

Significance of the Semiconductor Industry in the Indian Economy

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Abstract: *The semiconductor industry underpins the economic growth of nearly all global economies. Contemporary apparatus and industries such as Aerospace, Automotive, Telecommunications, Energy, Medical gadgets, Information Technology, Digital Infrastructure, and all electronic gadgets are constructed using semiconductor-based chips. The semiconductor sector will significantly influence economic growth and development, technological progress, and the creation of numerous employment opportunities for a nation. Taiwan, South Korea, Japan, the United States, and China are presently the leading producers of semiconductor chips and electronics. The semiconductor industry possesses significant potential in India, particularly for its numerous uses and impact on sustainable development. The demand for worldwide semiconductor chip requirements significantly exceeds its supply. India currently lacks its own semiconductor manufacturing and production facility, relying heavily on imports of microchips from other nations. India's projected Semiconductor Industry is a crucial component of the goal for Viksit Bharat by 2047, accompanied by significant expectations. India will primarily engage in the design, assembly, testing, and packaging of semiconductors. The Government of India is presently launching numerous initiatives, including the Production Linked Incentive (PLI) scheme and the Design Linked Incentive (DLI) plan, to ensure the project's success. However, India's anticipated semiconductor sector may encounter numerous hurdles in fabrication, including significant capital investment, a competent workforce, and the capacity to contend with formidable competition. Nonetheless, the successful execution of the initiatives and robust leadership would foster a conducive environment for the Semiconductor Industry in India, positioning the nation as a worldwide leader and powerhouse in the near future.*

Keywords: Semiconductor Industry, Viksit Bharat 2047, Production Linked Incentive, Global Leader

I. INTRODUCTION

Semiconductors are the foundation of an economy, as this industry is essential in manufacturing end-user items such as automobiles, computers, mobile phones, digital cameras, televisions, home appliances including washing machines and refrigerators, LED lights, advanced vehicles, and critical medical equipment. Semiconductor chips are essential components in all these. In response to the demand for semiconductors in critical areas and machinery, governments and industrialists worldwide are increasing investments in chip production. The industries are experiencing significant growth annually. The global semiconductor business is anticipated to grow by 13.1% in 2024, with a market valuation of \$574 billion in 2022, marking the largest yearly total ever recorded. The Government of India has approved several initiatives and programs to establish its own semiconductor value chain, aiming to become a worldwide leader and realise the goal of Viksit Bharat, 2047. The Indian government has implemented plans aimed at commercialising and enhancing the output of the semiconductor industry, with a special emphasis on "Digital India." The aim of this study is to comprehend the fundamental principles of semiconductors, the emerging semiconductor industry in India, and their influence on the Indian economy.



II. REVIEW OF LITERATURE

In their 2022 study "Harnessing Trade Policy to Build India's Semiconductor Industry," Pranay Kotasthane and Arjun Gargeyas examine the significance of trade and knowledge transfer in emerging countries, which is crucial for ensuring the semiconductor industry's advantages for India. The semiconductor industry in Taiwan was established through a technology transfer agreement with the United States. In the 1960s, Taiwan's liberal trade policies facilitated the expansion of state-funded foundries such as United Microelectronics Corporation (UMC) and Taiwan Semiconductor Manufacturing Company (TSMC), while Taiwanese engineers acquired technological proficiency through the agreement. Due to the persistent rise in private investment and enhanced access to machinery and plant supplies, Taiwan emerged as a global leader in the semiconductor manufacturing industry. India and other prominent semiconductor manufacturing centres can achieve greater success by emulating Taiwan's semiconductor industry in technology and business transfer. A study conducted by Himanshu Kushwaha and Anil Sethi titled "Future of Semiconductor Fabrication (FAB) Industries in India - Opportunities and Challenges (2017)" indicated that the demand for electronic items in India is expected to surge in the coming years, resulting in a significant increase in the cost of semiconductor devices, potentially reaching billions of dollars. Currently, numerous business units are involved in design, although they lack on-site fabrication capabilities. Currently, for design projects, they primarily rely on overseas fabrication facilities. A growth-oriented and well-maintained ecosystem built by the central government can enhance semiconductor wafer fabrication and R&D units in India. Professor Mamidala Jagadesh Kumar (2021) in his research work titled "Is India poised to become a major hub for semiconductor chip manufacturing?" discusses India's potential to become as a significant hub for semiconductor chip manufacture. India have the capability to design and manufacture semiconductor chips, hence fulfilling the need for semiconductor chip production. It possesses the potential and requisite skills to aid in the production of solar cells, energy requirements, water accessibility, and electronics-grade silicon. A robust collaboration between industry and academia is essential. The article asserts that India possesses the potential to emerge as a global hub for semiconductor chip manufacturing. Effective governmental regulations, escalating domestic demand, burgeoning entrepreneurship, and an increase in experienced local designers will position India as a worldwide hub and leader in the forthcoming years.

