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INDO-DUTCH SEMICONDUCTOR OPPORTUNITIES

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Foreword

Marisa Gerards
Ambassador of the Kingdom of the Netherlands to India, Nepal and Bhutan.

In September last year, the prime minister of the Netherlands travelled to India to attend the G20 Heads of State Summit in New Delhi. I was privileged to accompany him in some of his engagements. A highlight for us both was the bilateral meeting with honorable prime minister Narendra Modi. Both prime ministers praised the long-standing and strong ties that the Netherlands and India have. They also looked ahead and agreed that India and the Netherlands countries should work towards a strategic partnership. This would function as an overarching framework for our many existing collaborations and deepen our ties profoundly. One area that was identified as particularly important is collaboration on innovation and advanced technology. And semiconductors was singled out as one of the key areas to focus on in the coming years.

The Netherlands, renowned for its open economy and leading edge in innovative technologies, has long been a critical player in the global semiconductor sector. The Dutch government started early on by setting up public-private partnerships and making long-term investments in this sector. This led to successful global pioneers like ASML, NXP Semiconductors, and STMicroelectronics, and an industry which contributes significantly to the Dutch economy and holds a 9% share in the global semiconductor market. Our knowledge institutions, such as the Technical Universities of Delft, Eindhoven and Twente, have been instrumental in advancing semiconductor research and education. And these institutions have not only contributed to the Dutch semiconductor landscape but also fostered collaboration with global counterparts, some of them of Indian origin.

Together with Dutch prime minister Rutte we saw this with our own eyes, when we travelled to Bengaluru and visited NXP's facilities there. We learnt to see that NXP India employs thousands of highly talented professionals who work on semiconductor design and applications, and has its own teams working on Indian projects in the Netherlands as well. The Netherlands has observed that India is making great strides in the semiconductor sector and has for instance launched Mission Semicon, funded a 10 billion dollar incentive plan, and is attracting leading investors and expertise to India as well. It is therefore important for us to reassess and further strengthen our semiconductor relationship.

I am therefore grateful for the exploratory collaboration between our own Innovation Network and IESA, the India Electronics and Semiconductor Association. The report in front of you gives a comprehensive overview of the ecosystems of both countries, while outlining multiple paths forward to reinforce our relationship. More importantly, by creating this report and working closely side by side, the authors brought together countless experts from India and the Netherlands in several roundtables, interviews and events.

I express my sincere appreciation to all the contributors for their invaluable insights and foresight. Their collective wisdom paves the way for an Indo-Dutch semiconductor partnership that is set to redefine technological boundaries and spearhead innovation and economic ties for years to come.

Preface

Ashok Chandak
President IESA

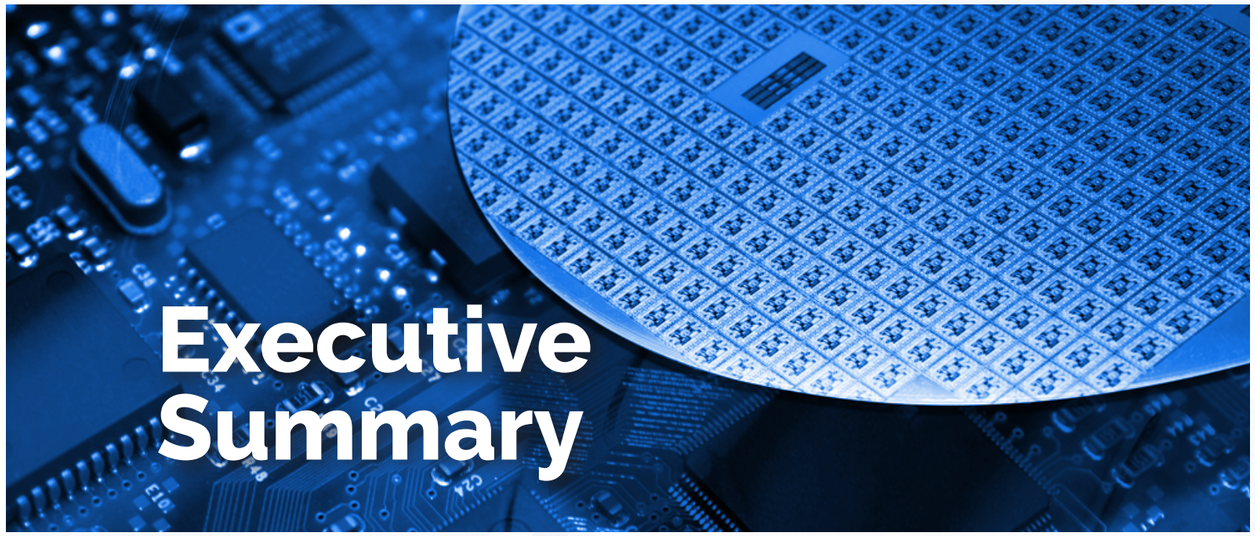
Col Anurag Awasthi (R)
Vice President IESA

The Indo- Dutch Semiconductor opportunities report is a fruition of a tremendous effort of over ten months by The Netherlands Innovation Network and India Electronics and Semiconductor Association. The aim of this report is to acquaint both ecosystems about the prowess and opportunities in both countries. The very premise of this report was to do this in the right earnest with interactive views of industry, academia and the policy makers from both the countries with carefully curated and focused interactions on myriad of subjects, in tune with the overall theme.

This is a unique report of joint effort, focused research and multistakeholder interactions. This brings to fore the strengths of the semiconductor industry in The Netherlands and the opportunities, as they present themselves in India. The Netherlands is a powerhouse in this space with the presence of some important entities in India since a long time. The Netherlands also has a vibrant academic and research landscape which can be harnessed by both the countries for mutual benefit in terms of skill development, exchange programs and various other aspects. The Indian semiconductor and electronics industry has undergone a sea change over the last two decades. These have primarily been in the product domain, the evolution of the retail channel and an evolving policy landscape. The requirements of both the consumers and businesses have evolved, leading to a demand for more innovative products. The industry's ecosystem has evolved to keep pace with the changing demand patterns. The supply chains are now far more complex, diverse, and optimized to meet the new industry structure. Currently, while a significant share of Indian demand is met by imports, the Indian landscape is being ushered into an era wherein besides the design aspects, the manufacturing of these vital chips as well as several components will be indigenized through an astute policy support and incentivized production from the government of India.

