paying attention to in-house training which has not been emphasized.

The overseas training is common now. Many of comprehensive technology acquisitions include extensive training ranging up to several hundred man-years at one company. This gives good technology buildup especially in manufacturing technology and maintenance. But it often lacks training in design and project management which are necessary to develop the next generation products.

Recently the Republic of Korea made arrangements for such a training with AT and T and ITT. Twenty trainees per year for five years are sent to each company. Areas of the training cover design and development in the microelectronics technology.

As the microelectronics industry is growing rapidly in the country and requires design capability, the shortage on middle level managers and design engineers is particularly keen. The top level managers can be transferred from other areas or can be recruited from overseas, and the entry level engineers can be provided from universities. Thus, engineers tend to be promoted to management too soon. Job hopping is very common, too.

Regrading professional upgrading, retraining programs have not been adequate so far.Recently, KAIST initiated the part-time masters program. It is working well except that KAIST can only produce less than forty graduates in the microelectronics technology per year.

Another area of the problem is poor access to information. The professional personnel cannot readily access up-to-date information material due to inadequate facilities.

10. International Cooperation

Korea needs cooperation and can offer cooperation at the regional and international levels. There are many areas in which the cooperation is desirable as exemplified in the first European Strategic Programme for Research and Development in Information Technologies(ESPRIT) of EEC[4]. The problem is not the areas, but the scheme. There has not been much cooperation in high technologies among the Asian countries unlike Europe. Geography, languages, and other factors may hinder such cooperation.

Areas of the cooperation can be as follows;

(1) IC Design Center

Design IC's with good computer aided design systems.

(2) Joint R&D Programs

Share large scale R&D programs or programs which need cooperation.

(3) Training Centers

Train managers and engineers

(4) Computer Networks

Install computer networks spanning the region for information exchange and access to computing resources.

(5) Pilot Plant for Wafer Fabrication

Function as a silicon foundry for custom chip production

(6) Consulting

Have an institution for consultation and system study.

Unit US$ Million

Year	Division	Consumer Equip.	Industrial Equip.	Sub-Total	Parts & Compo-nents	Grand Total
'70	Production	30	17	47	59	106
	Export	9	0.3	9.3	46	55
	Import	14	25	39	31	70
'71	Production	33	19	52	86	138
	Export	11	0.4	11.4	77	88
	Import	18	24	42	69	111
'72	Production	55	25	80	128	208
	Export	35	4	39	103	142
	Import	24	32	56	114	170
'73	Production	135	42	177	285	462
	Export	104	18	122	247	369
	Import	55	39	94	232	326
'74	Production	259	76	335	479	814
	Export	171	27	198	320	518
	Import	69	76	145	301	446
'75	Production	270	94	364	496	860
	Export	199	35	234	348	582
	Import	61	72	133	312	445
'76	Production	551	126	677	745	1,422
	Export	390	56	446	591	1,037
	Import	86	102	188	511	699
'77	Production	679	185	864	894	1,758
	Export	436	103	539	568	1,107
	Import	76	122	198	649	847
'78	Production	927	210	1,137	1,134	2,271
	Export	654	103	757	602	1,359
	Import	118	198	316	840	1,156
'79	Production	1,374	320	2,694	586	3,280
	Export	915	111	1,026	819	1,845
	Import	159	256	415	974	1,386
'80	Production	1,148	364	1,512	1,340	2,852
	Export	985	115	1,100	904	2,004
	Import	125	251	376	1,084	1,460
'81	Production	1,574	494	2,068	1,723	3,791
	Export	1,124	125	1,249	969	2,218
	Import	147	350	497	1,277	1,774
'82	Production	1,549	639	2,188	1,818	4,006
	Export	906	207	1,113	1,031	2,144
	Import	97	651	748	1,231	1,979

Table 1. Statistics of Production, Exports and Imports by Year and Classification [5, 8]

