INDIA: a *fab-less* wonder: case of SMDP

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Abstract

From IPod to I Pad, millions of electronics goods have rolled out of China, the global manufacturing hub. India's share of global electronic product market is less than 3%. Taiwan had $72 billion of investment in Fabs, where as India stands out as one the aspiring nation with no Fab. Yet, top 25 global semiconductor companies now have a presence in India through their captive centers, working in cutting edge technology nodes. Among the top twenty U.S. semiconductor companies, only two have not established a design center in India. While, Government of India is not successful in attracting manufacturing, appear to have made a significant contribution by focusing on talent supply. Department of Information Technology (DIT) implemented Special Manpower Development Programme in the area of VLSI design and related software (SMDP) and trained over 20,000 engineers. This paper is about SMDP as case study and is based on Impact Assessment of SMDP-II assigned by DIT on IIMA.

Prior to 1980s, the semiconductor industry was vertically integrated. Semiconductor companies owned and operated their own silicon wafer fabrication facilities and developed their own process technology for manufacturing their chips. These companies also carried out the fabrication, assembly and testing of their chips. Innovative chip design start-ups and Taiwan's business model led to the birth of foundry industry.

South Korea and Taiwan

In *Tiger Technology: Creation of a Semiconductor Industry in East Asia* John A. Mathews and Dong-Sung Cho gave a comparative account of the support given by the Korean and Taiwanese states to their local semiconductor producers. South Korean government considered semiconductors vital to the modernization of domestic industries and manufacturing consumer electronics. The state used Korea's large conglomerates, or *chaebol*, as a vehicle to move into the industry through direct brokerage with different firms and by offering substantial financial assistance. Taiwanese government did not have the convenience of large conglomerates that could be directed towards semiconductor production. Instead, the government sponsored initiatives to develop a domestic industry through the establishment of research and production capabilities before the creation of private firms.

At the same time, re-organization of production in the global economy also played an equally integral part for the transformation of East Asia and the development of domestic semiconductor industries in South Korea and Taiwan. In `*Globalisation of High Technology Production*', Jeffery Henderson places the focus of analysis on the development of networks of production in the global semiconductor industry. He asserts that these production networks developed after transnational corporations, such as Fairchild and Texas Instruments, found it more cost effective to spread different stages of production across national borders due to labor costs, looser governmental regulation, or more efficient production methods. He points out that the first off-shoring of production occurred in East Asia by American transnational corporations. From these networks, the diffusion of technology and knowledge to fledgling Korean and Taiwanese firms provided a low level of production that was continuously upgraded until globally competitive firms emerged. According to him, the inclusion of South Korea and Taiwan within this network of production and the exclusion of other semiconductor-producing nations is a primary reason for their success.

Foundry production is the largest segment of Taiwan's domestic industry; in 1999, foundry related business accounted for almost 60 percent of Taiwan's total industrial revenue. Two largest foundries in the world, Taiwanese Semiconductor Manufacturing Company (TSMC) and United Microelectronics Company(UMC) dominate the Taiwanese semiconductor industry. Combined, these two companies possess 70 percent of the global market.

Fabs in India

India's only foundry, Semiconductor Complex Limited (SCL) was set up in 1997 as Public Sector Undertaking under Department of Electronics with an investment of $100 million for a 6 inch wafer fabrication. The facility and capability remained marginal and finally in 2005 it was handed over to Department of Space.

Fabless chip manufacturing

Gradually, Foundries emerged as the cornerstone of the fabless model – providing a non-competitive manufacturing partner for fabless companies. Qualcomm tops the list of Fabless suppliers. The ranking of fabless chip companies continues to be dominated by U.S. companies that occupy eight of the top ten slots by sales volume. Europe is well represented in the lower ranks with Dialogue growing strongly with 77 per cent annual growth, according to IC Insights. Japan has only one company in the ranks of the top 25 fabless chip companies, MegaChips Corp. (Osaka, Japan), a developer of chips for games makers, camera companies, cell phone makers and security companies. Taiwan is represented Media Tek, MStar, Novatek, Realtek and Himax. China has some of the fastest growing firm like Spreadtrum growing at 95%.

India has no presence either in integrated firms with fab or fab less chip firms. However, segmentation of design work has provided an opening to India, in the form of design firms.

Fabless semiconductor design

The development and manufacturing of chips involve three primary activities in the value chain: design, fabrication, test and assembly. During design, the desired electronic circuits progress through a series of abstract representations of increasing detail. During fabrication, the circuits of the chips are built up on the surface of a flat, round silicon wafer in successive layers. Assembly is, typically, the process of cutting the wafer into individual chips (or die), which can number in the thousands, depending on die size, and packaging the delicate chip in a protective shell that includes connections to other components.

