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COMMERCIALIZATION OF INTEGRATED CIRCUITS

IN

DEVELOPING COUNTRIES

18109

UNIDO Report

by

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SUMMARY

of the study on

Quantity standards of plastic material used in agriculture and agronomic parameters appreciations

The utilization of plastic materials in agriculture started first in the so-called "rich" countries. However, today the tendency is for their use to become preponderant in the developing countries with temperate, arid and semi-arid climate.

Agriculture represents an important outlet for plastic products, their applications in the field of cultivating techniques constitute the main domain where the utilization of polyethylenes is primarily affirmed.

Plastic materials are also found in other activities such as packing in food industries where demand for these products is in constant increase for practical reasons.

This report puts the emphasis on the products most used in Algeria. Those are plastics which are called for in the production process of various-vegetals.

It also mentions the plastics used in food packing namely in dairy industry.

For all these products it reviews features relating to standards and quality control from an agronomical angle taking into account the climatic conditions prevailing in tempered, semi-arid or arid regions.

C O N T E N T S

Subject: **Means by which the commercialization of integrated circuits should be introduced to the policies of the developing countries; Emphasizing small and medium scale industrial products, as well as technological capacities of the developing countries.**

INTRODUCTION:

1.1. **Microelectronics** - which primarily refers to integrated Circuits (ICs) ranging from the Small Scale Integration (SSI) to very Large Scale Integration (VLSI) - is recognised as a vital ingredient of electronics equipment and systems. In fact, continuous increase in the level of integration is leading entire sub-systems and even systems being fabricated on a chip, few mm square size.

1.2 **Models for Growth:** The semiconductor industry developed in the beginning in USA followed by Europe. Japan entered in the race much later and recently developing countries such as South Korea, Taiwan, Hong Kong and Singapore have all launched major activities in microelectronics. The development of microelectronics in these countries can serve as useful model for planning the growth of microelectronics in other developing countries as well as Newly Industrialised Countries (NICs) and Japan would serve as a better model than USA.

1.3 The Japanese model is characterised by a strong Government control (Ministry of International Trade and Industry) (MITI) cooperative growth. The success of this model is proven by the fact that 6 Japanese companies figured in the top 10 companies of the world in chip production in 1988 with the first three positions being held by NEC, Toshiba, and Hitachi.

1.4 The South Korean model is characterised by the emergence of the 4 conglomerates, namely, Samsung, Lucky-Goldstar, Hyundai, Daewoo, which together sold chips worth US Dollar 1.2 billion in 1988.

The South Korean firms cater to the low end of the market vacated by USA and Japan.

For example, they are filling the gap for 256 K DRAMs as the Japanese shift to the manufacture 1 MB DRAMs. Taiwan, Hong Kong and Singapore are relatively new entrants into this arena but are fast making a mark through a program of liberal policies and incentives.

1.5 By the beginning of eighties USA and Japan have established off shore production lines for low end technologies to cut down mainly on labour costs. NICs took this opportunity and started assembly lines. Later on countries such as Philippines, Malaysia and others followed in setting up assembly plants. According to a world survey it is expected that the electronic production in USA would come down from 55% of world production in 1984 to 35% in 1993. 11% of this production is expected to be taken over by Row countries.(Fig.1.)

2. SCENARIO OF IC INDUSTRY IN DEVELOPING COUNTRIES:

2.1 **Patterns of Development in Developing Countries:** The Patterns of development of Electronics industry of a few representative developing countries such as Brazil, India and Korea are described.

In the late seventies and early eighties, the advent of a new generation of computers, based on a standard set of silicon microprocessors, transformed the organization of the computer industry. In US, new companies gained a foothold by competing successfully with IBM in the personal computer market. Even more interesting from the point of view of those interested in industrialization, was the spread of computer production capacity to NICs . Among these, Brazil and Korea were among the most successful. Since their success was based on very different models of state policy, industrial organization, and economic strategy, comparing the paths they chose should not only help us to understand these two countries but also to understand the problems confronting other developing countries interested in participating in high tech industry as well as the options open to them.

2.2 Latin America is relatively closed, domestically oriented industry. The structure of both industries is the result of "state intervention".

2.3 Korea had substantial, internationally-competitive, locally owned production of consumer electronics, including both components and final products. Brazil had a very small, uncompetitive, locally-owned consumer electronics production, but was the site of substantial manufacturing investments by foreign-owned computer TNCs. Despite the differences in the magnitude of the installed base in the two countries, the sectoral distribution of computer use is remarkably similar .

First in encouraging local manufacture and later in demanding exports to balance the imports used to generate local production and sales.

2.4 However, TNC domination of the local market also made it more difficult for local firms to emerge and is therefore connected to the second difference in industrial organization between the two countries, the relative historical weakness of local private capital in Brazil.

2.5 Korean firms have advantages over Brazilian firms mainly because of their overall experience acquired through years of manufacturing internationally competitive consumer electronic products, in the synergistic linkages and conglomerate economies of scale that they gain from operating in telecommunications and semiconductors and consumer electronics simultaneously as well as in the marketing and financial skills.

2.6 Historical dominance of TNCs within the Brazilian market has shaped its current computer strategies, so Korean strategies have emerged out of the historic strength of giant locally-owned chaebol in consumer electronics production. In both cases, state action has been important in supplying an impetus for moving beyond the historic status quo. In Brazil, the state was, of course, responsible for creating the space in which local producers could grow. In Korea, the state is currently providing strong incentives for the chaebol to move beyond low margin commodity products into the more risky area of larger machines.

2.7 It would be intere..ing to look at the developments in Korea in relation to another developing Country India.

The higher dependence on export has helped Korea higher export and resultant inflow of foreign exchange seems to have enabled Korea to look in for higher levels of technology, which in the international market is a costly affair.

