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Semiconductor FABs: A National Mission

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Semiconductor FABs: A National Mission

As the earlier plan of setting up semi-conductor FABrication (FAB) facilities failed, the government this time, to its credit, is ensuring that any incentive scheme should be able to address the requirements of industry. However, as setting up semi-conductor plants requires billions of dollars of investment, the government's support should also match the investments.

Introduction

Year 2000 AD (Y2K) was a great opportunity wherein India exhibited her prowess in software processing and delivering services to the customers both at home and abroad. Resultantly, we got a large IT qualified human resource and an economic base to assist India in transformation from an agricultural/industrial country to an information/knowledge entity economy.

Unfortunately, while software and service sectors grew, the hardware sector lagged. Main reasons were the sluggish demand, non-availability of indigenous semi-conductor components, lack of thinking as a 'system' and consequent absence of system integration capability. The manufacturing base was largely dependent on import of electronic components and chips and hence either could not deliver what the nation needed or provided that at an enormous cost. It is surprising to note that till about six years ago, we were importing components and semi-conductor chips for making TV set-top boxes.

With the onset of Information and Communication Technology (ICT) revolution, demand for integrated circuit (IC) and electronic components grew exponentially with consequent rise in imports. At one time, it was feared that the Indian import bill of semi-conductors may exceed that of oil. India had to be an important partner of this revolution. A forward looking and vibrant electronic industry was a strategic imperative for transformation of India to the information age and to support important programmes like 'Make in India' and 'Digital India' as enunciated by the Modi Government. Besides the economic imperative, focus on electronics hardware manufacturing up to the integrated circuit or the chip level was required due to growing security concerns.

> *'Building FAB facilities takes years and costs billions of dollars. There was no vision, there was no political will to support: infrastructure was absent and there was no market to motivate investors,' say experts.*

Lack of adequate infrastructure, domestic supply chain, high cost of finance, inadequate availability of quality power, short supply of components, limited design capability, lack of focus on R&D and very restricted availability of skilled human resource made Indian manufacturing uncompetitive. This situation, besides being unattractive economically, created serious security concerns related to possible vulnerabilities and deficiencies at strategic level. To obviate this situation, the National Policy on Electronics was promulgated in October 2012 (NPE 2012). NPE is a major milestone with the mission '*To create a globally competitive Electronic System Design and Manufacturing (ESDM) Industry to meet the country's needs and serve the international market.*'

The NPE was expected to create an indigenous manufacturing eco-system for electronics in the country that would foster the manufacturing of indigenously designed and manufactured chips to create a more cyber secure ecosystem in the country. It would enable India to tap the great economic potential that the knowledge sector offers. Increased development and manufacturing in the sector would lead to greater economic growth through more manufacturing and consequently greater employment in the sector. The policy specified concessions and other enabling provisions to attract capital investment and technology. Establishment of two semi-conductor fabrication (FAB) facilities (referred to as FAB hereafter) was one of the major recommendations. This was music to the ears of the Indian strategic community and security experts who had been

agitating for indigenous FAB facilities for more than two decades.

Semi-conductors: Catalyst of Development and Digital Economy

Semi-conductors have been key enablers in the advancement of electronics for the past 50 years and will continue to play an even greater role with the introduction of new technologies and applications, including internet of things (IoT), artificial intelligence (AI), 5G, smart cars, smart factories, data centres, robotics and so on. Since their origins in the 1960s, the size, speed, and capacity of chips have improved enormously, driven by technical advances that fit more and more metal oxide semi-conductor (MOS) transistors on chips of the same size – a modern chip may have many billions of MOS transistors in an area the size of a human fingernail.