Country	U.S.A.		Europe		Japan		Korea	
Year	'77	'81	'77	'81	'77	'81	'77	'82
Classification								
Consumer	8,119	11,404	10,558	13,560	8,686	16,765	633	1,549
Industrial	38,406	77,995	19,502	32,570	7,161	15,633	154	639
Components & Parts	9,985	24,375	7,555	9,521	6,562	14,922	926	1,818
Total	56,510	113,774	37,615	55,651	22,409	47,320	1,713	4,006

Table 2. International Position of Korea Electronics Industry [9]

Unit: US$ Thousand

Year / Amount / Nation	1981 Amount	1982 Amount	Growth Rate(%)
DOMESTIC			
Consumer Equipments	1,309,623	1,302,836	99.5
Industrial Equipments	259,457	336,036	129.5
Sub Total	1,569,080	1,638,872	104.4
Components & Parts	611,498	698,457	114.2
Total	2,180,578	2,337,329	107.2
JOINT-VENTURE			
Consumer Equipments	48,091	76,248	158.5
Industrial Equipments	192,508	237,411	123.3
Sub Total	240,600	313,659	130.3
Components & Parts	605,230	561,638	92.8
Total	845,830	875,297	103.5
FOREIGN			
Consumer Equipments	216,000	170,167	78.8
Industrial Equipments	41,745	65,468	156.8
Sub Total	257,745	235,635	91.4
Components & Parts	506,708	557,846	110.1
Total	764,454	793,481	103.8
Consumer Equipments	1,573,714	1,549,251	98.4
Industrial Equipments	493,711	638,915	129.4
Sub Total	2,067,425	2,188,166	105.8
Components & Parts	1,723,436	1,817,941	105.5
GRAND TOTAL	3,790,861	4,006,108	105.7

Table 3. Production of Electronics Products by Investment Source [8]

(Unit: US$ Thousand)

Classification	Item \ Year	'77	'78	'79	'80	'81	'82
Consumer	Amp	93,681	106,244	153,071	115,463	109,369	90,023
	Recorder player	106,403	176,103	277,270	243,258	256,818	350,356
	Recording reproducer	10,646	31,570	65,795	54,438	79,351	107,920
	Radio	66,688	61,151	58,506	33,326	51,211	19,650
	Color TV	16,237	85,447	71,443	190,208	551,619	584,123
	B/W TV	203,789	292,850	407,342	317,514	314,132	264,453
	Electronic Watch	32,693	55,839	111,551	82,599	69,853	61,548
	Others	20,812	23,028	37,984	2,343	35,379	7,006
	Sub-Total	631,372	936,162	1,374,230	1,147,551	1,573,715	1,549,251
Industrial	Computers	20,457	34,734	38,425	24,884	22,025	21,312
	Measuring Equip.	6,416	9,217	9,454	16,346	19,402	24,994
	Wire Telecom Equip.	21,527	102,079	160,905	220,162	235,006	364,009
	Wireless Telecom Equip.	100,641	60,482	73,995	46,535	120,321	103,886
	Others	5,854	10,956	36,754	56,508	96,957	124,714
	Sub-Total	154,895	217,468	319,533	364,435	493,711	638,915
Components & Parts	Electronic Tube	45,606	77,858	111,501	98,788	202,144	194,210
	IC	210,005	234,192	288,753	294,385	342,383	490,047
	Semiconductor	116,986	136,193	170,647	130,325	160,475	158,080
	Others	554,136	676,508	1,016,060	817,002	1,018,433	975,605
	Sub-Total	926,733	1,124,750	1,586,961	1,340,500	1,723,435	1,817,942
	Total	1,713,000	2,278,380	3,280,724	2,852,486	3,790,861	4,006,108

Table 4. Production of Electronics Products by Item [9]

(Unit: US$ Thousand)