The public sector units which dominated the scene in India and to fall back on the governments for subsidies. Moreover the higher imports and the consequent drain of foreign exchange would have acted as a factor retarding the acquisition of higher level of technology.

2.8 Indian public sector units show greater orientation towards basic research. The Korean counterparts do more of 'reverse engineering' i.e., replicating the imported parts and equipments. However, as we have already noted, in the post 1980 period the Korean firms have shifted their emphasis towards basic research. The above strategy enabled Korea to build up much more technological learning than India.

2.9 Export oriented strategy, large scale of operation, a product structure dominated by consumer elctronics and components, and rigorous R&D effort beginning with inverse engineering and then shifting towards basic research is the pattern of Korean development, which signaled success in contrast to the approach of India although the industrial scenario of India was much better than Korea in seventies.

2.10 TECHNOLOGICAL CAPACITIES OF VARIOUS DEVELOPING COUNTRIES:

In this section reference has been made about the technological capacities of some of the developing countries while discussing the industrial scenario in some of the developing countries. Korea today undoubtedly is in a strong position regards the technological capacities especially with reference to Integrated circuits industry.

2.11 Countries such as India, Brazil, China with tremendous industrial infrastructure, highly talented technical manpower still do not match Korea in its technological capacities specially in Micro electronics. Nevertheless it should be admitted that the technological capacities of these countries in general are high and all of them have very good potential for assimilating and digesting the micro electronic technologies.

2.12 With the advent of ASIC fabrication and design centre concepts more developing countries could acquire IC technologies. Several Arab Countries including Algeria, Syria, Tunisia, Iraq, Egypt have the technological capacities to work on ASIC fabrication centres alongwith design centres and as of now have to depend on a collaborator for a sophisticated silicon foundry. Most of the developing countries have the technological capacities specially to set up the ASIC fabrication and design centres.

2.13 **TECHNOLOGY TRENDS:**

In the area of technology development, DRAMs and SRAMs continue to be the key technology drivers. 1 M bit DRAMs are not employed in the same fine line processing technologies as the 4 Mbit DRAMs - are being shipped in prototype quantities. The minimum feature size has been shrinking steadily. The cutting edge production technologies of today is around 0.5 micron and is expected to be around quarter of a micron by the turn of the century. Another development which is close to commercialization is Gallium arsenide (GaAs) - on - silicon which unites the high speed and opto-electronic capability of GaAs with low material cost and superior mechanical and thermal properties of a silicon substrate. The CRAY-3 super-computer presently under development is expected to use almost all GaAs circuits. Fujitsu is committed to using high electron mobility transistors in a mostly GaAs computer.

2.14 In the area of packaging, Tape automated Bonding (TAB) is fast gaining ground. TAB takes up an area from a third to tenth of the size of most surface mounts while providing lead protection, burn-in and testability. In a different direction, research continues on molecular electronics with efforts of realise the bio-chip.

2.15 Regards the progress of ICs in developing countries there are broadly two groups. First the set of countries where sufficient technical infrastructure is available to absorb the IC technology which made a beginning with some wafer fab or assembly lines and the second set of countries where there exists competence to have design centres and are in the process of setting up wafer fab. To review this situation of industrial scenario in the first category India has been selected as it forms a typical case of developing country which couldbe arepresentative of this category.

2.16 DEVELOPMENT OF MICROELECTRONICS IN INDIAN SITUATION

VLSI technology is the driving force of the computer technology and India must have a right strategy for development in this important area. Immediate thrust will be given for the manufacture of Bipolar ICs required for consumer and professional applications as well as focus on Application Specific ICs (ASIC), which are increasingly being incorporated into the electronic systems. In case of both the digital CMOS and Bipolar as well as composite integrated circuits. Application Specific ICs capability based on cellular design approach is considered suitable.

2.17 Wafer level system integration will be the way the electronics industry will grow in times to come due to extra ordinary advantages in quality, reliability, compactness, speed and reduced power loss. ASIC capability involves system design of devices on specially created work stations. Merits in this design is density of packing, minimum pin outs and simplicity of layouts.

2.18 India has Semiconductor Complex Ltd. (SCL) and Bharat Electronics Ltd. (BEL) as the primary fabrication and design facilities. The country's major strength however, will be in wafer level integration of circuits and system and the thrust would be to promote ASIC design centres using state of the art workstations and creating multi-user cell libraries.

2.19 Design chips could be fabricated either at SCL or BEL or other national experimental facilities such as Indian Telephone Industries (ITI) depending on the application and complexity. The finer geometry application could be contracted through suitable foreign fabrication facilities, till it becomes cost effective to create additional fabrication facilities or when demand grows large enough in the domestic and export market.

2.20 CURRENT STATUS:

The current annual IC production is around 11 million silicon numbers valued at Dollar 8 million. It is estimated that import of ICs into India in 1987 in various forms viz., chips, chips on boards and chips as part of sub-systems was around Dollar 50 millions. The total percentage of semiconductors in the Indian electronic equipment is around 5% as compared to the international average of around 12%.

2.21 Manufacture of MOS ICs, till recently, was primarily carried out at the Semiconductor Complex Ltd. (SCL) before the device manufacturing and process R&D facilities were destroyed in a fire in February, 1989. Bharat Electronics Ltd. (BEL), Bangalore, primarily manufacturers bipolar ICs. In the private sector, ICs of the SSI/MSI complexity are manufactured by Hindustan Conductors Ltd. and Greaves Semiconductors. Spic Electronics Ltd. (SPEL), Madras, is essentially an assembly operation based on diffused wafers procured from abroad.