Semi-conductor Wafer Fabrication (FAB) are complex, very high technology, research intensive manufacturing units with long gestation period requiring significant and sustained investments of the order of billions of dollars. The system has five major components: Infrastructure, Software, Manufacturing, and Testing Facilities, Highly Qualified Human Resource and Logistics. Development in these areas was disjointed due to non-availability of finance, absence of a policy and bureaucratic procedures. Consequently, while India has islands of excellence in terms of chip design and electronics manufacturing, there have been challenges in setting up of FAB. The situation is compounded further by competition from countries like China and Vietnam due to their better cost-efficiency and well developed ecosystems. Security became a major concern with the advent of cyber technology. Implementation of NPE thus became a national strategic imperative.

Environment Scan

A series of unfortunate events early this year resulted in sudden and acute global shortage of Chips and resultant adverse effect on the economy and security of nations. The situation got compounded by the fact that only a handful of nations manufacture chips and have supporting Electronics System Design and Manufacturing or ESDM—Taiwan, the world's leader in chip-making saw climate change causing water scarcity (chip making requires huge amounts of water), while a blizzard in Texas, America's semi-conductor hub, saw FAB plants lose electricity. And if that was not enough, a fire hit one of Japan's top FAB factories. The timing and the consequent impact of this scarcity was worse since

the global economy was then recovering from the devastating effects of Covid-19. The fact that such a situation can develop globally edged many nations to have their own ESDM and FABs and distribute chip making at more locations.

Security of supply chain has become an absolute necessity as can be seen in Russia-Ukraine conflict. The current conflict will further delay the availability of the chips. Chip makers are running towards more aggressive sustainability programmes to reduce the environmental impact of chip production. The shortage is forcing foundries to optimize production and consumers to search for alternatives in chip manufacturing. For instance, major foundries are investing heavily in production automation, machine learning and data analytics, which can be used to reduce production cost and increase overall throughput, without losing quality. Furthermore, installation of new FABs has already started in the USA. At the customer end, big companies are migrating to in-house chip production and increasing the diversification of the supply chain. The urge for better distribution methods, the decentralization of chip production and the rise of AI driven manufacturing provide all the ingredients for innovation in the field. The criticality of holding and availability of chips can be understood from the fact that in the current geo-political conflict, chips are included as part of economic sanctions. Just one component, 'Neon' is adversely affecting the availability of lasers!

A recent technology for increasing the production is the 'Chiplet' technology.[4] Chiplets divide a single die into several criticality of dies that work together in an optimized package. 3D chiplets go one step further to stack multiple chiplets on top of each other. Both Intel and AMD are planning to implement chiplets in the next generation of processors, with AMD having the upper hand by using 3D stacking combined with the 7nm node in collaboration with Taiwan Semi-conductor Manufacturing Company (TSMC). USA has promulgated 'Chips for America' Act. With INR four lac crores worth of incentives and benefits from much better evolved tech ecosystem already in place, this could boost up the US in being a hub for this crucial component. Europe has followed in announcing a similar act. All three biggies, TSMC, Samsung and Intel are investing in American electronic manufacturing sectors in states like Texas and Arizona.

India too has envisioned plans to incentivise businesses to set up semi-conductor FAB design and testing facilities, aimed as part of the larger *'Atmanirbhar Bharat'* narrative. Accordingly, building on the strong foundation laid by the success of

Digital India and *Make in India* programmes in electronic manufacturing sector, India has embarked on a very crucial 'Semicon India Programme'. Success of this programme would make India an internationally conducive and competitive destination for semi-conductor and display projects.

> *According to applied materials, one foundry with 50,000 wafer starts per month consumes a terawatt-hour of energy, which is equivalent to a city with 100,000 people, and two to four million gallons of ultra-pure water a day.*

Semi-conductor Profile of India

India's record in developing semi-conductors was not very encouraging till very recently. It is a typical case of lost opportunities, lack of vision, indifferent attitude, financial constraints, poor infrastructure and above all the quality of leadership. The situation changed with the digital revolution and the impact of technology on the security and economy of the nation as indeed in the wellbeing of masses. Some of the cases elaborating the above statement are listed in the subsequent paragraphs.