2011 Top 25 Fabless IC Suppliers ($M)

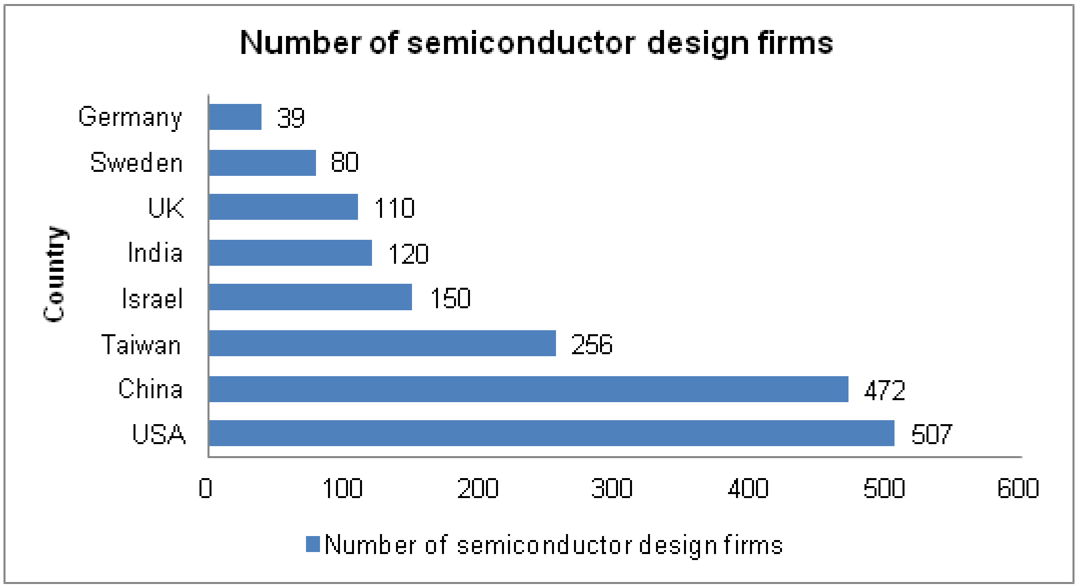
2011 Rank	2010 Rank	2009 Rank	Company	Headquarters	2009 ($M)	2010 ($M)	% Change	2011 ($M)	% Change
1	1	1	Qualcomm	U.S.	6,409	7,204	12%	9,910	38%
2	2	3	Broadcom	U.S.	4,271	6,589	54%	7,160	9%
3	3	2	AMD	U.S.	5,403	6,494	20%	6,568	1%
4	6	5	Nvidia	U.S.	3,151	3,575	13%	3,939	10%
5	4	6	Marvell	U.S.	2,690	3,592	34%	3,445	-4%
6	5	4	MediaTek	Taiwan	3,500	3,590	3%	2,969	-17%
7	7	7	Xilinx	U.S.	1,699	2,311	36%	2,269	-2%
8	8	10	Altera	U.S.	1,196	1,954	63%	2,064	6%
9	9	8	LSI Corp.	U.S.	1,422	1,616	14%	2,042	26%
10	10	11	Avago	Singapore	858	1,187	38%	1,341	13%
11	13	12	MStar	Taiwan	838	1,065	27%	1,220	15%
12	11	13	Novatek	Taiwan	819	1,149	40%	1,198	4%
13	15	16	CSR	Europe	601	801	33%	845	5%
14	12	9	ST-Ericsson*	Europe	1,263	1,146	-9%	825	-28%
15	16	15	Realtek	Taiwan	615	706	15%	742	5%
16	17	17	HiSilicon	China	572	652	14%	710	9%
17	27	67	Spreadtrum	China	105	346	230%	674	95%
18	19	19	PMC-Sierra	U.S.	496	635	28%	654	3%
19	18	14	Himax	Taiwan	693	643	-7%	633	-2%
20	21	—	Lantiq	Europe	0	550	N/A	540	-2%
21	33	30	Dialog	Europe	218	297	36%	527	77%
22	22	21	Silicon Labs	U.S.	441	494	12%	492	0%
23	29	20	MegaChips	Japan	445	337	-24%	456	35%
24	23	24	Semtech	U.S.	254	403	59%	438	9%
25	24	23	SMSC	U.S.	283	397	40%	415	5%
Top 25 Total			—	—	38,242	47,733	25%	52,076	9%
Non-Top 25 Fabless			—	—	11,091	14,781	33%	12,811	-13%
Total Fabless			—	—	49,333	62,514	27%	64,887	4%

*Represents the 50% share not accounted for by ST.