2.22 MICROELECTRONICS DEMAND, PRODUCTION & EXPORTS:

The Indian electronics industry is characterised by a microelectronics demand for a large variety of ICs in small quantities for commonly available diverse circuits designs and equipment as also systems based on imported know-how and components. It is estimated that for a production of equipment worth Dollar 12 billion in the year 1994-95, the demand of ICs would be about Dollar 650 million. Economics of scale would rule out meeting the entire demand for ICs through indigenous production. Current consumption and production data for microelectronics indicates that about 80% of the IC demand in 1988 was met through imports. It is, therefore, felt that about 50% of the demand in 1995 as also 2000 AD would still be met through production. It would be possible to create an industry with large exports of about Dollars 300 million in 1995 and Dollar 1.0 billion in 2000.

2.23 These targets for export might appear over ambitious but are considered necessary from the viewpoint of economic viability and also in light of the Government's drive to foreign exchange drain due to import of ICs. By the turn of the century, the microelectronics industry in India could be targeted to export more IC than the import of ICs. The key ingredient for realising this objective would be to provide all inputs to the microeletronics industry at near international levels including interest rates on short-term and long-term loans alongwith preferential access to foreign investors to the Indian market through fiscal incentives.

2.24 **SUMMARY OF THE INDIAN SITUATION:**

With all the basic technical infrastructure, manpower R&D facilities and two semiconductor plants; Commercialization of ICs has not been achieved. For India, establishment of several ASIC centres with the support of one big Silicon Foundry on economic scale of operations would be a better alternative for commercialization of ICs.

3.0 POLICIES OF VARIOUS DEVELOPING COUNTRIES:

Following are the policies in various developing countries. Excerpts from the industrial policies of these countries relevant to the present context of commercialization of ICs are presented here.

3.1 **PHILIPPINES:** The Department of Trade and Industry has initiated the formulation of ten year industry sector plans for ten industry sector groups including electronics/telecommunications, and is pursued with maximum private sector participation. The Plan also endeavors to strengthen the linkage between small-scale and large enterprises through the promotion of common facilities, services and the promotion of subcontracting arrangements.

3.2 **THAILAND:** The main industrial policy directions were the promotion of export oriented industries and dispersion of manufacturing industries to provincial areas.

Present policy for the VI Plan 87-91 identified 3 major groups of priority industries: (i) Export oriented industries; (ii) Small and rural industries or industries located in areas outside Bangkok and its surrounding area (iii) Engineering industry.

Exporters are supported financially by the rediscounting facilities of the Bank of Thailand and the newly established Export Development Fund. An export credit guarantee scheme is in the planning process. The Thailand Institute of Scientific and Technological Research (TISTR) functions under the Ministry of Science, Technology and Energy.

The TISTR management is conceiving the Institute's role as primarily that of an industrial research organisation adopting a quasi-commercial approach in providing specific assistance to Thai enterprises as well as guidance to the industrial sector regarding its potential development, e.g. through affective local resources utilization, and appropriate use of technological advances like genetic engineering and bio-technology, micro-electronic and solar energy.

3.3 **INDONESIA:** Until recently a striking feature of Indonesian industrialization strategy has been its almost complete orientation towards the domestic market. However now Indonesia has started emphasising on exports. Export industries tend to be labour-intensive, in Indonesia emphasis on the export oriented strategy is preferable for employment reasons. However the structure existing for experts could be utilised for increasing its export of assembled ICs on the lines of the NIC countries.

3.4 **ARGENTINA:** In 1977 the Government passed a new transfer of technology law which instilled greater flexibility into the previous system controlling licensing contracts. In 1981, the new law was replaced by a system which virtually abolished state intervention in this field. Contacts between independent firms no longer require state approval, while those between parent and subsidiary companies are only subject to control in regard to royalty levels.

This atmosphere is conducive for establishing package industries with relatively higher foreign investments.

3.5 **PAKISTAN:** Facing competition and seeking a higher share of the world market by means of a stronger orientation towards export-led industrialization requiring, among others, progress in tariff rationalization, modernization of production, quality control and standardization efforts.

Furthermore, the Government has implemented new guidelines oriented towards improving the private sector's access to foreign currency resources and towards facilitating the transfer of modern technology from abroad. These new guidelines formulate specified standard conditions which if they are adhered to will subsequently no longer require clearance of foreign credits or royalty and technical fees agreement by the State Bank of Pakistan and the Ministry of Finance.

3.6 **MALAYSIA:** 'Privatisation', a conscious attempt to reduce the relative size of the public sector and to promote a new relationship between Government and business, is strongly influenced by what is perceived as the Japan (and Republic of Korea) 'Model'.

'Privatisation', the gradual transfer to private ownership and management of such public enterprises as railways, ports, airlines, telecommunications and other infrastructure services, such as car parks and housing schemes.

Establishment of Malaysian trading companies to handle export promotion more efficiently, on the model of the Japanese sogo shosha.

3.7 **BANGLADESH:** All public manufacturing enterprises since 1987 have been subject to commercialization and a comprehensive policy reform package with the objective of developing an integrated planning, budgetary and performance evaluation system is being developed through a UNDP-financed project within the context of RIP.

Dismantling of control and a generalized reduction of policy intervention is expected to permit the inherent dynamism of private enterprise to generate growth, increase foreign exchange earnings and inflows. The new policy packages have been developed with the close collaboration of international financial agencies.

3.8 As can be seen from the policies of various developing countries mentioned above by and large they stress and address themselves on liberalisation of rules to increase exports. The suggested means of commercialization of ICs such as ASIC centres, setting up Assembly lines presented in the next section are suitable to the new policies of these countries which encourage exports and tie up with foreign collaborators for acquiring suitable technologies. As mentioned earlier exports would not only help getting foreign exchange but also establish international quality and price, a yard stick for commercialization of ICs. This incidentally increases the potentiality of these countries to take up high technology products with time.

