

## **The National Si-Soft Project**

Chun-Yen Chang

*National Endowed Chair-Professor & President*

*National Chiao-Tung University*

*HsinChu, Taiwan*

&

*Foreign Associate, National Academy of Engineering, USA*

*E-mail: [cyc@cc.nctu.edu.tw](mailto:cyc@cc.nctu.edu.tw)*

Professor Charles V. Trappey\*

*Department of Management Science, National Chiao Tung University*

*E-mail: [trappey@cc.nctu.edu.tw](mailto:trappey@cc.nctu.edu.tw)*

### **Abstract**

Taiwan's electronics industry emerged in the 1960's with the creation of a small but well planned IC packaging industry. This industry investment led to bolder investments in research, laboratories, and the island's first semiconductor foundries in the 1980's. Following the success of the emerging IC manufacturers and design houses, hundreds of service firms and related industries (software, legal services, substrate, chemical, and test firms among others) opened for business and completed Taiwan's IC manufacturing supply chain. The challenge for Taiwan's electronics industry is to take the lead in the design, manufacture, and marketing of name brand electronic products. This paper introduces the Si-Soft project, a national initiative that builds on Taiwan's achievements in manufacturing (referred to as Si-Hard or Silicon Hardware) to launch a new wave of companies. These firms will contribute to the core underlying technology (intellectual property) used in the creation of electronic products.

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\* Please send all correspondence to Prof. Charles Trappey (E-mail: [trappey@cc.nctu.edu.tw](mailto:trappey@cc.nctu.edu.tw)).

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## *The History of Taiwan's IC Industry*

Taiwan's IC industry began in the 1960s with IC packaging, the industry process whereby pre-manufactured wafers are packed into lead-frames and substrates to form the chips used in computers and other electronic devices. Packaging involves molding the chips into small components that can be mounted on boards that are fitted into electronic devices such as personal computers. Packaging requires less technology and more labor than wafer fabrication and much, much less technology than logic design. Since Taiwan had little IC technology in the 1960s, packaging was used as a test case to demonstrate that there was a viable and sustainable market. By 1970, the government supported several laboratories to transfer the necessary technologies to build the fabrication and manufacturing facilities for an upstream supply chain. By the 1980's, IC fabrication sites and IC design laboratories completed the supply chain, forming the first nascent IC industry in the Hsinchu Science-based Industrial Park (Hsinchu SIP or HSIP).

### *1960s -- IC Packaging*

During the 1960's, Taiwan's Gross National Product was about \$237 US dollars per capita. Industry was concentrated in commerce (46 percent) and manufacturing (31 percent). Although agricultural contributed 23% to the economy, the manufacturing sector was developing and creating a shift in the economic structure. The trend at the time was to build the textile, plastic, glass, and paper industries through government incentives. The greatest incentives were given to companies that attracted advanced technology and patents that would increase the production of exports. A special industrial zone was set up in Kaoshiung in 1966 to facilitate the export of domestically manufactured goods and to reduce the trade deficit. Kaoshiung Electronics Company and Phillips Taiwan set up facilities in the HSIP and were the first to package ICs.

### *1970s -- ITRI's Electronics Laboratory*

The first global oil crisis occurred during 1973, causing a 23 percent rise in domestic prices, an inflation rate of 41 percent, and a decline in the economic growth rate to one percent. During the 1970's, Taiwan's agricultural sector was in decline and although the manufacturing sector had grown and was a major contributor to the economy, Taiwan's overall exports were badly hit by the rise in inflation. The government sought new ways to stimulate the economy by increasing public spending on six major transportation projects. In addition, a 10-year national development plan was formulated to improve infrastructures and facilities, to speed up industrial

modernization, and to build heavy industries such as steel, copper, iron, aluminum, shipbuilding, automobiles, machinery, and petrochemicals.