Source: Company reports, IC Insights' *Strategic Reviews Database*

The economic characteristics of each step of the process differ significantly. Design is skill intensive, and requires expensive EDA (electronic design automation) software, which is typically licensed per design engineer. Fabrication requires a huge fixed investment (currently on the order of $2 billion) to build a plant (called a fab) that holds a wide variety of expensive equipment and that meets extreme requirements of cleanliness. Assembly also requires expensive equipment, but the overall costs of plant and equipment are much lower than for the fab, as are the average skill requirements. Overall, worker skill requirements go down along the value chain (i.e., design is more skill-intensive than manufacturing, which is more skill-intensive than assembly).

All parts of chip design and development, from specification to finished chips, can be done by different teams, either in-house or outsourced, and either locally or offshore. The easiest part of chip design to offshore or outsource is physical design because it is a relatively standardized task. It is also the least sensitive part of design in terms of revealing the customer's intellectual property. Low-cost design engineering resources can be tapped through international outsourcing, although to date most design outsourcing by U.S. companies takes place domestically. The leading suppliers of design services worldwide are the leading design automation software vendors, Cadence Design Systems, Synopsys, and Mentor graphics. Their annual services revenue is about $300 million out of a total outsourced design market estimated at $2.5 billion. As this suggests, the remaining market is highly fragmented.

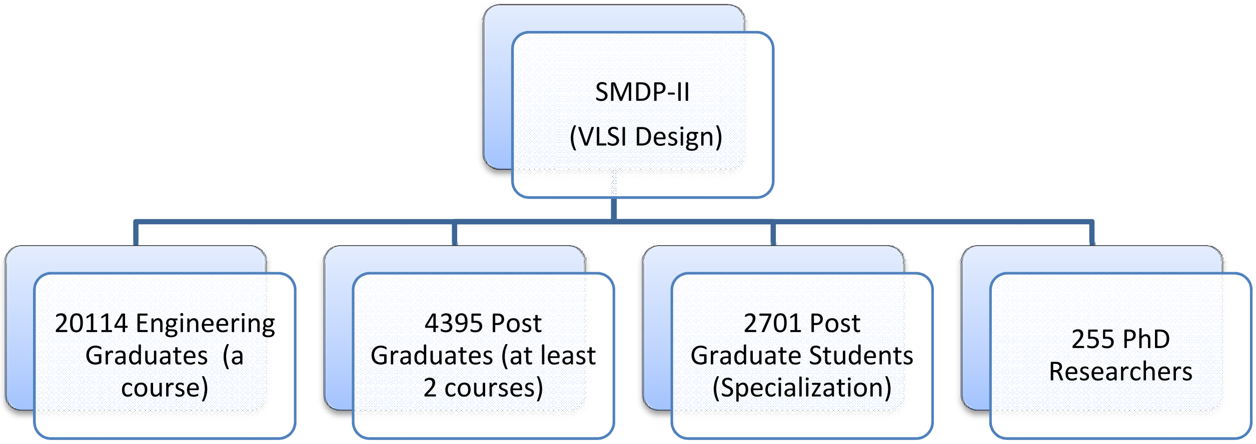


Case of "Special Manpower Development Programme" (SMDP)