In the 1960s, at the beginning of the silicon revolution, Fairchild Semi-conductor considered building a FAB here in India, but bureaucratic lethargy chased them away to Malaysia. After the 1962 war, Bharat Electronics Ltd. set up a FAB to manufacture silicon and germanium transistors. 'Our silicon transistors were in such demand that companies would queue up to place orders', says N. Ravindra, retired Senior DGM. BEL. When cheaper ICs from China, Taiwan, and South Korea entered the market, BEL couldn't match global quality and price standards, and many of the FAB units had to be shut down. In the mid-1980s, Metkem Silicon Limited produced polysilicon wafers for solar cells and electronics in partnership with Bharat Electronics Limited (BEL). *This could have catalysed an electronics revolution in India.*

The most tragic story is that of Semi-conductor Complex Ltd. (SCL), Chandigarh. Starting with a 5000-nano meter (nm) process in 1984, SCL rapidly advanced to the 800 nm technology, which was the cutting edge only a year or two before. At that time China and Taiwan had not even entered the FAB space. Intriguingly, the entire complex was gutted in a devastating fire in 1989, and our semi-conductor progress was set back by a decade. ISRO revived SCL and used it for

low volume manufacture of chips for its programs, but it is only a shadow of what it could have been. SCL Mohali has since been handed over to Ministry of Electronics and Information Technology (MeitY) from the Department of Space and it is being opened as a commercial FAB for wider participation by Indian semi-conductor design companies. This is expected to strengthen India's quest for technological sovereignty and a favourable destination for semi-conductor design and manufacturing with more than 50,000 design professionals and many design services companies on board today with over 2000 ICs and chips designed in India in the last few years.

Intel had declined to set up a silicon FAB in India in 2014 primarily due to lack of infrastructure, non-availability of finance and skilled human resource. In mid-2005, a major multinational semi-conductor company started operations in South India, hired seasoned experts, and set up a class-100 cleanroom for checking impurities of semi-conductors. Facing roadblocks at each step, the endeavour became a stillborn child. China grabbed this opportunity and welcomed the project, giving the company everything it needed. India not only lost a good semi-conductor facility, but also gave away 4000 jobs to China. Another multinational semi-conductor company in the process of setting up their FAB here withdrew after seeing the horrific experience of this multinational company.

In October 2013, after the release of NPE 2012, there have been attempts by private sector companies to set up semi-conductor FAB units here:

- Hindustan Semi-conductor Manufacturing Corporation (HSMC), a consortium of companies that included ST Microelectronics and Silterra Malaysia was aiming to kickstart chip manufacturing plant in Gujarat, a project worth Rs.30,000 crore. The government in 2019 cancelled the letter of intent granted to HSMC since they could not comply with the essential conditions.

- Another consortium led by Jaiprakash Associates, which partnered with IBM and Tower Semi-conductor of Israel to start chip manufacturing in UP. In 2016, debt-ridden Jaiprakash (JP) Associates pulled out of the Rs. 34,000-crore project.

At present there is no formal proposal from any private company to initiate such a project though some industrial majors have shown keen interest. TATA Group

has reported plans to set up $300 million semi-conductor manufacturing facility on wartime basis. The Group is having discussions with several states to identify the land to build chip making unit. Reports indicate that the group plans to run the group as an Outsourced Assembly and Testing (OAST) Facility. So far, Tamil Naidu, Karnataka and Telangana have been identified as possible locations. A very recent report indicates that Vedanta Group plans to spend Rs 60,000 crores to manufacture semi-conductors in India. They are forming a Joint Venture with Foxconn and are reported to be looking for possible locations. This is the first joint venture after the announcement of the Policy.