Classification	Item \ Year	'77	'78	'79	'80	'81	'82
Consumer	Amp	98,230	98,178	125,590	75,643	105,700	65,291
	Recorder & Recording reproducer	99,367	160,418	253,745	273,461	314,528	273,650
	Radio	65,535	60,559	49,104	33,096	36,256	19,499
	Color TV	16,627	88,423	71,425	133,314	184,117	185,008
	B/W TV	82,417	134,495	231,123	283,718	314,474	225,067
	Electronic Watch	24,166	39,000	52,577	54,880	43,210	34,110
	Others	22,265	17,661	28,644	13,243	34,086	103,772
	Sub-Total	455,736	654,180	914,544	984,877	1,132,212	906,397
Industrial	Electronic Calculator	14,815	27,086	36,098	25,298	21,209	19,718
	Electronic Measuring Equip.	5,924	7,399	6,391	12,374	16,112	20,130
	Wire Telecom Equip.	7,182	15,295	23,780	23,380	41,475	71,497
	Wireless Telecom Equip.	33,283	50,697	37,236	22,796	40,084	45,002
	Others	1,814	2,033	7,156	25,858	26,104	50,662
	Sub-Total	63,018	102,510	110,661	114,706	144,984	207,009
Components & Parts	Electronic Tube	23,826	32,522	53,786	56,580	21,590	7,549
	IC	203,087	221,884	281,187	320,998	343,130	497,845
	Semiconductor	102,820	107,467	138,766	118,936	139,371	125,608
	Others	215,256	240,588	346,428	407,704	437,281	400,022
	Sub-Total	544,989	602,461	820,167	904,218	941,372	1,031,024
	Total	1,063,743	1,359,151	1,845,372	2,003,801	2,218,568	2,144,429

Table 5. Export of Electronics Product by Item [9]

(Unit: US$ Thousand)

Classification	Item \ Year	'77	'78	'79	'80	'81	'82
Consumer	Amp	19,384	18,304	9,714	13,890	8,847	4,030
	Recorder & Recording reproducer	48,281	91,787	81,246	68,351	73,462	6' 720
	Radio	10,491	9,132	54,772	45,539	42,799	13,666
	Color TV	6,032	8,430	2,960	4,036	3,929	3,280
	B/W TV	2,849	6,923	5,010	3,961	2,067	911
	Electronic Watch	2,937	336	3,331	5,323	7,613	7,125
	Others	4,319	1,055	2,283	4,321	4,763	6,496
	Sub-Total	76,390	135,967	159,316	145,441	143,480	97,228
Industrial	Electronic Calculator	8,818	11,181	5,273	10,282	6,036	4,967
	Electronic Measuring Equip.	16,479	30,518	27,543	57,839	52,289	87,292
	Wire Telecom Equip.	7,387	20,026	16,356	18,173	19,801	262,391
	Wireless Telecom Equip.	30,886	21,648	57,837	23,127	12,797	35,588
	Others	38,748	96,666	149,337	141,885	268,144	260,595
	Sub-Total	102,318	180,039	256,346	251,306	359,067	650,833
Components & Parts	Electronic Tube	11,421	159,263	32,619	45,496	76,898	31,656
	IC	28,508	148,147	68,334	79,502	98,750	86,294
	Semiconductor	114,561	76,654	44,011	45,057	57,497	44,188
	Others	494,664	456,322	828,721	893,587	1,007,488	1,068,794
	Sub-Total	649,154	840,386	973,685	1,063,642	1,240,633	1,230,932
	Total	847,246	1,156,392	1,389,347	1,460,390	1,743,180	1,978,993

Table 6. Import of Electronics Products by Item [9]

(Unit: Thousand Persons)

Year / Classification	'82	'83	'84	'85	'86
Total	237	314	400	454	567
Engineers	12	18	29	43	62
Technicians	52	65	78	95	113
Assembly Workers	136	176	214	256	300
Others	37	46	59	74	92

Table 7. Total Numbers of Employees of Electronics Industry [6]

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