4.0 RECOMMENDATIONS FOR REALISING COMMERCIALIZATION OF INTEGRATED CIRCUITS IN DEVELOPING COUNTRIES.

After a brief survey and analysis of the existing industrial scenario of ICs in various developing countries as well as a study of the policies and technical capacities of various countries the following recommendations have been suggested:

Following are the suggested features for realising commercialization of Integrated Circuits in Developing Countries:

* ASIC fabrication and Design Centre
* Establishment of consortiums by developing countries for setting up Wafer Fabs and Assembly Lines.
* Thrust on exports by creating the proper climate and liberalisation of controls.
* Establishment of Assembly lines for ICs and focus on assembly alone of hightech devices with time.
* Human Resource Development for updating technology levels.
* Establishment of feeder industries to manufacture raw materials in small scale and medium scale sector.
* Vertical integration to manufacture equipment and system to attract market pull.
* Identification of IC products of local needs for a given country and market survey.
* Monitoring the production yields, quality and extend preferred export support.

4.1 Commercialization of IC depends very much on an appropriate technology base production base and market both domestic and international. These relevant points would be discussed in the frame work of developing countries:

4.2 ASIC fabrication and Design Centre.

Conventional wafer fab requires high level of technology. Capital investment and market demand matching the output of the wafer fab with economic scale of operations. Considering these factors it

seems that commercialization of ICs using such Silicon foundries is unrealisable by many of the developing countries because of financial constraints. The rapid changes occurring in semiconductor technologies could be insurmountable hurdles. ASIC route could be encouraging in such a scenario.
ASIC: Application Specific Integrated Circuit. ASICs have a special relevance for developing countries since their electronic industries are characterised by the requirements of a large number of different circuits in small quantities.

ASICs permits an equipment or system designer to create an IC to suit his specific needs. This certainly leads to higher reliability, reduction in volume and finally a less expensive end product as compared to designing a product with standard IC parts. ASICs are the fast growing segment of micro-electronic Industry. The trend is expected to continue as they provide security of design and competition advantage in both cost and functionality.

Features of ASIC:

- Low level to moderate level of investment
- Design intensive
- Phasing of technology development for ASICs is more conducive than conventional VLSI technology.
- Plays a vital role in supplying the much needed special ICs in professional equipment, defence and control electronics.

ASICs are generally classified into programmable logic devices or arrays (PLD/PLAS) Semi-custom ICs and full custom ICs.

Briefly the ASIC involves Design, Standard Cells or Gate arrays metallisation masks interconnects and packaging.

ASIC centre can process all the steps and has to buy only Standard Cells or Arrays from Silicon Foundries. ASICs are usually cost effective in the range of 1000 to 100000 pieces.

ASICs are fast growing segment of microelectronics family. As microelectronics content of system increases and ASICs continue to provide competitive advantage in both cost and functionality.

According to the findings of Dataquest every dollar sales of ASIC's is associated with a total microelectronics sale of Dollars 5 and system sale of Dollars 30.

High volume customer specific products such as watch chips, microprocessors and controllers have the potential of developing new markets and producing good profits.

A low cost PC system development effort should aim for a low price of 200 to 250 Dollars which could be achieved by designing and fabricating ASIC glue chips or chip sets that can replace a large number of chips on the mother board. This can be realised by developing countries such as India, Brazil, China etc. Similarly, each country could develop special ASICs for need based products be it a watch, toy, medical electronics or a modern identified as the commercially exploitable product in that country.

4.3 Establishment of Consortium by developing countries for wafer fabs: The option available is to set up a reasonably good wafer fab with current technologies with 1 to 1.5 micron feature size and economic scale of operations with a matching packaging facility which is extremely expensive and normally beyond the reach of many of the developing countries. However the need of electronic devices containing ICs is increasing fast in every country in all its sectors consumer, telecommunications, professional equipment and defence.

The unacceptable alternative to this investment is a continuous financial drain year after year in foreign reserves.

The proposed solution for such a situation is to set up a consortium silicon foundry by like minded countries. While perhaps this may sound strange in the field of Electronics this is an accepted norm resorted to by several European countries where they have established consoritums in the fields of Science and Technology, be it Synchrotron Laboratory, Nuclear Reactor for fundamental research or other centres for advanced research.

The reason for starting such consortiums is again the inability for a single country to set up such advanced research centres with huge investments.

A world class silicon foundry could be established by a consortium of 5 or 6 neighbouring countries. Each country should have its own ASIC fabrication centres. The ASIC centres of member countries can order their standard cells and arrays from the silicon foundry and fabricate the products required for their nations. This would enable the member countries both standard ICs and ASICs.

This arrangement not only leads for a successfully commercialization of ICs but also provides a unique opportunity for training of manpower, updating the technology as well as create possibility of exporting certain ASICs. Since both talent and funds are pooled a continuous upgradation of technology and moving from right to left of the cycle of IC curve is possible.(Fig.2.)

4.4 Thrust on exports by creating the proper climate and liberalisation of controls.

Export Market:

Acceptability of the product is one of the chief requisites for commercialization. It can take long time for establishing acceptability in domestic market. However once the acceptability is achieved in international market even to a limited extent it becomes far more easier for the same product to be sold in domestic market.

When a product is sold in the International market specially in countries such as USA, Europe or Japan the credibility for quality is established which in turn can generate larger domestic market.

INFORMATION ON EXPORTS:

It is not easy for a busy buyer abroad to get reliable and up-to-date information on sources of supply in a particular country "A" thus the country "A" can lose export opportunities by default, for the simple reason that trade information is not made easily available even in international countries like Hong Kong, even to persuade a serious prospective buyer to invest time and money on a visit to the country "A" to explore sources. A certain amount of reliable and concrete information is required to be made available to him abroad.