The message is piquantly relevant. India should have had its own semi-conductor FAB decades ago. In 1987, India was just two years behind the latest chip manufacturing technology. Today, we are 12 generations behind. Our semi-conductor dream has been sabotaged. We have missed the bus several times, for reasons that are unpardonable, i*t is 'now or never' situation for India. We have to deliver.*

Let us have a look at some of the companies and start-up ventures that are making it big in the semi-conductor industry in spite of the stated environment. All these companies or start-ups have established substantial credibility in this country. Each one of them is viewed as reliable by their clients. The top chip makers in India are:

Bharat Electronics Limited (BEL). Founded in 1954, it is involved in the cutting-edge electronic products for aerospace and defence companies including semi-conductors. It successfully fabricated germanium semi-conductor in the year 1962. Since then, they have worked a lot in the field of semi-conductors and innovated considerably in semi-conductor technology Today, it is the country's premier semi-conductor manufacturing Company.

Continental Device India (CDI). Established in the year 1964, it is regarded as the pioneer of manufacturing silicon semi-conductor chips and devices in India. The company boasts of having the best professionals and technology. CDIL is trusted around the world.

Applied MATERIALS. Established in 1967, the company has developed cutting edge technology in manufacturing. It provides services related to silicon development and fabrication.

TSMC India. One of the most renowned companies for seamless silicon fabrication services in the world. Plans to serve many FAB less companies.

Micron Technology. A semi-conductor manufacturing company founded in 1978. Specialises in making memory chips using **DRAM technology**. Builds high density memory chips.

SOLEX Energy Company. Founded in 1998. Manufactures solar panels, semi-conductors, and other electronic components.

Masamb Electronics. Established in 2007, the company provides semi-conductor services in India. Specialises in VLSI design, OEM design and EDA. The company has veterans who have vast experience in the field of semi-conductors**.**

Semitronics Micro Systems Pvt Ltd. a semi-conductor manufacturing company that makes power electronic products.

SAMSUNG Semi-conductor INDIA. A FAB-less semi-conductor company providing all kinds of semi-conductor services in India. It produces semi-conductor material for smart phones and other electronic devices.

BROADCOM. A leading provider of highly integrated semi-conductor technology solutions in broadband communications and networking of voice, video and data services. The company's strength lies in designing, development, and supply of complete system-on-a-chip (SoC) solutions incorporating digital, analogue and radio frequency (RF) technologies, as well as related system-level hardware and software for broadband connectivity and digital TV and HDTV entertainment applications.

All these companies have gained years of experience and are well-trusted in the semi-conductor industry. Besides, all of them have also been putting their individual insights and that many years of R&D for the development of the semi-conductor technology, thereby pioneering capabilities to manufacture the best semi-conductors.

India is still growing its semi-conductor manufacturing capabilities now and the new initiative from the Indian government towards the manufacturing of these products is a renewed impetus. Besides, more and more start-ups and

companies are also entering the mentioned field to help the country steer past the scarcity of semi-conductors if not solve the entire crisis involving the semi-conductors. While large scale semi-conductor manufacturers face challenges to take off, several start-ups are building chips for embedded systems like IoT and telephony on a much smaller scale and are also disrupting the scene. There are many prominent start-ups here like the *Signalchip*, a semi-conductor company based in Bengaluru, which rolled out 4G and 5G modem chips. Saankhya Labs is another Bengaluru-based start-up that has been creating chipsets for use in defence, satellite communication and broadcast. Another one is IIT Madras which has developed a micro-processor called 'Shakti,' which can be used in mobile computing devices, embedded low power wireless systems like smartphones, surveillance cameras and networking systems.

The nation thus has the nucleus to become a dominant player in semi-conductor manufacturing. The need of the day is to integrate these resources and add value to the nation's capabilities. These along with enabling policies will reduce the rising dependency on chip imports and help in creating semi-conductor manufacturing units within the country. The government needs to make sure that there is proper infrastructure and investments are made so that scalable manufacturing units can be created. Implementation of NPE 2012 and a half-hearted response of the industry necessitated changes to be made in NPN 2012.