The development of Taiwan's IC industry began in 1974 when the Industrial Technology Research Institute founded the Electronic Research and Service Organization (ERSO). ERSO was the launch point for the IC manufacturing industry and provided the basic laboratories and personnel for the transfer of technology. A key milestone for ERSO was a 1976 project with RCA to transfer CMOS IC technology. The project was instrumental in demonstrating the feasibility of industry and government working together to build a new industrial sector. During 1979, regulations governing the establishment of science and industrial parks were written and the first IC industries began to build facilities in Hsinchu.

#### *The 1980s -- IC Manufacturing and Design Industries Launched*

During the 1980's, Taiwan was affected by the global recession, resulting in falling demand for Taiwan's products and a decrease in private investment. With government backing, the United Microelectronics Corporation (UMC) was founded and represents the first step towards moving the electronics industry from IC packaging into IC manufacturing. Taiwan continued to adjust the industrial structure by promoting the information and electronics industry through incentives and regulations. The regulation called "Encouraging Investment Conditions and Requirements" had a positive effect on the investment climate and helped to build the electronics sector in spite of the global recession.

When America's telephone monopoly was dismantled, the newly formed regional companies began to send orders to Taiwan firms to manufacture telephone parts and telecommunications equipment. Orders from the "Baby Bell" companies helped UMC and others in the Science Park survive a difficult start-up period during adverse economic conditions. The Taiwan Semiconductor Manufacturing Company (TSMC) was established in 1987 and began the island's first IC design business and created the dedicated semiconductor foundry industry. As a result of the formation of UMC and TSMC, the foundation for the IC industry was completed. Taiwan began making computers, PC peripherals, and communications devices and to create products that boosted the demand and increased overall IC production.

#### *1990's -- Building the IC Industry Supply Chain*

During the 1990's, Taiwan aggressively developed the electronics industry and added support industries to the supply chain. After 30 years of development, the design and manufacturing supply chain system was completed with over 150 related IC companies, as shown in Figure 1. The workforce exceeded 50,000 employees,

most of whom are college educated and bi-lingual. Investment commitments at the end of the 90's almost reached 80 billion U.S. dollars, setting a record for growth and using up all of the land in the Hsinchu industrial park. The IC firms began planning and building facilities in the Tainan Science-based Industrial Park (TSIP).

Research and development investments in the global IC design industry typically account for 11 percent of a company's total expenses. By comparison, Taiwan's IC R&D expenses accounted for less than five percent since local companies are large-volume OEM production. The next decade of development will show greater emphasis on the creation of intellectual property and greater investment in research.

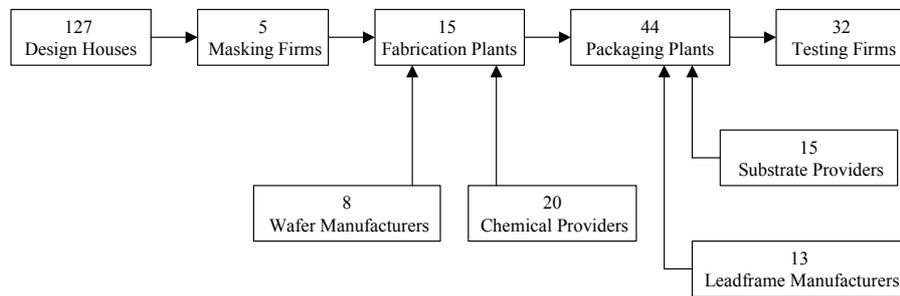


Figure 1. The ERSO/ITRI (2000) diagram of the Taiwan IC industry supply chain

*2000 and Beyond – Innovation, Design and Creation of Intellectual Property*

The objective of the next ten years is to foster the design and creation of intellectual property based on Taiwan's existing strengths in the areas of hardware and manufacturing of electronic components (Figure 2).