This joint effort, which is a one of its kind will provide a ready reckoner to both the Dutch and Indian entities to study the landscape and look at collaborations at all levels. It will also provide the requisite metrics to both the academia and various other innovation organizations to look at this important space which can be the future powerhouse. We wish to put on record, our deepest appreciation for the Netherlands Innovation Network, Embassy of the Kingdom of the Netherlands in India, Embassy of India in The Netherlands, Academia and Industry Captains for their valuable time for long interactions, Feedback Advisory, policy makers from the government from both sides and Indian Semiconductor Mission (ISM).

We hope that this joint endeavour from us is a harbinger of change, leading to meaningful joint collaborations of the future and also paves a way for further joint interactions and deliberations.



Executive Summary

The Netherlands is a global leader in the semiconductor space with a large footprint of equipment manufacturing entities, academic and research facilities and a well-developed ecosystem. India is the world's fifth largest economy with a large semiconductor design prowess and is embarking towards manufacturing as well as packaging domains. In 2021, India's end equipment market stood at $119 billion in terms of revenue. It is expected to grow at a CAGR (Compound Annual Growth Rate) of 19% from 2021 to 2026. This demand is being pushed by the increasing pace of digital transformation among the country's consumers, enterprises and public sector through the adoption of new technologies, from advanced connectivity to content consumption to the cloud. These cover smartphones, PCs, wearables, cloud data centres, Industry 4.0 applications, IoT, smart mobility, and advanced telecom and public utility infrastructure.

The Indian Semiconductor policy unveiled in December 2021 followed by various policies as given out by the State governments have galvanised the effort towards self-reliance in this domain for the future. Indian government policies to include Production Linked Incentive (PLI), Design Linked Incentives (DLI), Electronics Manufacturing Clusters, (EMCs) and Scheme for Promotion of manufacturing of Electronic Components and Semiconductors (SPECS) are all being equipped to boost domestic design, manufacturing and assembly. All these aspects are discussed in detail in the designated chapters of this report. To augment economies of scale, well known Asian entities are establishing plants in India. With US and Europe leading in R&D, East Asia to include Taiwan and Korea leading in manufacturing/OSAT and China with its capital-intensive expertise in packaging and testing, the global value chains in this sphere are disjoint and disintegrated and thereby require greater collaborations. To this end, India and The Netherlands can be suitable partners in the future.

This report aims at creating synergies between The Netherlands and Indian semiconductor ecosystem and addresses various topics of manufacturing, enabling policies, design, skilling, R&D, academia, supply chains with a vast research data for the entities of both the countries. The report has been curated jointly with notable inputs of industry leaders, policy specialists, government functionaries as well as academia of both countries through multiple interactions and round tables.

The report also looks at future vistas of opportunities between the two countries in this crucial sector. It is an endeavour to imbibe the best practices and dovetail the prowess and opportunity of both countries together to enable business to business (B2B) processes and correspondingly build a collaborative ecosystem of the future. A large quantum of effort has been put in by the Embassy of the Netherlands in New Delhi and India Electronics and Semiconductor Association for this report. We thank the Embassy of India at The Hague for their inputs for the report as well.

There are some compelling reasons now for the Netherlands to evaluate and build partnerships with India in the semiconductor sector.

Pull-factors for the Semiconductor sector in India

Potential areas for collaboration with Indian companies in research and development for Dutch institutes and businesses.

Semiconductor Design Collaborations

Dutch and Indian firms and institutes could jointly develop innovative chip designs, leveraging India's design expertise and the Netherlands' strengths in fabrication and equipment.

Innovation Ecosystem Enhancement

Joint innovation programs can be established to help Indian firms improve their innovation cycles and develop cutting-edge products.

Joint Research Programs

Joint research initiatives focused on emerging semiconductor technologies, such as photonics and quantum technologies.

Technology Transfer and Licensing

Dutch firms could explore opportunities to transfer technology or license their innovations to Indian firms.

Collaborative Start-up Incubation

Institutes and firms from both countries can collaborate to support semiconductor-related start-ups. Incubation programs can provide mentoring, resources, and funding to nurture innovative ideas.

Joint Participation in Government Initiatives

Both countries can jointly participate in Indian government initiatives, such as the Design Linked Incentive Programs.

Market-Specific Solutions

Developing semiconductor solutions tailored to specific market needs, such as automotive, healthcare, and telecom sectors.

Cross-Border Technology Transfer

Both countries can jointly facilitate the transfer of semiconductor technologies across borders, enabling both parties to benefit from each other's strengths.

Resource Sharing

Sharing resources such as research data, testing facilities, and specialized equipment. Leading to cost savings and improved efficiency in R&D efforts.

Potential areas for collaboration with Indian academic institutions

India generates more than 1.5 million engineering graduates each year, establishing itself as one of the foremost contributors of engineering expertise globally. Additionally, India boasts a highly skilled and cost-effective workforce, presenting significant opportunities. The country's advancements in the Innovation Index, with a Compound Annual Growth Rate (CAGR) of 20% in the semiconductor sector, are particularly noteworthy, driven largely by increasing demand for Electric Vehicles (EVs).

Joint Research Projects

Focus on emerging semiconductor technologies, materials science, fabrication processes, and innovative device designs.

Faculty and Student Exchange Programs

Dutch institutes can offer expertise, while Indian students gain exposure to advanced research facilities.

Ph.D. Programs and Co-supervision

Combined strengths of both institutions can lead to interdisciplinary research and comprehensive outcomes.

Skill Development Workshops and Training

Enhance the skills of students and researchers in semiconductor design, fabrication, characterization, and packaging.

Technology Transfer and Commercialization

Collaborations can result in technology transfer from academic research to practical applications.

Access to Advanced Facilities

Dutch institutes can provide access to their cutting-edge research infrastructure, clean rooms, and labs, enabling Indian researchers to conduct high-quality experiments.

Joint Publications and Patents

Collaborative research can lead to joint publications, patents, and intellectual property, contributing to the academic reputation of both institutions.

Talent Development and Training

Help India meet its ambitious goal of training a large number of semiconductor professionals and create a skilled workforce for both nations.

Potential areas for Investing in India for Dutch firms

01 Investment in Semicon Equipment Parts – Green field Unit in India

Opportunity for India to be part of Global Semicon Equipment Parts Supplier base is very high given the twin factors of:

- India's strong presence in Engineering Manufacturing / Auto Components Ecosystem providing the Dutch firms with local cost quality manufacturing and workforce advantages
- Netherlands strong presence in Equipment Manufacturing Ecosystem and having a Global Supply Chain Base.