A very forward-looking policy by way of NPE 2019[9] was thus promulgated by the Government. It has since taken several initiatives to implement the provisions of NPE 2019. The first amongst them is the appointment of fully empowered *Indian Semi-conductor Mission* (ISM)[10]. In order to drive the long-term strategies for developing a sustainable semi-conductor and display eco system, a specialised and independent 'India Semi-conductor Mission '(ISM) is being set up. It will be led by global experts in semi-conductor and display industry. It will act as a nodal agency for efficient and smooth implementation of the schemes for setting up of Semi-conductor and Display FABS. One hopes that this mission would give positive results like those of our space and nuclear missions.

As a matter of strategy and complexity of the task, major requirements would be identified and given as separate projects, duly empowered and with complete accountability. ISM would monitor the whole task, specify parameters for integration and standards, be proactive and ensure adherence to the timelines. Accordingly, three schemes as given below were notified in April 2020 with an

incentive outlay of around $ 7 billion. This has marked a new era for electronics manufacturing.

Modified Electronics Manufacturing Clusters Scheme (EMC 2.0)

The Modified Electronics Manufacturing Clusters (EMC 2.0) Scheme seeks to strengthen the infrastructure base for the electronics industry and deepen the electronics value chain in India. The development of industry-specific facilities like Common Facility Centres, Ready Built Factory Sheds/Plug and Play facilities will not only strengthen supply chain responsiveness and promote the consolidation of suppliers but also decrease time-to-market and lower logistics costs. EMC 2.0, therefore, provides financial incentives for creating quality infrastructure as well as common facilities and amenities for electronics manufacturers. Financial Incentives of up to INR 3,762 Crore will be disbursed over a period of eight years.

Scheme for Promotion of Manufacturing of Electronic Components and Semi-conductors (SPECS)

Development of supply chain is essential for the manufacturing of electronic products with higher domestic value addition. The vision of National Policy on Electronics 2019 (NPE 2019) is to position India as a global hub for Electronics System Design and Manufacturing (ESDM) by encouraging and driving capabilities in the country for developing core components, including chipsets, and creating an enabling environment for the industry to compete globally.

Electronic components are the basic building blocks for Electronics Industry and entail maximum value addition. Therefore, a vibrant electronic components manufacturing ecosystem is vital for the overall long-term and sustainable growth of electronics manufacturing in India and essential to achieve net positive Balance of Payments (BoP). The scheme will provide financial incentive of 25 percent on capital expenditure for the identified list of electronic goods that comprise downstream value chain of electronic products, i.e., electronic components, semi-conductor, display fabrication units, Assembly, Testing, Marking and Packaging (ATMP) units, specialised sub-assemblies, and capital goods for manufacture of aforesaid goods, all of which involve high value-added manufacturing.

The Scheme will be implemented through a nodal agency which will act as Project Management Agency (PMA) and be responsible for providing secretarial, managerial and implementation support and carrying out other responsibilities as assigned by the MeitY from time to time.

The *Production Linked Incentive Scheme (PLI) for Large Scale Electronics Manufacturing* proposes a financial incentive to boost domestic manufacturing and attract large investments in the electronics value chain including mobile phones**, el**ectronic components and Assembly Testing Marking and Packages (ATMP) units. Production Linked Incentives of up to INR 40,951 crores will be awarded over a period of 5 years.

A fourth scheme, namely the *Production Linked Incentive Scheme (PLI) for IT Hardware*, was notified in March 2021.This scheme proposes a financial incentive to boost domestic manufacturing, attract large investments in the value chain and incentivise companies to utilise the existing installed capacity to fulfil the increasing domestic demand. Product Linked Incentives of up to INR 7,300 crore will be awarded over a period of 4 years.