4.5 **ESTABLISHMENT OF ASSEMBLY LINES FOR ICs AND FOCUS ON ASSEMBLY ALONE OF HIGHTECH DEVICES WITH TIME:** Low end technologies such as IC Assembly lines have been established by USA & Japan in third world countries to take advantage of low wages. It is known that this kind of operations in developing countries specially in the pacific rim such as Korea, Taiwan and Hongkong resulted in instant success in commercialising ICs. Other countries such as Philippines, Malaysia and Thailand have also set up assembly lines. It is however important that economic scale of operations are adhered to for commercial success.

For some of the small developing countries which cannot form consortium the best option is to set up assembly line and continue take up high valued ICs and Memories and move from right to left of the IC cycle curve. Maintaining exports is the key factor for success. Thus government support in creating the proper business climate is very essential.

4.6 **HUMAN RESOURCE DEVELOPMENT FOR UPDATING TECHNOLOGY LEVELS:**

IC Technology is not only sophisticated technology but known for its obsolescence. Linkages between IC Industries and academic institutions as well as R & D Labs is essential to establish a good rapport and generate skilled man power, assimilation and updating technologies help to move into high technology and value added products.

4.7 **ESTABLISHMENT OF FEEDER INDUSTRIES TO MANUFACTURE RAW MATERIALS IN SMALL SCALE AND MEDIUM SCALE SECTOR:** To ensure the commercial success of IC industry the developing countries should set up a programme to reduce the imports of raw materials by developing and manufacturing the semiconductor materials such as high purity chemicals, gases, photo resist materials, epitaxial wafers and substrates. This will ensure availability of the much needed materials for the production of ICs and provides the cutting edge by reducing the production expenditure.

4.8 **VERTICAL INTEGRATION TO MANUFACTURE EQUIPMENT AND SYSTEM TO ATTRACT MARKET PULL:** One of the most important factory for commercial success is market pull. There is need from equipment and designers for guiding the microelectronics industry in a profitable direction. It should be recognised that the value added is significantly greater in the process of integration of electronics components in equipments and systems. As explained in earlier section an ASIC with one dollar results in 30 Dollars worth system. This aspect of vertical integration can boost the commercialization of ICs in developing countries such as India, Brazil, China etc. where there is substantial technical infrastructure and good level of equipment manufacturing capabilities exist.

4.9 **MARKET AND TECHNOLOGY SURVEY:**

A sectoral market survey for the region, of electronic products and systems, as an essential part of defining both a system and component development strategy.

The survey should cover electronic products and companies in consumer electronics, communications, computers, controls and instrumentation, in terms of both imports and local production.

The existing facilities may need to develop greater flexibility in incorporating a more diversified product mix. New designs may have to be introduced, that are compatible with the existing technology, and current designs being produced should be enhanced;

Collecting and disseminating information about electronic and microelectronic activities in the respective country, and to assist in carrying out the proposed market survey would be a worth while exercise in the first stage.

Application specific ICs, when they are properly identified, may present a good market, since in their case the cost is calculated not in terms of ICs alone, but other factors as well: design efforts, value added etc.

Developing countries should establish a R&D line or Pilot line to try out various process, optimise production parameters, introduce innovations.

The Pilot line should be manned by experienced and skilled personnel to thoroughly study the product and pross parameters.

4.10 PRODUCTS OF LOCAL NEEDS:

Good understanding of local needs and capability of responding to local needs with specific microelectronics applications form an important component for commercialization.

Specific designs developed locally may offer the best response to more pressing national needs; examples for such applications could be varying in different countries. It could be a PC, TV and Radio in countries such as India, China, Watches, Calculators and Souvenirs in tourism based countries. Bilingual equipment terminals, PCs, printers are ofcourse immediate needs in several countries.

It is known that there are both Bipolar as well CMOS facilities in various developing countries including India, Iraq, Algeria, to name a few which are under utilised for various reasons. In most of the cases it is because of wide ranging product mix and the products in demand are not required in large numbers resulting in an economical scale of operations of the wafer fab. This can be best remedied by pooling the various needs of the neighbouring countries, which results in not only viability but also commercialization of several products. The idea of pooling the needs of various developing countries with a consortium is explained elsewhere in the report.

Commercial success depends to a large extent on the demand of the manufactured product.

4.11 MONITORING THE PRODUCTION YIELDS, QUALITY AND EXTEND EXPORT SUPPORT FOR SELECTED INDUSTRIES.

A nodal agency can be set as a part of Governmental body whose functions would be to monitor and evaluate the parameters such as production yield, the quality improvement, consistency in various batches of production & deliveries. Based on these evaluations a company could be picked up to encourage by giving incentives for expansion, help to provide the most needed the organisational support to have competitive edge in internal market. Even if a single company gets large assistance in realising commercial success in the international scene it would set a fine example to be followed by several to achieve that status.

This would also generate a competitive spirit, as well as make entrepreneur clearly understand the criteria necessary to get Government support for commercial success either at domestic or at international markets. This would greatly help in creating the much desired conscience for achieving quality and optimum cost.

Export is extremely important not only for earning the much needed foreign exchange but also achieving international quality and price for the product and paving the way for getting hold of higher technologies to manufacture sophisticated devices. The country going for the manufacture of high grade devices not only overcomes the inherent obsolescence in this rapidly changing field but also attains a status by which it can continue to earn foreign exchange and keep updating the technologies continuously and move from right to left of the IC cycle Curve as indicated in figure 2.

5.0 PRODUCTS FOR MEDIUM SCALE AND SMALL SCALE INDUSTRIES:

An analysis of the cost structure of Semiconductor Industry indicates specially in developing countries that over 55% of the sales realisation goes towards the procurement of imported raw materials, thus, the developing countries invariably siphon off more funds to developed countries.

5.1 In developing cuntries such as India, where technical infra structure and R&D facilities are available in various national laboratories a significant program for indigenous development and manufacture of raw materials and equipment has to be set up. Following is a list of raw materials which can be produced in Medium Scale Industries:

1. Special ultra pure gases
2. Ceramic packages
3. Quartz ware
4. Emulsion and Chrome Mask blanks
5. Fine wires
6. Lead Frames
7. Photo resists
8. Epoxies and Silicones.