Dutch firms could look at the following options in investing in India:

- Encourage their Tier 1 / 2 Component suppliers to set up a Green field Unit in India and derisk their global supply chains
- Develop and Source Components / Spares from Existing Indian firms

IESA could further help in identifying specific opportunities for any Dutch Equipment firms given their specific needs / expectations from India.

02 Investment in Semicon Design Firms – Acquisitions

India is a Semiconductor Design Capital of the world and firms in India contribute at a very high end spectrum of Design needs of the Semiconductor Industry.

Dutch firms have the opportunity to invest / acquire niche and strategic Indian Design firms in India. Brief Profiles of key Indian Design firms

IESA could further help in identifying specific opportunities for any Semicon firms given their specific needs / expectations from India.

03 Investment in OSATs / ATMPs

Semi Firms in Netherlands, strong in many areas of the Semiconductors specifically in Photonics, Sensors, Micro controllers and MEMS could look at investing in India as an alternate destination to derisk their manufacturing activities. These products could be made in India and exported to global markets.

Opportunity for Dutch firms to look at setting up OSAT / ATMP units to begin with and then later explore opportunities in Fab at a later date. Dutch firms could invest on their own or partner with a major India corporate to invest in India. Many Indian Corporate Houses are open for Technology Investors / partnerships.

The key advantages which the country provides are highlighted below:

- India has proven its credentials as a strong contender for firms to diversify their Supply Chain activities, in the current geopolitically sensitive environment. This is already demonstrated by the Mobile / Wearables Manufacturing business which is now in the process of creating a Mobile / Wearables GVC in India.
- This is further made attractive by the strong push for incentives by the Government of India and other State Governments to attract Semiconductor manufacturing in India. Micron has shown its commitment by starting on its large ATMP facility in India and many more are in pipeline.
- The talent available in India and a large pool of highly skilled workforce at a very reasonable cost would be an added advantage.
- Many manufacturing disabilities are now taken care by many Governmental initiatives such as creation of Electronic Manufacturing Clusters, heavy infrastructure investments, ease of doing business and lower taxes.

Recommendations

This report has three sets of recommendations, aimed at government officials, the private sector and researchers.

First step: A Strategic Partnership between the Governments of India and The Kingdom of Netherlands

Prime Minister Modi of India and Prime Minister Rutte of the Netherlands agreed to form a strategic partnership in 2023. This would be an overarching framework for collaborating on a myriad of topics. This could be important to deepen the existing relationship and strengthen ties on topics such as semiconductors. To set up the strategic partnership in the field of semiconductors, similar agreements signed by India with nations such as USA (ICET agreement) and Japan. The agreement should cover a wide range of subjects, such as governance of the strategic partnership trade relations and investment frameworks, research and innovation collaboration & talent development and technology transfer.

Facilitating Technology transfer agreements between companies

Invest in semiconductor R&D and Science under bilateral knowledge and innovation agenda

Opening up the key strategic areas of Space for Dutch Semicon Companies.

Stepping up the Trade activities between the two nation in Semicon

01 In the roundtables we organized we understood there is a lack of knowledge of Dutch businesses and other stakeholders about the Indian semiconductor field.

- Therefore it is necessary to set up inbound and outbound missions to India.
  - » Innovation missions to bring in scientists and innovators.
  - » Arrange and facilitate Government delegation visit to NL and IND.
  - » Trade mission to IND with leading players like ASML

02 It is advisable to have a formal association / MOU between key trade bodies such as Semiconductors, Holland Hightech and IESA.

03 There are opportunities for Dutch firms / Institutions to have formal agreements with several State Governments in India.

04 There is a specific need to encourage

- Tier 1 and Tier 2 Component firms of the Equipment Supply Chain to evaluate investments in India
- Investigate setting up logistics and distribution facilities by leveraging the geographical advantage of India,
- Explore collaborations in the Indian Chemical industry ecosystem and forming Joint Ventures for a robust supply chain management

05 Mapping database of hardware startups and exploration of joint opportunities together

Talent Development and Research & Development initiatives

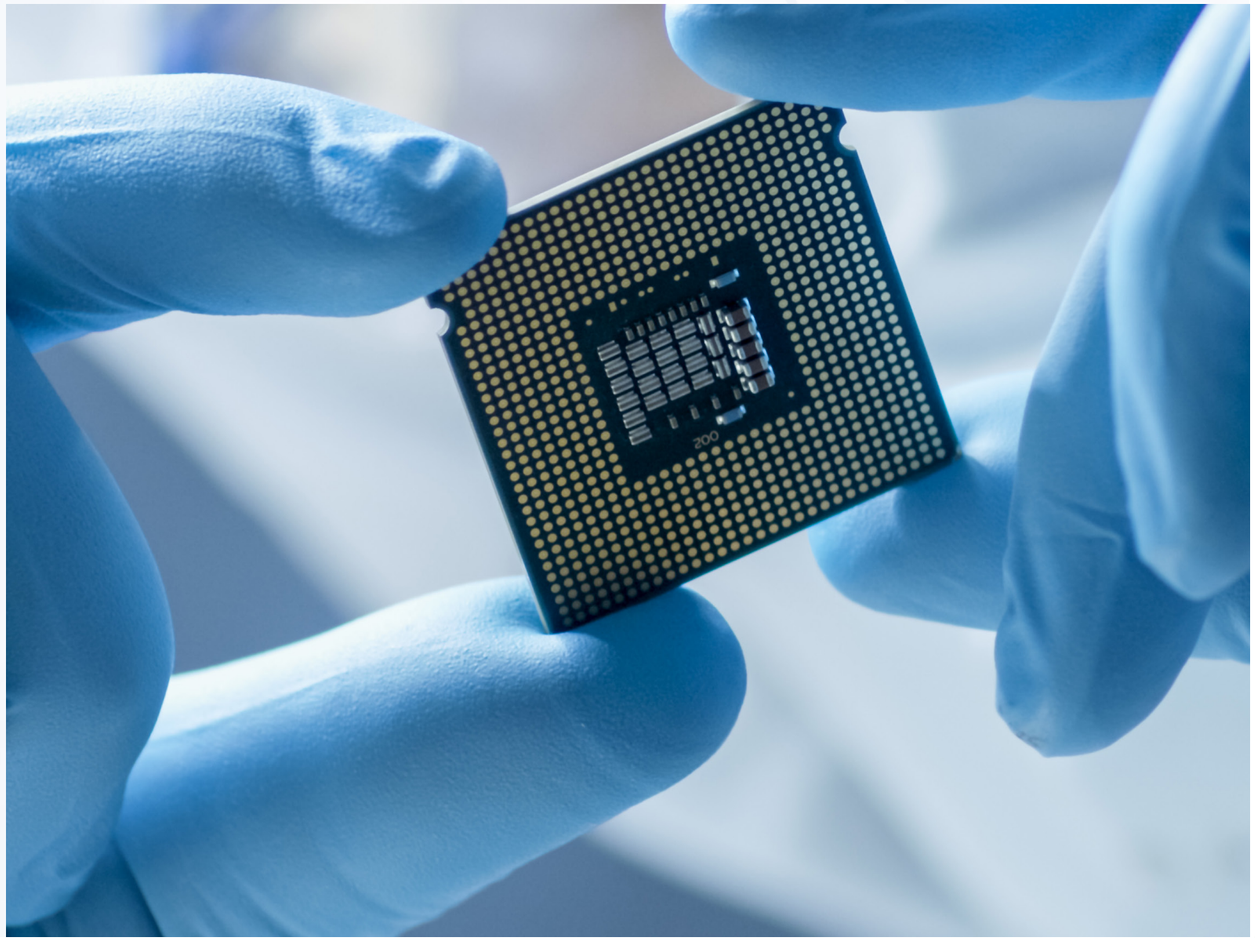
01 Netherlands Institutes could be part of the newly formed India Semiconductor Research Center, as there are already talks with other International institutes such as The Purdue and MIT.