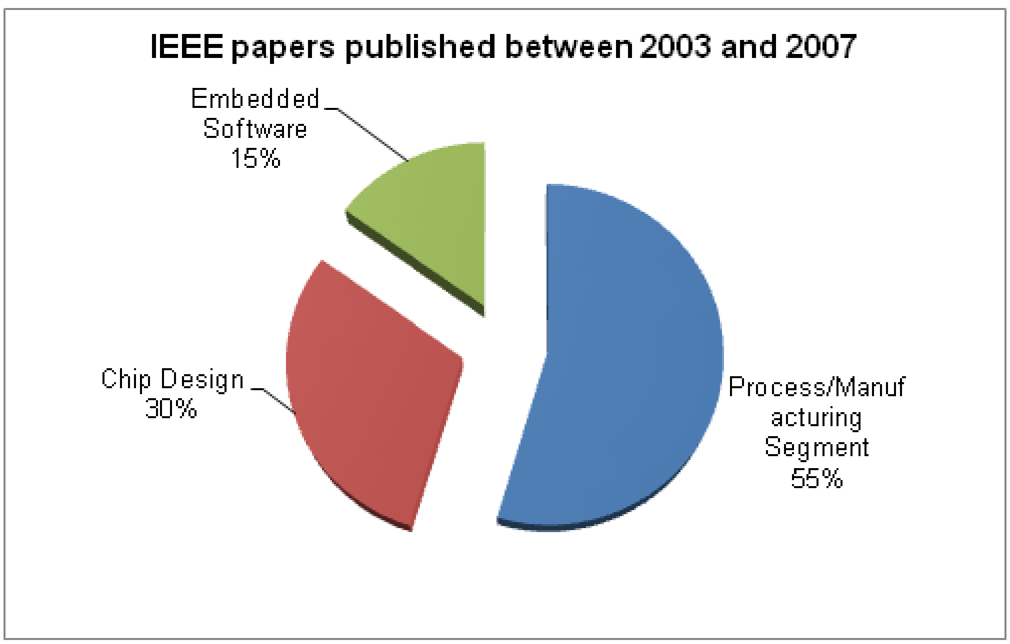
Unlike East Asian nations, Indian government intervention was more focused on manpower development. A strong thrust was given to Microelectronics, including VLSI, by MHRD in the early and mid 1980's. This led to some highly trained graduates in this area in the job market. It is likely that this attracted the first design companies to India in the mid and late-1980's. This led to a further interest and increase in VLSI courses in the country, and a virtuous cycle ensued. A notable role was played by the Department of Information Technology, which launched 2 phases of the "Special Manpower Development Programme" (SMDP) in 1998 and 2004.

A long term perspective was taken by the department to develop skilled manpower to design VLSI and related software. In the first phase 7 institutes were selected, 5 IITs, IISc and CEERI. They were equipped with latest EDA tools, provided for recruitment of Lab engineer to anchor student projects and liberal grants given to faculty to carry out research. In the 2nd phase 25 additional institutes, mostly NITs were selected. The first 7 institutes were categorized as Resource Centers (RC) with an additional responsibility to mentor the new batch of 25 institutes, called Participating Institutes (PI). Model curriculum was developed and RCs under Instruction Enhancement Programme (IEP) trained 522 faculty/ lab engineers of PI.

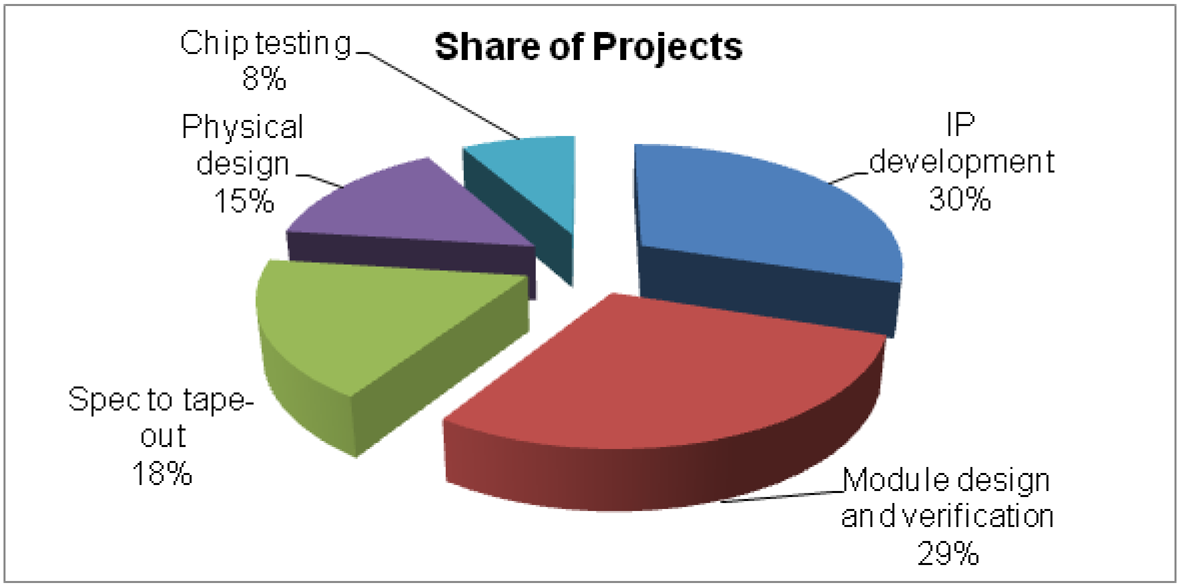
Under SMDP-II, a total of 20,114 engineering graduates in Electronics/ Communication/ Computer Science/ Instrumentation etc had taken a graduate level course in VLSI design. At PG level, 4,395 students had taken at least two courses in various aspects of VLSI Design and CAD. An addition 2,701 PG students had their specialization at ME/MTech in VLSI design & CAD. Further PhDs were awarded to 255 researchers in various aspects of VLSI design & CAD.