Objective of the study

- To discuss about technological fragment of Semiconductor and Semiconductor Industry
- To discuss how semiconductor industry will work as a milestone for Vikshit Bharat, 2047
- To study the impact of semiconductor on economic growth and development, technological advancement and creation of multiple job avenues of a country.
- To learn about the schemes and initiatives taken by the government of India to promote the semiconductor industry in India.
- To identify the challenges that industries will have to overcome

III. RESEARCH METHODOLOGY

This research article relies exclusively on the accessible secondary data. Data is sourced from diverse publications of central and state governments, foreign governments, international organisations and their affiliates, prior research papers, articles, magazines, and credible websites, as well as publicly accessible published data.

IV. DISCUSSION

Technological fragment of Semiconductor and Semiconductor Industry.

To dominate the global marketing sector, all products derived from semiconductor materials manufactured inside the semiconductor industry must exhibit low power consumption, compact size, high speed, lightweight characteristics, and cost-effectiveness based on integrated circuits. This integrated circuit comprises semiconductor materials. A substance exhibiting conductivity between that of conductors and insulators is referred to as a semiconductor material. They may



consist of pure substances such as silicon or germanium, or may include mixes like gallium arsenide or cadmium selenide, among others. While these materials are insulators at ambient temperature, their conductivity can be modified by various procedures depending on the application. Typically, current is conducted by free electrons in a circuit's conductor. In the event of semiconductor obligations

Due to its crystalline form, it can exhibit intrinsic properties (with electrons and holes as charge carriers) or extrinsic properties, where holes serve as charge carriers in p-type and electrons in n-type, achieved by incorporating pentavalent and tetravalent materials with pure silicon, germanium, or other semiconductors. A semiconductor can be utilised in diodes, transistors, integrated circuits, light-emitting diodes, solar cells, storage devices, communication integrated circuits, and microprocessors for unidirectional current conduction, as well as for responding to thermal and photonic stimuli. Semiconductor manufacturing procedures encompass wafer fabrication, packaging, and assembly. Silicon wafers undergo transformations via methods such as photolithography, etching, and doping to produce intricate patterns and layers for integrated circuits. The photolithography technique is employed to delineate the circuit layout on the wafer's surface, then followed by the selective removal of extraneous materials from the wafer through etching. Subsequently, Physical Vapour Deposition and/or Chemical Vapour Deposition techniques are employed to fabricate transistors and other components on the wafer surface. The ion implantation method modifies the electrical characteristics of silicon by doping. Chemical/Mechanical Polishing is employed to eliminate flaws and surplus material. The Government of India has created three units in Gujarat for this fabrication component under Viksit Bharat. Completed chips are linked to the external circuit and appropriately packed. An assembly and testing plant has been created in Jagiroad, Assam, to ensure high-quality product packaging. To ensure quality control, there is a necessity for skilled personnel, particularly cleanroom technicians, process engineers, lithography engineers, quantum computing engineers, experts in AI and ML, as well as researchers to adapt to rapidly evolving technologies, especially in nanotechnology, within a global context and marketing landscape. Furthermore, substantial capital investment is necessary for the establishment of a clean room for production. The current cost of an ISO 6 Clean Room is approximately Rs 4000 per square foot.

Viksit Bharat: 2047 and Semiconductor Industry

The Techade of India signifies a determination to embrace the digital era, provide new employment opportunities, enhance living standards, solidify its position in the global technology arena, and promote sustainable development. The semiconductor sector in India is integral to its aspiration for "Viksit Bharat" by 2047. The nation is striving to establish itself as a global leader in the semiconductor sector and to forge a significant position in the international technology arena. In this context, here are several recent advancements in India's semiconductor industry. On March 13, 2024, the Government of India virtually inaugurated the foundation for three semiconductor projects valued at approximately Rs 1.25 lakh crore. The Government of Assam and Tata Group facilitated the establishment of a semiconductor plant in Jagiroad, Morigaon district, Assam, by executing a 60-year leasing deal for 170 acres of land. The Outsourced Semiconductor Assembly and Test (OSAT) plant will be established at the site of the defunct Hindustan Paper Corporation Limited and will be designated as Tata Semiconductor Assembly and Test Pvt Ltd (TSAT). The government would allocate Rs 27,000 for its establishment. The project is scheduled for completion by mid-2025. This plant is anticipated to manufacture up to 48 million semiconductor chips daily, utilising sophisticated packaging methods such as flip chip and Integrated System in Package (ISIP). Additionally, Tata Electronics Private Limited (TEPL) will establish a semiconductor production facility in the Dholera Special Investment Region (DSIR) in Gujarat. The facility's capacity will be 50,000 wafers per month. Thirdly, CG Power and Industrial Solutions Limited would establish an additional Outsourced Semiconductor Assembly and Test (OSAT) facility in Sanand, Gujarat, with an investment of around Rs 7,500 crore.