02 India could be a source of Skilled Manpower for the Netherlands Semicon Industry. There are already plans which are in the implementation phase to train and educate 85,000 Semicon Professionals over the next 5 years in India. Netherlands Institutions participation now in this initiative could help in customising the requirements of the Skilled Workforce as per their requirements.

03 It is advisable to work closely together with semiconductor companies (such as NXP India) and government bodies to set up programs on talent development and research.

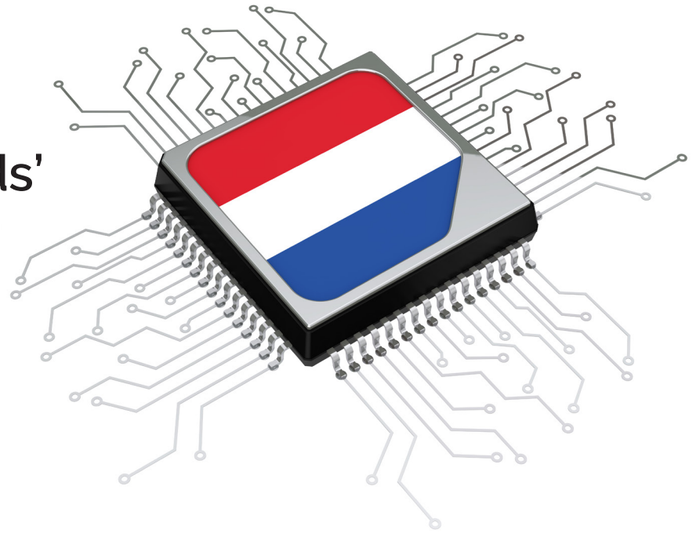
04 Through PhD funding initiated by both governments at institute level mobilize student exchange, knowledge sharing, deepen research bonding.

05 Some of the identified topics of research in the roundtables are the following: e.g. applications of semiconductor technology in the automotive sector, ultra-low-power... etc



Chapter 1

The Netherlands' Semiconductor ecosystem



Abstract:
This chapter sets out an overview of the Netherlands Semiconductor ecosystem. It includes an estimate of the overall number of firms in the Dutch Semiconductors value chain, key firms in equipment, design and the key academic institutions in Semiconductors.

1.1 Introduction to Netherlands Semiconductor ecosystem

The Netherlands government has recently shared its ambitions to strengthen its semiconductor ecosystem. The increasing demand for semiconductors and the changing geopolitical and geo-economic relationships make the realization of these ambitions urgent. It has been active in pursuing this goal through national and international policy frameworks and platforms such as the National Technology Strategy, which singles out semiconductors as one of the priority technologies for the Dutch government. The European Chips Act, the Important Project Of Common European Interest Micro-Electronics & Communication Technology (IPCEI ME/CT), but also the EU-India Trade and Technology Council further highlight the importance on international collaboration in this domain.

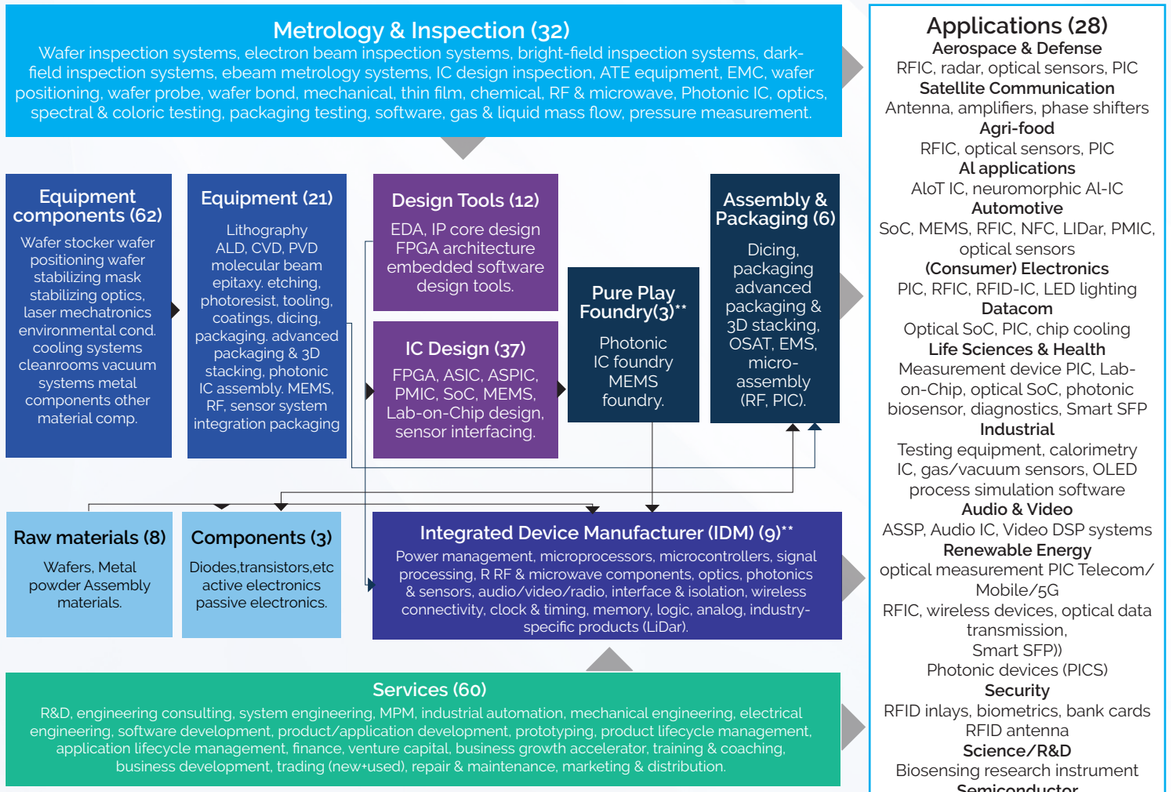
Together with industry and the knowledge field, the government is committed to growing the market share of Dutch semiconductor companies within the global value chain over the next ten to fifteen years. This objective can only be achieved through increased efforts on a number of underlying policy priorities related to increasing the business climate, talent development, physical space for growth, the protection of knowledge and technology and international partnerships to further the ambitions. The government aligns to provide consistent and reliable government policy to promote certainty among companies and stimulate long-term investments. Internationally, the Dutch government intends to proactively enter into partnerships to safeguard its relevant position in the value chain.