The schemes for development of a supply chain ecosystem, and building of new manufacturing clusters in the country, have been carefully constructed to incentivise the electronics manufacturing industry. Electronics manufacturing in India has grown rapidly with a CAGR of around 23 percent during the last 5 years, with domestic production of electronics hardware touching $76 bn in 2019-20. While the global semi-conductor market was valued at Rs33 lakh crore in 2020 and expected to reach Rs75 lakh crore by 2030, the Indian semi-conductor market stood at Rs1.13 lakh crore in 2020 and is estimated to reach Rs4.73 lakh crore by 2026. It is estimated that by 2030, India's semi-conductor market will be driven by wireless communications, consumer electronics and automotive electronics with 24 percent, 23 percent and 20 percent of the market share, respectively. The electronics manufacturing industry currently provides employment for over two million people in India. We will see a marked increase in the demand of a million people over the next five years.

Expression of Interest (EoI) for Setting-up FABs

At macro level, the NEP 2019 has two components, viz, setting up of ESDM including infrastructure and semi-conductors and display FABs. These

are extremely complex activities requiring in depth understanding of the environment. Accordingly, the Government issued an Expression of Interest to understand policy support requirement and set up communication channels between the Government and the Business (G2B). Inputs received under the EoI were evaluated by MeitY with reference to proposed technology, proposed wafer capacity, FAB loading strategy, financial viability based on the project and incentive support from Government of India. Following, broad incentives have been approved for the development of semi-conductors and display manufacturing ecosystem in India.

The Schemes for Setting up of Semi-conductor FABs and Display FABs in India shall extend fiscal support of up to 50 percent of project cost on *pari-passu* basis to applicants who are found eligible and have the technology as well as capacity to execute such highly capital and resource intensive projects. Government of India will work closely with the State Governments to establish High-Tech Clusters with requisite infrastructure in terms of land, semi-conductor grade water, high quality power, logistics and research ecosystem to approve applications for setting up at least two greenfield Semi-conductor FABs and two Display FABs in the country.

The Scheme for Setting up of Compound Semi-conductors, Silicon Photonics/ Sensors (including Micro-Electro-Mechanical- System (MEMS), FABs and Semi-conductor Assembly Testing Marking and Packaging (ATMP)/ Outsourced Assembly and Testing (OSAT) facilities in India shall extend fiscal support of 30 percent of capital expenditure to approved units. At least 15 such units of compound semi-conductors and semi-conductor packaging are expected to be established with Government support under this scheme.

The Design Linked Incentive (DLI) Scheme shall extend product design linked incentive of up to 50 percent of eligible expenditure and product deployment linked incentive of 6-4 percent on net sales for five years. Support will be provided to 100 domestic companies of semi-conductor design for ICs, Chipsets, System on Chips (SoCs), Systems & IP Cores and semi-conductor linked designs, facilitating the growth of not less than 20 such companies which can achieve turnover of more than Rs.1500 crore in the coming five years. As stated, earlier ISM is the nodal agency for efficient and smooth implementation of the schemes for setting up of Semi-conductor and Display FABs. The project has been named 'Semicon India Programme'.

India Semi-conductor Mission has received five applications for semi-conductor and display FABs with total investment to the tune of USD 20.5 Bn (INR 153,750 crore). Three companies viz., Vedanta in JV with Foxconn, IGSS Ventures Singapore, and ISMC have submitted applications for semi-conductor FABs. The applications have been received for setting up 28 nm to 65nm semi-conductor FABs with capacity of approx. 120,000 wafers per month and the projected investment of USD 13.6 bn wherein fiscal support from the Central Government is being sought for nearly USD 5.6 Bn.

Display FABs

Displays constitute a significant portion of the electronic products. India's display panel market is estimated to be ~USD 7 bn and is expected to grow to ~USD 15 bn by 2025. Under the Scheme for setting up of Display FABs in India, applications have been filed for setting up Gen 8.6 thin film transistor (TFT) Liquid Crystal Display (LCD) Display FAB as well as 6th Generation Display FAB for the manufacture of state-of-the-art AMOLED display panels that are used in the advanced smartphones. AMOLED is a display technology and stands for Active-Matrix Organic Light Emitting Diodes. It is a type of Organic Light Emitting Diode (OLED) display and is used in smartphones.