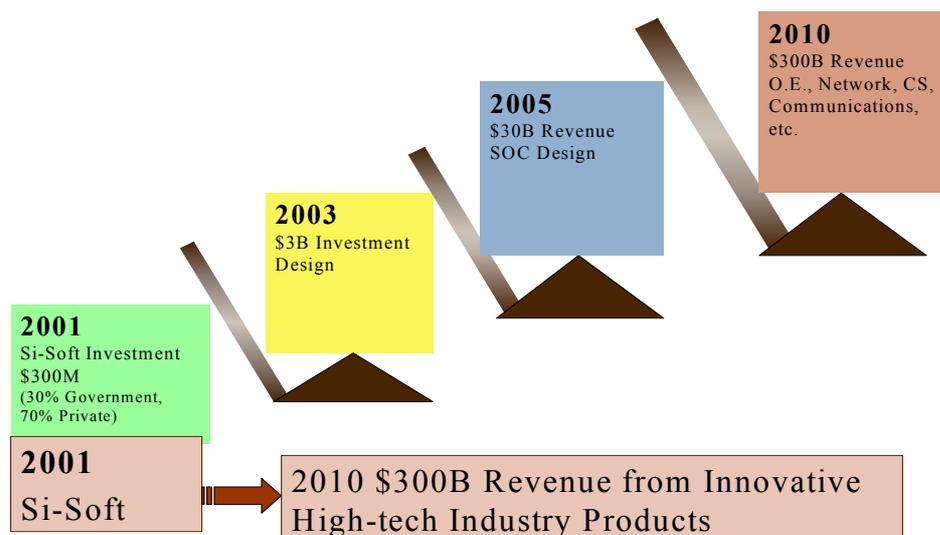


Figure 2 Si-Soft builds opportunities for knowledge workers including designers, engineers, programmers, managers, and legal experts

The long-term plan is to invest up to \$300 billion in the development of innovative products (intellectual property base) in cooperation with well-known and well-established technology firms.

### *Introduction to Taiwan's National Si-Soft Project*

Taiwan has developed one of the most comprehensive semiconductor industries in the world with an infrastructure that includes design houses, semiconductor and other component manufacturing facilities, masking process plants, testing companies, and a wide range of component packaging lines. Companies comprising the semiconductor supply chain are globally linked, meaning that they are integral to the worldwide production of electronic parts, components, and equipment. The state of development for the semiconductor industry has reached a high level of efficiency with production that often surpasses expectations of quality and delivery time. As a result, Taiwan's foundries are ranked first among competitors and hold 76% of the global market share. Fabless design houses are ranked second (after the US) and hold a 20% market share, while testing and packaging are ranked first with a 35% market share.

Taiwan's electronics industry has experienced success in the area of electronics manufacturing and foundry based production of semiconductors since the 1980's. However, innovative design and the creation of brand name products have not reached the desired level of development. Undoubtedly, there have been overwhelming successes with innovation and brand name development and the cases of Acer, TSMC, UMC, and others are frequently cited. These companies, through good management and excellent research and development, have become global members of the electronics supply chain and are producing extraordinary amounts of goods and services. The limitation is that not enough of Taiwan's electronics companies are driving the designs for global consumer products and contributing to the core underlying technology (intellectual property) used in the creation of these products.

The long term objective and vision of the Si-Soft project is to promote the creation of intellectual property by Taiwan's design houses and to lead the third wave of industrial development where Taiwan companies are not only important members of the global electronics supply chain but are direct contributors to the design, manufacture, and marketing of name brand electronic products and consumer goods. Taiwan has as its strengths the ability to design, build and operate the world's best semiconductor foundries and packaging factories. The design houses are world renown as are the local testing, design services, EDA, and IP industry products. However, even these successes lag behind achievements in the Silicon Valley, the

world center for semiconductor design and innovation.

Europe, Japan, Korea, the US and Taiwan are transferring design and manufacturing technology to the developing China market, each according to their specialty. The impact to Taiwan is that industry's traditional role as an OEM and ODM center is changing, businesses are facing new challenges, and entrepreneurs are recognizing new opportunities. Si-Soft addresses this marketplace dynamic through the strategic restructuring of industrial development. Taiwan's manufacturing strength must be used as an engine to drive new designs. Whereas the past emphasis has been on production, the new emphasis is being placed on products and the final step will be to emphasize brands.