This is not a recent position, it goes a long time back. The innovative strength of Philips gave rise to several major businesses that have become essential to the global high-tech ecosystem. Over the years, many Dutch chip design companies have contributed to applications for major clients across Europe, Asia and the US. During the last several decades, an invaluable ecosystem of SMEs, knowledge institutions and universities has grown out of these corporate businesses. This ecosystem strengthens itself and maintains a national focus in the chain. It is a valuable system that is of major added value to the global semiconductor industry.

The Kingdom of Netherlands has achieved a global top position within the semiconductor equipment industry. The second top position within this value chain is the chip design industry. Both positions are of great added value to increase Europe's strategic autonomy and generate nearly 20% of the global market value.

The Dutch Semiconductor ecosystem consists of nearly 280+ organisations spread across the value chain as shown below in Chart 1

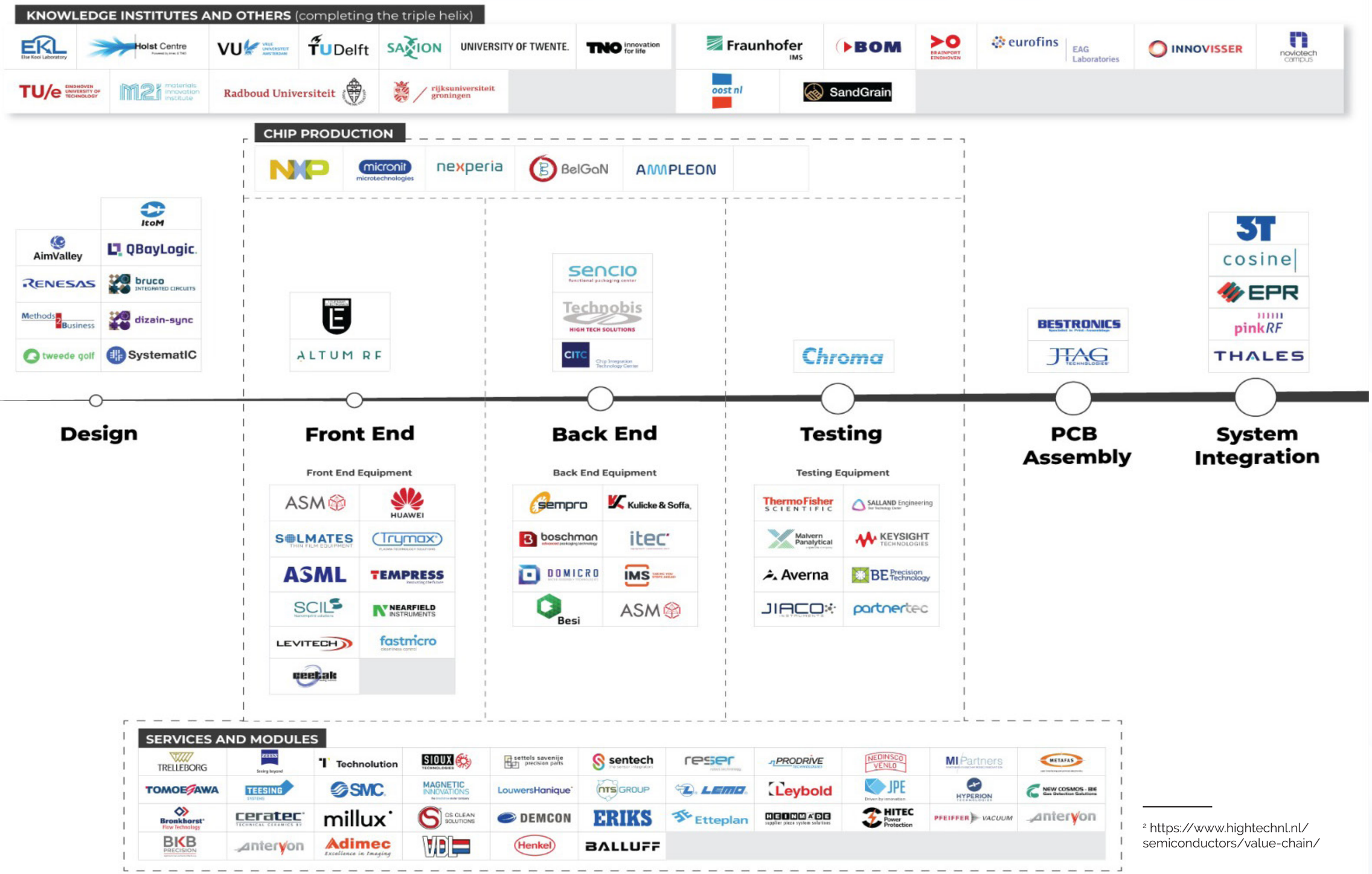
Dutch semicon value chain: 280 organisations*



* Organisation can be active in more than one segment of the value chain.
** Foreign-owned IDMs and Pure Play Foundries are listed as service providers when they do not conduct full IDM and Foundry activities in NL

[1] Source: RVO

The Chart 2 below showcases the complete Semiconductor Value Chain in Netherlands and the key companies engaged in various activities in this Value Chain[2].