Two companies, viz., Vedanta and Elest have submitted applications for Display FABs with the projected investment of USD 6.7 bn wherein fiscal support from the Central Government is being sought for nearly USD 2.7 bn.

The applicant companies under the Semi-conductor and Display FAB Schemes have been issued acknowledgment by the India Semi-conductor Mission (ISM) who will coordinate with the applicant companies to provide access to world class infrastructure. It will work closely with the state governments to establish high-tech clusters with 300-500 acres of developed land, 100 KVA power, 50 MLD water, availability of natural gases and common facility centres for testing and certification.

Comments and Recommendations

Most of the big names in the business now prefer to outsource their FAB needs to large vendors so that they can focus their energies on research and product development. Some of these global corporations are also consolidating their

global facilities which are running at only 60-70 per cent of their capacity. The spare capacity can be used by India for manufacturing and training in the interim period when we are building our own FAB. India needs FABs to ensure her sovereignty, security, and economic growth. It is a strategic imperative: Period. Enough damage has been done by the naysayers. The major challenge is how to close the gap vis-a-vis our adversaries. We need a very innovative and proactive approach.

Concurrent Management is the possible solution wherein various activities like infrastructure, ESDM, human resource, training, R&D and so on are done concurrently. Close monitoring of targets and their integration must be done minimum at two levels: Project Manager and the ESDM. Concurrent Management is like an orchestra wherein the mission is the conductor and the schemes are the members of the orchestra. While each of them has different instrument and notes but the tune is one as guided by the conductor.

There is an urgent need of a twenty-year perspective plan with review every three years. This plan can be modified only at the highest policy-making level. The Plan should be a road map as to how we induct the technology, priority for R&D, how to close the technology gap, human resources including experts from other nations, outreach to national institution and academia, timelines, exports, financial aspects, and interaction with other departments of the government.

Semi-conductor supply chains are marked by geographical specialisation with 75 percent of global manufacturing capacity in East Asia. Geographic specialisation creates vulnerabilities emerging due to natural disasters, infrastructure shutdowns or geopolitical events. Therefore, it is critical to develop secure and resilient semi-conductor supply chains for industrial growth, digital sovereignty, and technological leadership. India's prior experience with policy efforts to set up a FAB suggests that assured demand, developed ancillary ecosystem and a dedicated institution to drive semi-conductor strategy are critical for setting up a semi-conductor FAB in India. NEP-19 has addressed these issues and those which emerged after the release of NEP-12. Those pertain to transfer of technology, participation by the government, Infrastructure, ESDM, single point authority, duly empowered and skilled manpower. This may reduce India's huge electronics import bill. The quantum of import would increase exponentially with the programmes like Digital India/Make in India maturing and proliferation of disruptive technologies like AI, 5 G , IoT , robotics and so on. Without ESDM

and FABs, the nation would become more vulnerable with associated impact on 'technological sovereignty'. Nation must achieve a high degree of self-sufficiency in electronics to reduce very high risks to the supply chain particularly when alternate source is not available.

India has missed many opportunities to develop an ESDM, and fabrication foundries with consequent adverse impact on its economy and security. A very serious vulnerability in our national capability exists. One of the major reasons stated for this situation wherein our likely adversaries are far ahead in this field, has been the lack of political will. It is to the credit of this Government that as a matter of strategy an integrated team consisting of the top leadership and prominent industrialists will be guiding us in the implementation of these projects as a 'national mission'.

India has embarked on transformation from an agriculture and industrial nation to an Information Age nation with visions articulated as follows:-

- Digital Infrastructure as a utility to every citizen;
- Governance and Service on demand;
- Digital empowerment of citizens.