5.2 The norms of Medium scale operations differ from country to country. However the raw materials presented above fall in the class of medium scale industries. It is necessary for the countries with advanced technical infrastructure to set up such industries to save foreign exchange and provide easy access for the raw materials required for Semiconductor Devices.

5.3 Equipment: It is gnerally believed that economies of scale do not justify local manufacture for Semiconductor industry. However sophisticated equipment such as diffusion furnaces, bonders, metallisation system, moulding tools are generally hand assembled with purchased and sub contracted parts in medium sized companies.

With labour cost less by ten times and the ensured value addition by assembling and intergrating the systems with imported sub assemblies and parts, foreign exchange is saved considerably. The capital equipment could be made available at much lesser cost compared to imported value by establishing medium sized industries meant to assemble equipment.

The savings in Semiconductor equipment cost as well as foriegn exchange would contribute to a large extent for commercial success of the industry.

5.4 DESIGN CENTRES AND SOFTWARE:

ASIC Centres are growing rapidly all over the world. Design centres and software shops can be developed as feeder units to ASIC Centres. Design centre need not be the monopoly of a big semiconductor house. With a modest investment of 30,000 to 40,000 Dollars one can build a design centre for designing a gate array. A design centre can work for the replacement of a lot of boards that have many components by a single ASIC Chip reducing the system size, improving performance and reliability and specially the reductic in manufacturing costs.

Design centres, software packages and work stations are some of the crucial cost saving sectors which are within the scope of small scale industries.

6.0 **CONCLUSIONS**: Many of the developing countries have developed IC technologies some of them on their own and few by collaborative efforts. However a majority of the countries failed to establish Bipolar & CMOS Silicon foundries at economic scales of operation resulting in unsuccessful commercialization of ICs with notable exceptions such as Korea, Taiwan etc.

With the development of ASIC there is a new hope for these countries to commercialize ICs. In the opinion of the author. There are mainly three strategies that could be employed to realise commercialization of ICs in developing countries.

1. Develop ASIC Centres with a support of one major silicon foundry working economic scale of operations in the country or collaborate with a large foreign silicon foundry.

2. Consortium: A conglomerate of 5 or 6 developing countries should form a consortium to set up major silicon foundry with each country having its own ASIC Centres.

3. Promoting an aggressive export policy and take advantage of setting up assembly line for the ICs offered by developed countries and later on enter into high technology ICs with time.

BIBLIOGRAPHY

1. A Compendium of Technology Plans and Policies in selected developing countries 1986 UNIDO-UNIDO/IS.64.

2. Automation and the world restructuring of the Electronics Industry: Strategic implications for developing countries, World Development, No.3, 1985.

3. Microelectronics in India - A Blue print for 2001 (A report of the Joint Scientific Committee to the Department of Electronics India June 1988).

4. Various Reports of Electronic Commission of India and Department of Electronics, India 1985-88.

5. Technology Atlas - An Interim Report - March 1987 Asian and Pacific Centre for Transfer of Technlogy - Bangkok.

6. Selected aspects of Micro Electronics Technology and applications custom and semicustom integrated circuits - Sigurdson J. UNIDO, 19631, 1986.

7. Datamation Reports.

8. UNIDO Reports on several countries including Thailand, Malaysia, Argentina etc. on Industrial Policies.

9. Private Communications.

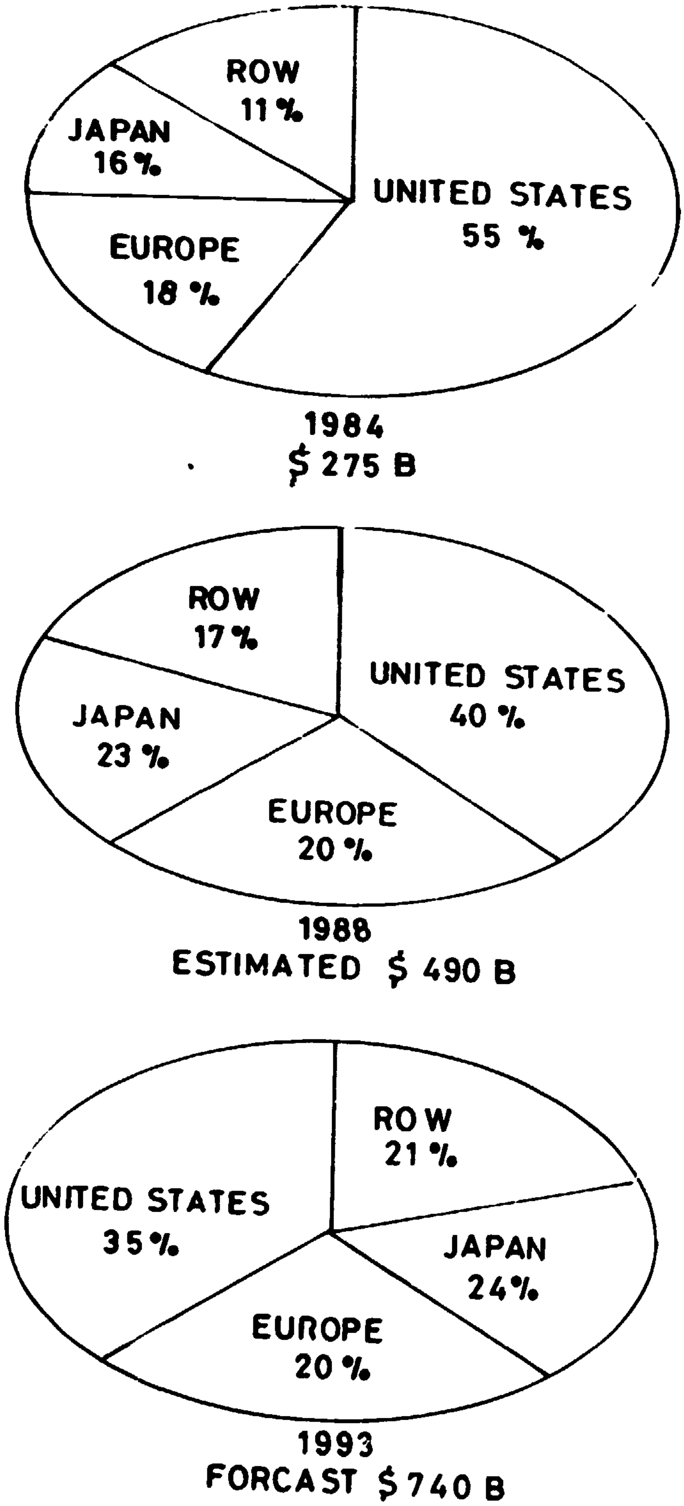
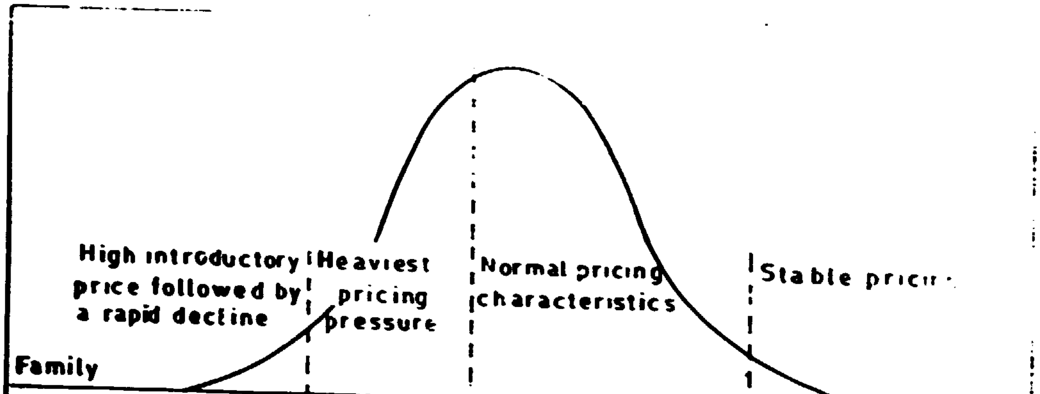