[2] https://www.hightechnl.nl/semiconductors/value-chain/

Competitive position of the Dutch ecosystem (market and know-how)

- The Netherlands has a strong global position for Semiconductor Manufacturing Equipment.
- This strong global position is co-enabled by many Dutch OEM suppliers, like VDL ETG, Demcon and Prodrive.
- The strong global position is also co-enabled by world-class know-how and knowledge, both in the companies and in Dutch Universities and RTOs (like ARCNL, TNO).
- As a result of this strong global position of Dutch companies, the Dutch ecosystem for Semiconductor Manufacturing Equipment Industry has an important contribution to the European sovereignty and to the earning power of the Netherlands.

Continuous innovation over the past 5 decades, has enabled major innovations in the industries using/applying ever improving ECS, co-enabled by important Dutch inventions. Proof can be found in the introduction by:

- ASML of Extreme Ultra Violet Lithography for leading edge logic and memory technology for sub 5nm IC-nodes;
- ASMI of several high-productivity systems to deposit enabling new materials by (Plasma-Enhanced) Atomic Layer Deposition and Epitaxial Depositions;
- BESI of Advanced Packaging Equipment for Exposed Die Molding Wafer Level Packaging (WLP);
- ThermoFisher of Transmission Electron Microscopy to measure and qualify materials and transistor structures down to the atomic scale.

Manufacturing Equipment

Netherlands has a very strong ecosystem of Semiconductor Manufacturing Equipment Industry[3]. Some key Equipment Companies in wafer-fab equipment and assembly equipment are:

a. Wafer-Fab Equipment

• ASML (with head office in Veldhoven) and its ecosystem of partners and suppliers address the Lithographic Equipment with built-in Measurement/Diagnostic Equipment for Holistic Lithography. They are the global leaders in the Lithography segment.

• ASMI (with head office in Almere) is into Atomic Layer Deposition ("ALD") Product lines. ALD represents more than half of the ASMI equipment revenue. ASMI's other product lines includes Epitaxy product lines, PECVD and Vertical Furnaces.

• ThermoFisher Scientific (head office in USA) has its main R&D and manufacturing site for high-end Transmission Electron Microscopes ("TEM") in Eindhoven.

• The Dutch Semiconductor Manufacturing Equipment suppliers form vibrant ecosystems together with OEM module suppliers like VDL-ETG, Demcon, Prodrive, Sioux and others. These OEM module suppliers also supply to other international Semiconductor Manufacturing Equipment companies.

b. Assembly Equipment

- BESI (with head office in Duiven) is mainly into Die Attach Equipment, followed by Packaging Equipment and Plating Equipment.
- Other companies, like Boschman, K&S (with Head Quarters in Singapore with part of its R&D in the Netherlands), and Solmates are into Assembly equipment.

Chip Design

Chip design plays a key role in the global semiconductor value chain. This is clear when looking at the global average added value of chip design: It is 50%, compared to manufacturing's 24% and the 12% that equipment brings to the table. Netherlands is home to the best chip designers in the world when it comes to RF, mixed signal and Edge AI.

Dutch chip design companies play an important role within these European clusters, second only to those in the United Kingdom. The Dutch private chip design ecosystem consists of about seventy-five OEMs, design houses, IP block and design tool companies. These companies are concentrated around four hotspots in the Netherlands: Brainport Eindhoven, Twente and the regions around Nijmegen and Delft. Each of these regions has its own strengths. More importantly, the Dutch ecosystem (from universities of technology to businesses) is one of the best in the world and has a high degree of interconnectedness[4].

Semiconductor Academic Institutions

A number of Dutch Academic institutions are leaders in the semiconductor field. The academic landscape is strong in the following fields:

- Disciplines - Materials Science, Electrical, Mechanical and Software Engineering
- Semiconductor Value Chain – Very strong in Semiconductor Equipment Technology and Chip Design
- Emerging Technologies – Photonics and Quantum technologies

[3] HTSM roadmap for Semiconductor Manufacturing Equipment Version 1.0, July 1, 2020

[4] CHIP DESIGN NL, THE NATIONAL CLUSTER

The Netherlands Semiconductor Academic landscape is made up of three key Technical Universities, namely Delft University of Technology, Eindhoven University of Technology and Twente University of Technology and key Technical Institutes namely, Advanced Research Center for Nanolithography (ARCNL) and Netherlands Organisation for Applied Scientific Research (TNO), and Foundation for Dutch Scientific Research Institute (NWO) which funds all research. Some of the focus areas of these institutes are:

- Delft University of Technology (TUDelft) – Next Generation Sensing, RF power amps, sensor interfaces
- Eindhoven University of Technology (TU/e) – focused on Nano-opto-electro-mechanical systems for sensing and communication
- University of Twente & MESA+ Institute for Nanotechnology – IC Design: Analog RF CMOS, Receivers, Transmitters, AD DA Converters, nanotechnology
- TNO, focused on Equipment (lithography / Metrology) & Quantum Technologies
- Chip Integration Technology Center (CITC) – Heterogenous integration and advanced Semiconductor packaging technology
- IMEC (in Belgium) – world leading semiconductor R&D and innovation center
- Photonic Integration Technology Center (PITC) for packaging and reliability engineering phases
- Holst Center – Wireless sensor Technology

1.2 NL in India: Case Study of NXP India

The most significant presence of a Semiconductor firm in India is NXP Semiconductors. NXP's presence in India goes back more than 50 years and is one of NXP's largest design centers. NXP Semiconductors, founded in 2006, has Center of Excellence functions from four sites across India with more than 4000 engineers and over 500 patents, and is focused on innovations for the Automotive, IoT, Industrial and Mobile markets[5].

- Noida is a Center of Excellence for hardware and software design, validation and enablement specifically around edge processing and automotive processing. A VLSI team within the India Design Center advances trends through sophisticated process technologies and efficient design methodologies.

- NXP Bengaluru is their largest site & Headquarters in India and it is a hub of innovation for NXP's connectivity, security, advanced analog and radio frequency products with the automotive and IoT markets as key drivers. The team specializes in various domains like SoC, IP and system-level design, firmware/software, validation and design enablement.

- The Pune site focuses on end-to-end solutions for Wireless LAN, and Bluetooth® connectivity. Established in 2007, it becomes part of NXP through the acquisition of Marvell's wireless business in 2019.