Impacts

The objective of The Indian Semiconductor Mission (ISM) is to establish a sustainable semiconductor ecosystem. This will position India as a global leader in electronics manufacture and design. Semiconductors significantly influence economic growth and development, technological progress, and the generation of various employment opportunities inside a nation. It facilitates technical breakthroughs in several manners.

On technological advancement

Semiconductors constitute the foundation of all electronic components utilised in various consumer devices, including computers, smartphones, and televisions. Furthermore, the amalgamation of physical and digital systems that enhances communication among equipment, systems, and networks is solely facilitated by semiconductor chips. Semiconductors are the essential components for transistors, integrated circuits, and solar cells. The sector has experienced swift progress in computational technology. It forecasts the duration required for the quantity of transistors on a chip to double (Moore's Law). Semiconductors facilitate AI and machine learning algorithms that enable real-time intelligent decision-making. The advancement of 5G/6G technology has escalated the demand for semiconductors capable of facilitating faster data speeds and enhanced communication among diverse systems. The amalgamation of physical and digital systems can facilitate the establishment of smart factories. This is facilitated by semiconductors. Furthermore, Semiconductors possess the capacity to contribute to advancements in quantum computing. In the medical sector, semiconductors have the potential to significantly contribute to advancements in electronics. Semiconductor firms are partnering with diverse high-tech enterprises, car manufacturers, and research institutions to promote innovation and expand product offers.

On Job Creation and Skill Development

The capital-intensive semiconductor industry has the ability to generate high-quality employment and foster skill development in India. Moreover, it can catalyse the cultivation of a proficient workforce in advanced technologies. Specialised domains such as nanofabrication, chip design, and sophisticated packaging are expected to enhance STEM (science, technology, engineering, and mathematics) teaching and research in Indian institutions in accordance with industry demands. The Indian government has announced a \$10 billion incentive program to entice semiconductor manufacturing firms to the country. This initiative is anticipated to provide more than 50,000 employment opportunities in India's semiconductor sector. The OSAT, Morigaon unit, would not only advance technological advancement but also yield substantial socio-economic advantages by creating 15,000 direct jobs and 11,000-13,000 indirect jobs, hence fostering regional economic growth in Assam and surrounding regions. The OSAT plant in Gujarat would provide up to 1,200 employment opportunities and will concentrate on sophisticated semiconductor assembly and testing. Sardar Vallabhbhai National Institute of Technology, Surat, and Gujarat Technological University partnered with the organisation to cultivate a proficient staff for the sector.

On economic growth and development

The Indian semiconductor industry was valued at US\$21.75 billion in 2021, is predicted to be roughly \$38 billion in 2023, and is projected to reach \$109 billion by 2030. The acceleration of the semiconductor sector in India may mitigate the country's trade deficit by enhancing exports and diminishing imports. In the forthcoming years, the semiconductor industry is anticipated to accelerate its growth due to rising demand from end-user sectors, with an expected production of 70 million chips daily. Countries can strategically position themselves to dominate the supply chain through the utilisation of semiconductor manufacturing facilities. It will not only enhance economic strength but also serve as a catalyst for investment and the creation of high-tech employment opportunities. Emerging economies such as India are strategically positioning themselves to seize possibilities offered by developed nations. The National Electronics Policy (NEP) seeks to enhance electronic hubs for electronics system design and manufacturing (ESDM), encompassing semiconductors. India is set to attract investments from global entities with a \$363 million allocation to



the Indian Semiconductor Mission. The entity will be structured to encompass critical areas including automotive, electric vehicles, telecommunications, and consumer electronics. The project is poised to become one of the nation's foremost manufacturing locations. It corresponds with the nation's overarching objective of creating a self-sustaining semiconductor ecosystem. The facility's substantial daily output will cater to both domestic and international markets, positioning India as a pivotal player in the global semiconductor supply chain.