The desired outcome where Taiwan firms move from manufacturing to brand and product development depends upon the support and creation of design houses. Platform service development, such as the sale and re-use of virtual components, the enhanced access to software programming talent, and the training of a larger pool of knowledge workers and design artists is ongoing across Taiwan. A strong platform of services provided by knowledge workers and designers is the base for new products that can be rapidly manufactured by Taiwan's highly integrated electronics supply chain.

The creation of the Taiwan's knowledge economy does not mean a complete shift from one manufacturing strategy to another. Rather, the Si-Soft strategy builds on the existing industrial infrastructure and utilizes existing industrial strengths. On one hand, the traditional strengths were built from the Si-Hard (or Silicon Hardware) ODM/OEM manufacturing and manufacturing services. Over the last twenty years, government, industry, and academic research efforts have yielded fast-follow technology development and transfer in the areas of micro-electronic machines (MEMS), nano-device technology, material science, manufacturing, engineering and the pure sciences. In many cases, such as in the development of semiconductor manufacturing and packaging, the technological does not follow but leads the world market. On the other hand, the Si-Soft project (or Silicon Software) places emphasis on product development that upgrades the existing manufacturing base. The products that best match the existing manufacturing capabilities are information appliances (personal digital assistants), energy products (batteries), electro-optical devices (LCD's, optical communication devices), Internet devices (routers, switches), SoC based products, and bio-medical products (bio-chips). The development of these special classes of products cannot be realized without a well-developed Si-Hard supply chain.

The Taiwan government has been very generous in investing in and encouraging the electronics manufacturing. The first government sponsored program began with

UMC, a 110 NT million dollar investment that remains to this day a private (and not government controlled or public) electronics manufacturing leader. Taiwan Semiconductor Manufacturing (TSMC) is another case in point and in 1987 received 300 NT million from both private and public sources. During the last two years, the Taiwan government has invested over 150 NT billion in Integrated Circuit (IC) development by investing in UMC, TSMC, WinBond, Mosel, VSMC, and others. Investment has also been used to build the Liquid Crystal Display (LCD) manufacturing capabilities with 30 billion NT\$ investments in companies like Chi Mei. Another 7 billion NT\$ is planned to further develop the thin-film (GaAs and EpI) technologies. The scale of Si-Hard investment, over 180 billion NT\$, represents about two-thirds of the total planned investments for Si-Soft. The Si-Soft project predicts over 300 billion NT\$ revenue from the development of innovative products and innovative design companies.

The experienced learned from the development of Si-Hard companies is that public financed investment will have greater success if managed by industry professionals. Government controlled enterprises tend to remain isolated from market forces, are slow to fail, and can become a public burden. Thus, Si-Soft insures that 70% of the investments are solicited from private sources and 30% are derived from government sources. The schedule of investment will be increased in the year 2003 to support further development of innovative design capabilities. Revenue yields from the investment are targeted to reach the 30 billion NT\$ level in the year 2005, particularly from the sale of virtual components (intellectual property blocks) used in System on a Chip (SoC) applications. The Si-Soft investment will further stimulate at least 300 billion NT\$ revenue in the year 2010 from the marketing of innovative products.

As world electronics market develops shifts in production invariably occur and manufacturing facilities move to take advantage of materials and labor. Mainland China is showing increased manufacturing development whereas other regions in Asia are seeing a boom in service and intellectual property development. That is, manufacturing growth in one area is complemented by the growth of knowledge-based economies in other areas. China began semiconductor production from mid-range technology (0.25 micron) and will migrate to 0.18 microns this year. The manufacturing advances in China are complementing and supporting the market shifts in Taiwan. Taiwan is phasing out mid-range manufacturing and is producing chips using advanced processes at the 0.13 and 0.1 micron levels. In addition to these changes, the Taiwan semiconductor industry is shifting toward the creation of intellectual property, the innovation behind the products manufactured in the increasingly sophisticated and expensive semiconductor fabrication facilities. Further,

the creative design of integrated circuits, and the ability to build a system on a chip by integrating blocks of intellectual property is fueling the growth of Taiwan's knowledge based economy. These changes to the economy (Figure 3) are encouraged and supported by the National Si-Soft Project with funding from the Ministry of Economic Affairs (MOEA).