- NXP's design center in Hyderabad is focused on NXP's edge processing and advanced analog businesses. World-class production-quality software is developed here for the communication and infrastructure markets. Additionally, our advanced analog team in Hyderabad produces a broad portfolio of high-speed SerDes and automotive Ethernet products as well as PHY and switch SoCs that enable end users to connect their vehicle systems faster, safer and more efficiently

[3] HTSM roadmap for Semiconductor Manufacturing Equipment Version 1.0, July 1, 2020

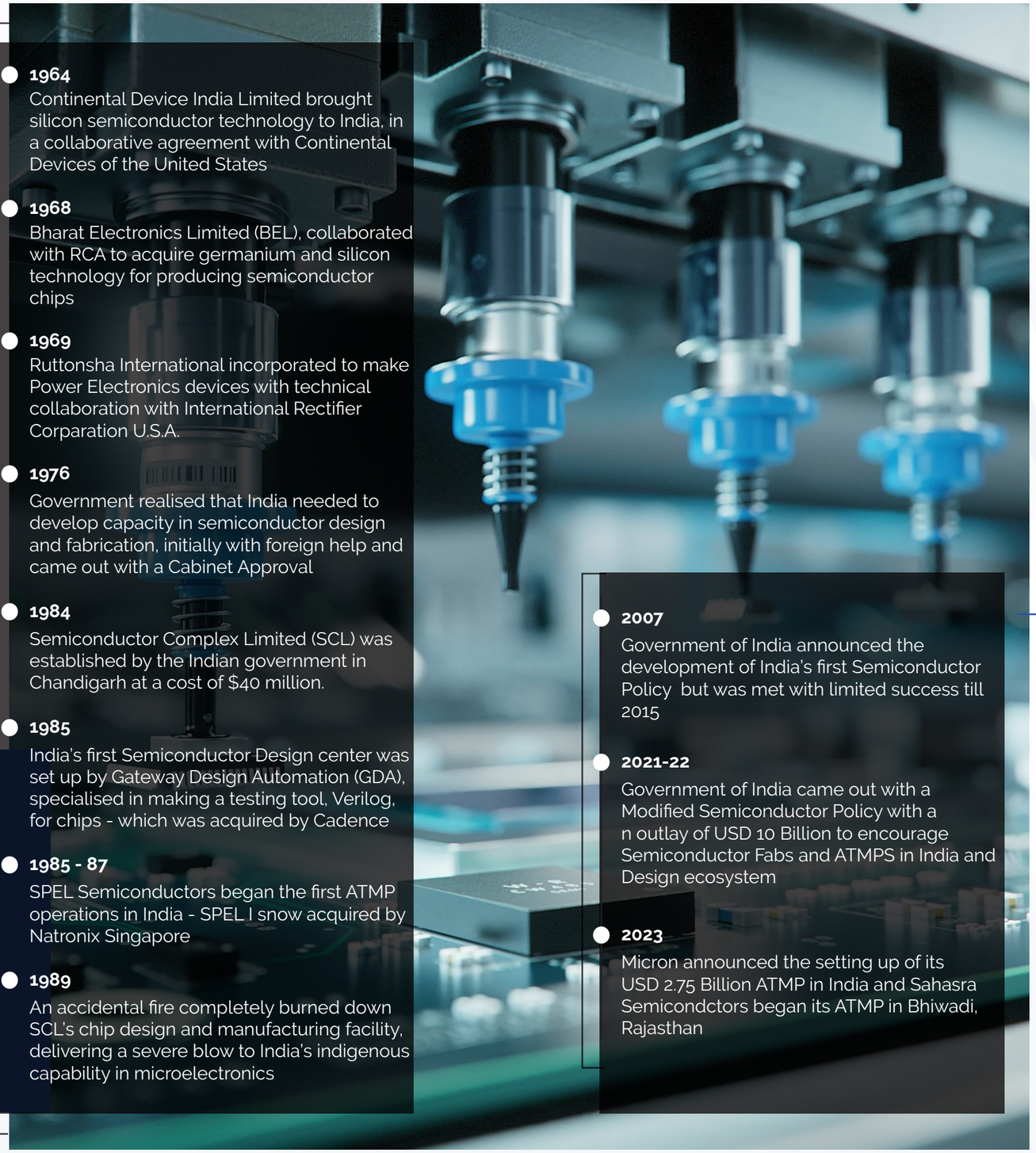
Chapter 2

India's Semiconductor Policy Framework

Abstract:
This chapter discusses the various policies related to Semiconductors in India. These includes policies for Semiconductors manufacturing, design and for skill development. It also sets out the key policy outcomes and how the various States in India match up for attracting Semiconductors ecosystem in their States.

2.1 Semiconductor history of India

India has had a long Semiconductors history and at one point in history, the Fab in India was just one Generation behind the Global leaders. Unfortunate incidents policy paralysis over the years and faulty policies has led to the lack of any meaningful manufacturing in India. This journey is captured here:



1964
Continental Device India Limited brought silicon semiconductor technology to India, in a collaborative agreement with Continental Devices of the United States

1968
Bharat Electronics Limited (BEL), collaborated with RCA to acquire germanium and silicon technology for producing semiconductor chips

1969
Ruttonsha International incorporated to make Power Electronics devices with technical collaboration with International Rectifier Corparation U.S.A.

1976
Government realised that India needed to develop capacity in semiconductor design and fabrication, initially with foreign help and came out with a Cabinet Approval

1984
Semiconductor Complex Limited (SCL) was established by the Indian government in Chandigarh at a cost of $40 million.