According to the ISA-Evalueserve study 2008, 70–75% of semiconductor research activities are concentrated in the IITs, IISc and in BITS, Pilani. Nearly 78% of the projects are related to chip design and 22% are in the fields of testing and verification. Around 47% of the projects are in the areas of analog and mixed signals. Of the IEEE papers published between 2003 and 2007, Indian institutes show maximum activity in the process/manufacturing segment (47%), followed by chip design (26%) and embedded software (13%).



Availability of skilled manpower enabled industry to take up value added design work.



Finally it attracted MNCs to set up R&D Centers in India. Among the top twenty U.S. semiconductor companies, only two have *not* established a design center in India. This movement to establish design centers in India is quite recent, and for most companies is in a very early stage. The size of the operations varies widely, from about several thousand engineers at Intel and TI to fewer than 100 at smaller companies.

India Design Centers of the 20 Largest US Chip Companies

Company	Global rank(2005)	No of employees (2005)
Intel, Bangalore	1	2700
TI, Bangalore	3	1100
Freescale, Delhi	12	780
AMD, Bangalore	16	120
IBM, Bangalore	17	100
QUALCOMM, Bangalore	18	150
Broadcom, Bangalore	23	150
Analog Devices, Bangalore	24	100
SanDisk, Bangalore	26	60
National, Bangalore	27	25
Agilent, Delhi	30	50
ATI, Hyderabad	31	100
Maxim, Bangalore	35	25
Agere, Bangalore	36	250
Xilinx, Hyderabad	37	75
Marvell, Bangalore	38	75

Summery

India's share of Trillion dollar Electronic Market is less than 3%, all the factors considered essential for success in this area are missing from Indian scene. We do not have Silicon Valley culture of mushrooming start-ups emerging as giant killers, very little manufacturing capability in hardware miniaturization, MEMs, no government supported aspiring private firms like Samsung, could not attract Fabs like Taiwan and finally no global scale production of high tech electronic products like China.

China appears to be following the Taiwan pattern of industry development: government sponsorship, access to local system firms such as Haier, Huawei, and TCL that are increasingly engaged in global markets, and active involvement of expatriates returning from the United States or experienced engineers relocating from Taiwan. In little over a decade, Chinese firms have developed impressive fabrication capability, with the help of the Chinese government and of foreign companies as investors, technology licensors.

The Chinese government has taken many steps in support of chip design firms, some of the largest of whom are state-owned. Measures include tax reductions, venture investing, incubators in seven major cities, and special government projects. The return of Chinese nationals with education and work experience has been an important part of China's recent technology development. The returnees provide valuable management experience and connectivity to global networks that tend to accelerate the pace at which China's chip sector can develop. The government maintains statistics on student returnees. In 2003, it was reported that, of 580,000 students that had gone abroad since 1978, one-quarter (or 150,000) had returned. These returnees had started 5,000 businesses, including over 2,000 IT companies in Beijing's Zhongguancun Science Park (one-sixth the park total).

Three factors that keep India on the radar of chip design are:

1. **Skilled manpower**: The India semiconductor sector employs over 163,000 engineers of which an estimated 20,580 serving the VLSI Design Services industry directly. Cumulatively, these 20,000+ engineers worked on a total of 4,150 projects in 2011, from clients spread across North America, Europe, Asia and other parts of the world. On the technology front, Indian companies have designed chips on a 28 nm scale that have already been successfully taped out. In 2012, it is expected that 22 nm scale chips designed in India will also be taped out to hit markets across the world. Further, it is expected that Indian companies will graduate to 3D chip designing in the forthcoming quarters.
2. **Preference to work with MNCs**: Chinese engineers prefer to work for domestic start-ups and domestic companies rather than MNCs – virtually the opposite of what interviews revealed in india. Many young Chinese engineers, especially returnees, want to take the risk working for an emerging company that may result in great wealth. Foreign chip companies have been attracted to India by Indian engineers' knowledge of English and the successful Indian software sector. Many of the early Indian investments by chip companies were software-focused and involved writing the microcode that becomes part of the chip. Over time, the Indian affiliates have taken on a bigger role that can extend to complete chip designs from specification to physical layout. In contrast to China, Indian engineers, according prefer multinationals and large local companies over local start-ups, since engineers and their family members do not tend toward taking risk.
3. **Fear of Chinese clones**: In a marked difference with India, multinational companies have opened far fewer design centers in China. Concerns over intellectual property protection appear to pose a greater barrier to foreign design activity there than in India.

Reference:

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