Government Initiatives

The Indian government has instituted many efforts and policies to foster the domestic semiconductor manufacturing industry, driven by rapid expansion and decreased reliance on imports. The Semicon India initiative commenced in 2021 with a budget of Rs 76,000 crore. The initiative is designed to advance the national semiconductor sector. This project encompasses not just manufacturing facilities (fabs) but also various areas of the semiconductor industry, including packaging, display wiring, Outsourced Semiconductor Assembly and Testing (OSATs), sensors, and other essential components, therefore fostering a full ecosystem. The Indian government has initiated various efforts to bolster the semiconductor sector to mitigate the trade deficit. Key government efforts include the Make in India program launched in 2014. The campaign aims to enhance the manufacturing sector in India and position the country as a global manufacturing powerhouse. Several initiatives have been implemented to promote semiconductor manufacturing, including the Production Linked Incentive (PLI) program for several electronics sectors. The program is an exceptional initiative that allocates a \$1.7 billion incentive package to companies establishing semiconductor manufacturing facilities in India. This new legislation will not only promote semiconductor manufacturing firms but also generate indirect and professional job opportunities. Eligible firms participating in this initiative may get a portion of their augmented sales as an incentive. Last year, firms such as Taiwan's Foxconn and Vedanta were attracted to the production-linked incentive program, which offered assurances of multi-billion-dollar investments for the creation of semiconductor manufacturing facilities, utilised in various applications from autos to mobile phones. The government has initiated Design Link Incentives (DLI) to bolster the electronic sector. The objectives of this DLI Scheme are to cultivate and promote the development of domestic enterprises, start-ups, and MSMEs, as well as to encourage import substitution and value enhancement.

The semiconductor design infrastructure for start-ups and MSMEs in the electronics sector should be reinforced to ensure accessibility. The DLI program seeks to offer financial incentives for the development of infrastructure support throughout multiple phases, including the disposal of semiconductor designs for chipsets, system on chips (SoCs), integrated circuits (ICs), systems, and IP cores, as well as semiconductor-related designs over a span of five years. In addition, the government has initiated various programs, including the Chip to Start-up (C2S) initiative, the Electronic Components and Semiconductor Promotion Scheme, and the Electronics Manufacturing Clusters (EMCs). The Indian government, under the EMC initiative, has established Electronics manufacture Clusters throughout various regions of the country to create a conducive environment for semiconductor manufacture. These clusters provide infrastructure, shared facilities, and a conducive atmosphere for enterprises in the semiconductor sector. The government has concentrated on modernising the Semiconductor Laboratory in Mohali and executing the Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS) alongside the Production Linked Incentive (PLI) Scheme for Large-Scale Electronics. These initiatives guarantee assistance for all facets of semiconductor manufacturing, cultivating an ecosystem that includes chip design, fabrication, testing, and assembly.

Challenges

India possesses a substantial workforce of proficient engineers and technological experts, rendering it an attractive locale for the semiconductor manufacturing sector. The expanding electronics and mobile device sectors in India generate significant demand for semiconductor products, enhancing the prospects for domestic manufacture. The Government of India has initiated programs such as "Make in India," along with the Production-Linked Incentive (PLI) and Design Linked Incentive (DLI) schemes, to foster domestic manufacturing, particularly in semiconductor



fabrication. Furthermore, increasing investments from various Indian firms and international semiconductor corporations have expressed interest in establishing fabrication facilities in India, potentially resulting in industry success. Despite its considerable potential, India's semiconductor sector encounters numerous hurdles in fabrication. The semiconductor business, especially its manufacturing, necessitates significant financial investment. Robust government backing is required to attract substantial domestic or foreign enterprises. Until now, India has not had a specific policy to encourage domestic enterprises or to attract international investment for establishing semiconductor fabrication facilities. Secondly, there is a deficiency of personnel with expertise in semiconductor manufacturing, resulting in a considerable skills gap. It is projected that approximately 30,000 experienced people will be needed in the fields of chip fabrication, VLSI design, ATMP processes, and advanced packaging. Third, India has formidable competition from existing semiconductor powerhouses such as Taiwan, South Korea, and China, who have developed resilient ecosystems of suppliers and customers. The preeminence of leading firms such as TSMC, NVIDIA, Intel, and Samsung hinders the ability of new competitors to penetrate the market. The availability of essential minerals such as gallium and germanium, vital for semiconductor manufacturing, presents a significant difficulty. China dominates 98% of the worldwide supply of gallium and 68% of germanium. India must investigate alternate materials and procure resources as a component of its long-term plan.

V. CONCLUSION

Notwithstanding these hurdles, there is an increasing local and international need for semiconductors, propelled by the swift advancement of information and communication technologies and the transformations they have introduced to our daily lives regarding the items and services we utilise. The geopolitical tensions regarding Taiwan's association with China and the Western world's apprehensions about China's dominance, alongside the supply chain disruptions experienced during the Covid-19 pandemic, create an opportunity for India to establish itself as an alternative semiconductor supplier. All stages of the semiconductor value chain, including research, design, production, assembly, and packaging, transpire inside a globally integrated network. Semiconductors are intricate products that necessitate sophisticated design and manufacturing processes, depending on a convoluted worldwide supply chain for raw materials, equipment, research and development (R&D), technology, skilled personnel, testing, and distribution. This is a crucial element of the industry's success.

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