FIG 1 WORLDWIDE ELCTRONIC EQUIPMENT PRODUCTION



Family	INTRODUCTION	GROWTH	MATURITY	SATURATION	DECLINE (OBSOLETE)
RAMS	1M DRAM 256K SRAM 64K ECL SRAM	256K DRAM 64K SRAM 16K ECL SRAM	64K SRAM 16K SRAM	16K DRAM 4K SRAM 4K ECL SRAM	4K DRAM 1K SRAM 1K ECL SRAM
ROMs	1M ROM 4M ROM 64K PROM 1M EPROM 64K EEPROM	256K ROM 512K ROM 32K PROM 128K EPROM 256K EPROM 32K EEPROM	64K ROM 128K ROM 16K PROM 64K EPROM 16K EEPROM	16K ROM 32K ROM 8K PROM 32K EPROM 4K EEPROM	4K ROM 4K PROM 4K EPROM 16K EPROM 1K EEPROM
MPUs	32-bit MPU MPU-EEPROM	DSP Single chip	16-bit MPU DSP chip set	8-bit MPU	4-bit MPU
Logic	EPALs EEPALs	ASTTL LSTTL ALSTTL	STTL CMOS logic	TTL	
Linear	CMOS op amp	Monolithic A/D Monolithic D/A Switching voltage regulator	Hybrid A/D Hybrid D/A BIFET op amp Series voltage regulator		Bipolar op amp
GaAs	1K SRAM Gate arrays	SSI, MSI logic MMIC			

DSP digital signal processor.