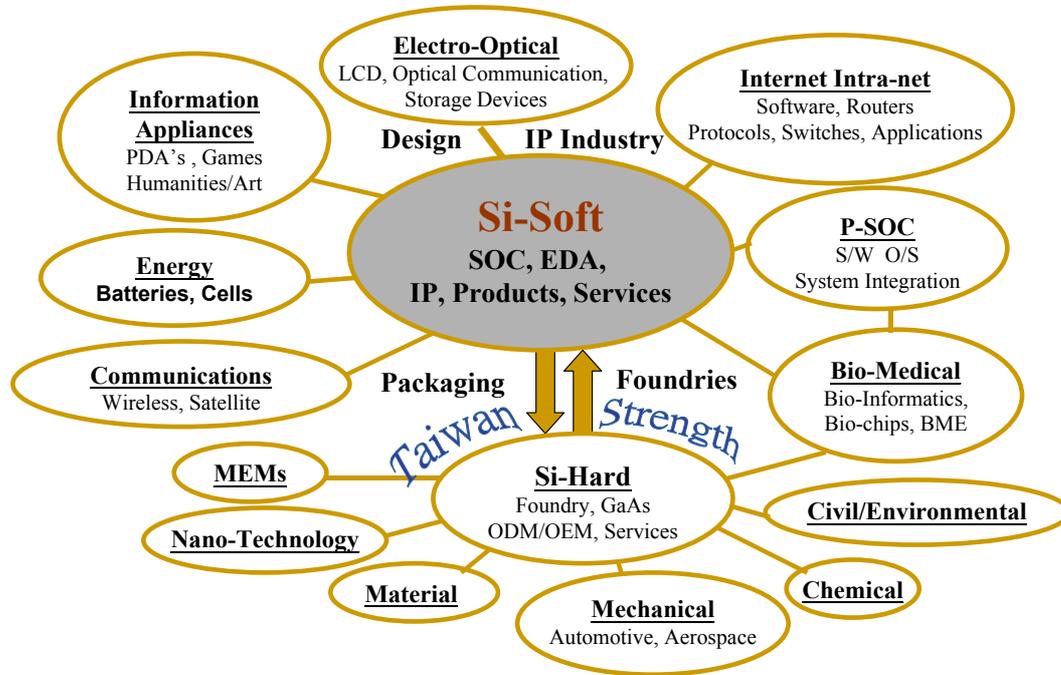


Figure 3 Building out the Taiwan electronics industry supply chain with Si-Soft

The goal of the National Si-Soft project is to develop the System-on-Chip (SoC) infrastructure for domestic as well as international production facilities. These new facilities will enable the international supply chain to source designs, mix-and-match intellectual property, manufacture, and test deep-sub micron integrated circuits. The Si-Soft project is divided into five parts:

- Innovative product designs: Three product lines will demonstrate SoC solutions and the excellent design environment in Taiwan.
- Silicon Intellectual Property (SIP) development: Customers will be provided with a broad range of SIPs needed for the three product lines mentioned above. All SIPs will be verified for robustness and classified into Gold, Silver and Bronze categories for customers one-stop shopping.
- Electronic Design Automation (EDA) flow integration: New design platforms will be developed to satisfy the ever increasing demand for software to test and verify virtual component designs for re-use.
- SIP Mall: A variety of SIPs will be put together for customers to quickly select

and integrate the SIPs into SoC designs

- Design service solutions: A new design-service industry will be developed and will be used to appraise the performance of the SoC project. In addition, the construction of a SoC industrial park is proposed to better serve customers around the clock and around the world.

In summary, the Si-Soft project will provide new types of electronic design automation software, IP design flow integration, IP trade services, as well as develop long-distance collaborative design networks. With the creation of a leading SoC environment in Taiwan, the global electronics supply chain will gain a better source of ideas and products for consumers.