These programmes would need a very large number of semi-conductors, chips, components, display devices, power sources, communication equipment and so on. In short, India has only two options, import or produce. The environment dictates to go for the second option. Break in the supply chain due to Covid 19, the ongoing conflict between Russia and Ukraine and exponential demand for the semi-conductors and chips due to induction of new technologies have compelled many nations to set up their FABs and ESDM. Further, there are a very few organisations which have the technology and experience. India would have to expedite the selection and ensure quick establishment of various facilities and try for the first mover advantage. R&D Labs must be established for research, testing, and training in Indian scenario. We have to interact and have projects with labs of other countries and outreach to Indian diaspora and get them to work with us for a period of three to five years. Semi-conductors and establishment of FABs in the curricula of graduate and post-graduate programmes have to be introduced. Students should be encouraged to study for PhD and undertake research or take specific projects. Selection of human resource must start immediately on selective

skills since the subject is complex and number of people required is very large. India must concentrate on exports, keep abreast with technology, conduct R&D, evolve standards, processes, and procedures through interaction with other countries/establishments.

ESDM and FABS are two wheels of the system, and these must work in complete unison. ISM will have to monitor their functionality in an integrated manner. Establishment of FABS has five major components: infrastructure, software, manufacturing facilities, highly qualified human resource and logistics. These are inter-dependent and must be considered as one system. A flaw in any of these would have detrimental effect on security, schedules, manufacturing and economy. Availability of these is to be ensured 24/7 through periodic maintenance.

The Central government has set up an empowered committee for manufacturing in high technology areas, which will be headed by the minister of Commerce and Industry, and notable people from the Indian industry, including Tata Sons chairman N Chandrasekaran, Bharat Forge Chairman Baba Kalyani, Mahindra Group managing director and CEO Pawan Goenka, Zoho Corp CEO Sidhar Vembu, and semi-conductor expert Anshuman Tripathi. This, with the ISM and access to the Prime Minister, shows the political will and sends a clear message that all resources of the nation are available to ensure quick execution of the Mission and the resultant addition to the nation's comprehensive power.

Setting up of EDMS and FABs would remain a 'work in progress' as the demand increases, and different kind of chips have to be produced. Technology would lead the production always since harnessing of technology would take up to four years. Our systems would be safe comparatively as we would be using our indigenous chips, processes, and components.

The key to success of a semi-conductor entity is contingent on a dedicated cluster by way of a 'Semi-conductor Park', holding all the elements of the supply chain in addition to the FAB, Special attention will have to be given on the resilience and availability of the supply chain. Global semi-conductor community is close knit network of companies which thrives on functional specialisation and technology upgradation. India will need a dedicated institution for sustained engagement with global majors to keep abreast of technology, processes, finance and ensure that voice of India is heard in the comity of nations and that India' interests are taken care of. Indian Semi-conductor Mission may take on this responsibility.

Conclusion

The process of manufacturing semi-conductors is not something that can be easily understood and/or performed, but we owe our very existence to them. Semi-conductors are in every facet of our lives from health to travel, toys to cars, to aircrafts, rockets, and missiles, sailing boats to aircraft carrier, computer games and so on. The quantum and types of the chips required are mind boggling. It is not possible for any one nation to have all technologies, infrastructure, and knowledge of processes. International linkages and cooperation are a must. Joint R&D and projects will save on finance and efforts.

Security aspects would have to be factored in both at the design and manufacturing stage. Semi-conductors would be recognised as critical resource and FABs as strategic infrastructure. Testing for malware in accordance with mutually agreed upon routines would be an essential parameter requiring special labs and human resource with appropriate skills. Considerable resources are deployed in the development of better, faster, cheaper technologies to make smaller and cheaper semi-conductor devices, such as transistors and MEMS (micro-electro-mechanical systems). There is likelihood of nations not sharing the technology and a possibility of race for 'technological dominance'.

These improvements and those which we cannot think of today, would have direct impact on the security, economy, society, and human beings of the nations. Systems and sub-systems employing these chips would contribute substantially towards the comprehensive power of the nations and hence the degree of 'technological sovereignty'. A silent revolution is brewing up and India must be prepared and be proactive.

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