FIG.2 - IC LIFE CYCLES

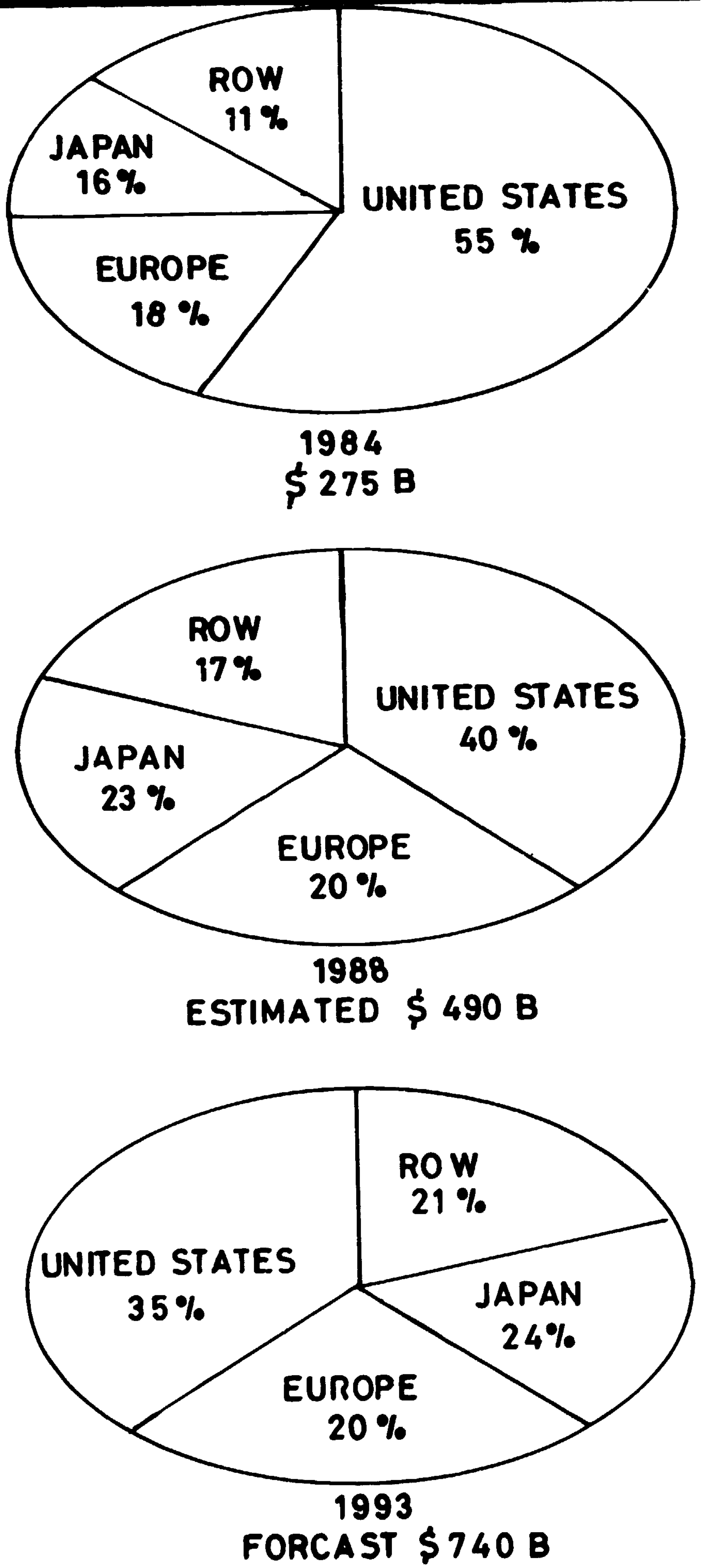


FIG.1 WORLDWIDE ELCTRONIC EQUIPMENT PRODUCTION

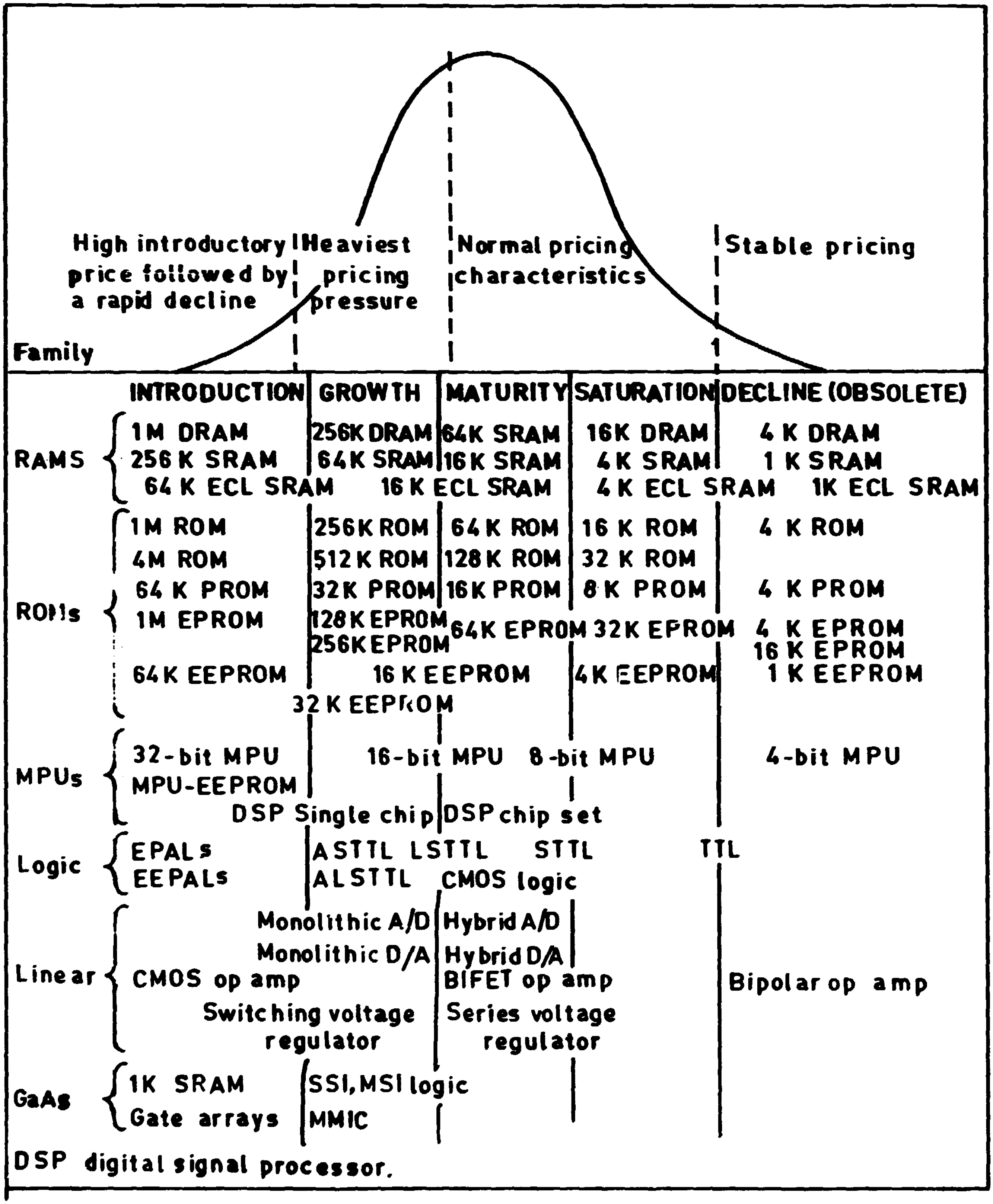


FIG.2 _ IC LIFE CYCLES