

Semiconductor fab: the unfinished agenda

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To set up a semiconductor fabrication plant in India is not mere hubris. There is a growing market. There are also strategic reasons: India's susceptibility to coercion increases due to its dependence on the import of semiconductors. Therefore, the government's 2022 Semiconductor Mission is laudable. But today, there is still uncertainty about whether India will have a fab. In this context, it is important to understand why earlier attempts failed and examine alternate approaches.

Earlier attempts

The first serious attempt was made in 2007 in the form of a Special Incentive Package (SIP), but it yielded no response. The second attempt in the form of Modified SIP in 2012 fared better. After over two years of extensive outreach with practically all the major fab companies in the world, India came close to having a fab. Two consortia were approved by the Cabinet with an attractive set of incentives. Jaiprakash Associates in partnership with IBM and Israeli company TowerJazz constituted one, while the other was led by Hindustan Semiconductor Manufacturing Corporation along with ST Microelectronics. The two fabs together involved investment of \$10 billion, and the government offered incentives amounting to nearly \$5 billion in the form of cash and tax cuts. Locations for the fabs were finalised and land was allotted. But finally, both failed to mobilise resources.

Semiconductor fabrication represents the ultimate frontier of human tech advancement. The frontier has been advancing adhering to Moore's law that the number of transistors in a unit area doubles every 18 months. But the progress of miniaturisation is accompanied by higher complexity and costs. As a result, the industry has seen a decline in the number of participants.

China started late in the semiconductor fab industry. But backed by massive government financial support over the last two decades, it acquired hundreds of loss-making fabs from around the world and built its fab industry. Aided by lower manufacturing costs and a massive electronics manufacturing industry, China's chip production has grown rapidly. By the time the U.S., the traditional leader in this game, realised, China had become one of the major producers of chips. Aided by its market supremacy in rare earths, which are essential for chip production, it has a strategic stranglehold on chip-making. Over the last year, the U.S. and its Western allies have blocked the transfer of the latest fab-related technology to China. But this could be a case of closing the stable door after the horses have bolted. The U.S. enacted the CHIPS and Science Act in 2022, with nearly \$40 billion in subsidies, in an effort to bring back semiconductor manufacturing to the country. The European Union sanctioned €7.4 billion for a new fab in France. India will have to contend with these countries in what has become an intense chip warfare.

Investment in a semiconductor fab is one of the riskiest. Billions of dollars need to be recovered before the technology becomes obsolete. This necessitates substantial production volumes for economic viability, often reaching levels that are adequate to meet global demand. It is therefore difficult to conceive of a fab which is based on the domestic market only. The advantage of semiconductors having a small freight-to-price ratio and a zero-custom duty regime under the Information Technology Agreement, 1996, facilitates production in a single location and global sales. This is why no company is interested in setting a greenfield fab.

Developing an ecosystem for chip manufacturing in a greenfield location is a major challenge. Hundreds of chemicals and gases are required for chip fabrication, people need to be trained, and abundant clean water be made available. But above all is the art of chip-making. Despite the best of equipment, poor quality and low yields can make fabs fail.

There are other issues, such as whether to set up a logic/processor, memory or analog fab. An electronic equipment and its functionalities are characterised by their logic chips, which are therefore strategically important and generate the highest profit. The most advanced set of technologies is needed to manufacture them. Analog chips are essential, but have the least strategic value. Memory fabs use the most advanced feature nodes, while analog fabs can be even as large as 130 nm. Logic fabs are the most expensive and analog fabs the least. A relatively easier option is Assembly, Testing, Packaging and Marking (ATMP), to get the fab ecosystem developed before the full-fledged fab is set up. But ATMPs have little value in terms of actual chip-making.

Lessons from China

India's strategy has been to set up a new logic fab. China, which acquired loss-making fabs and then set up its own logic fab, provides lessons. Acquiring existing fabs has many advantages: they are reasonably priced, have stabilised technology, a supply chain ecosystem, an established product line, and market. They will enable India to build the fab ecosystem and train human resources. Much lower subsidies would be required, and the funds saved could be used for advanced R&D in fab technologies which will help build state-of-the-art fab in next few years. Another strategy could be setting up ATMPs. Tessolve, now acquired by Tatas, had set up an ATMP in 2013-14. This ATMP is successfully packaging chips upto 7 nm feature size. China has over 100 ATMPs.

China started on the fab journey about 20 years ago. As the Chinese saying goes, the best time to plant a tree was 20 years ago, but the second best time is now.