1985
India's first Semiconductor Design center was set up by Gateway Design Automation (GDA), specialised in making a testing tool, Verilog, for chips - which was acquired by Cadence

1985 - 87
SPEL Semiconductors began the first ATMP operations in India - SPEL I snow acquired by Natronix Singapore

1989
An accidental fire completely burned down SCL's chip design and manufacturing facility, delivering a severe blow to India's indigenous capability in microelectronics

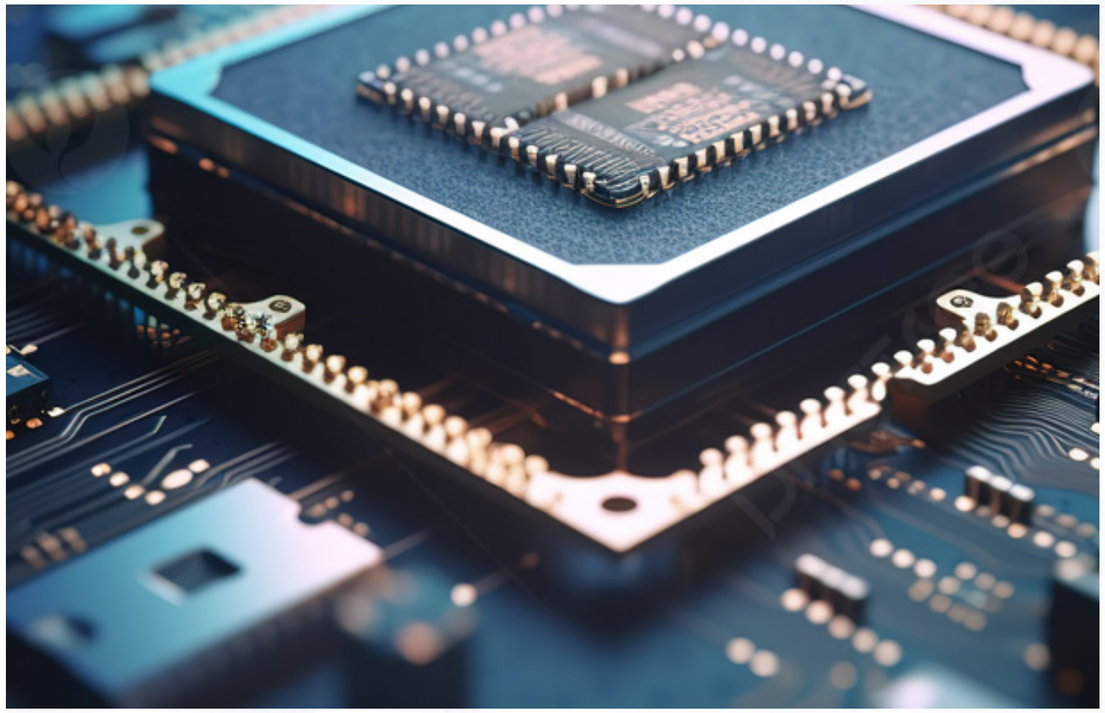
2007
Government of India announced the development of India's first Semiconductor Policy but was met with limited success till 2015

2021-22
Government of India came out with a Modified Semiconductor Policy with a n outlay of USD 10 Billion to encourage Semiconductor Fabs and ATMPS in India and Design ecosystem

2023
Micron announced the setting up of its USD 2.75 Billion ATMP in India and Sahasra Semicondctors began its ATMP in Bhiwadi, Rajasthan

◁ ◀◀

Semiconductor Complex Limited formed technology licensing agreements with Hitachi, AMI, and Rockwell, and began producing semiconductor chips, which were about one generation (three to four years) behind the state-of-the-art in the United States (Starting with a 5000 nm process in 1984, SCL rapidly advanced to the 800 nm technology)



Recent Semiconductor related events in India

2021

Sep-21 — USA, India, Japan, and Australia (as part of QUAD) announced plans to establish a semiconductor supply chain initiative "to secure access to semiconductors and their components".

15-Dec-21 — Indian government cleared a INR 760 billion (>US$10 billion) package to boost semiconductor and display manufacturing. The program aims to provide attractive incentive support to companies / consortia that are engaged in Silicon semiconductor fabs, display fabs, compound semiconductors / silicon photonics / sensors (including MEMS) fabs, semiconductor packaging (ATMP / OSAT), semiconductor design. Incentives worth INR 2.3 trillion (approx. US$30.16 billion)will be available to position India as global hub for electronics manufacturing.

2022

1-Jan-22 — The Ministry of Electronics and Information (MeitY) sought applications from 100 domestic companies, start-ups and MSMEs under its Design Linked Incentive (DLI) Scheme. The scheme has three components – Chip Design infrastructure support, Product Design Linked Incentive and Deployment Linked Incentive. The DLI scheme aims to nurture at least 20 domestic companies involved in semiconductor design and facilitate them to achieve turnover of more than INR 15 billion in the next five years.

May-22 — The iCET (initiative on Critical and Emerging Technology) initiative was launched by Indian Prime Minister Narendra Modi and U.S. President Joe Biden with the goal "to elevate and expand" Indo-U.S. "strategic technology partnership and defense industrial cooperation between the governments, businesses, and academic institutions" of the two countries. Some of the key technology sectors identified under the initiative include defense, semiconductor supply chains, space, and STEM. There is an emphasis on finding ways to engage in co-development and co-production while underlining the importance of "innovation bridges" in the key technology areas through expos, hackathons and pitch sessions.

Oct-22 — Indian Government modified the Semiconductor & Display package to make it more attractive for investors and included 50% capex incentive for all types of Semiconductor Projects other than CMOS

Oct-22 — The Ministry of Electronics and IT has plans to spend US$1.25-US$1.30 billion to modernize and upgrade its semiconductor laboratory (SCL) in Mohali. This spending is also targeted at strengthening intellectual property rights in India's semiconductor sector. The SCL has now invited bids for the lab upgrade; qualified bidders must have a commercial partner on board to produce fabrication of chips designed by the lab.

2023

Jan-23 — The US Semiconductor Industry Association (SIA) and the India Electronics and Semiconductor Association (IESA) decided to form a private sector task force to strengthen bilateral collaboration in the global semiconductor ecosystem. This was the background to US Secretary of Commerce, Gina Raimondo, and India's Minister of Commerce and Industry Piyush Goyal signing a Memorandum of Understanding (MoU) on establishing semiconductor supply chain and innovation partnership under the framework of the India – US Commercial Dialogue.

20-Jun-23

The Indian Government has given its approval to Micron's US$2.7 billion investment plan to set up a semiconductor ATMP unit in Gujarat. Micron Technology, an American semiconductor manufacturer, revealed its plans to allocate a maximum of US$825 million for establishing a fresh chip assembly and testing facility in India. Micron stated that with backing from the Centre and the Gujarat government, the total investment in the factory will amount to US$2.75 billion.

Jun-23

Apple has expressed its intentions to expand its sourcing efforts in India, while Google Pixel is reportedly considering shifting a portion of its device production to the country. The Ministry of Electronics and Information Technology (MeitY) anticipates that the electronics manufacturing sector in India will reach a value of US$300 billion by 2026.

27-Jun-23

Indian Government has approved five applicants to the Design-Linked Incentive (DLI) Scheme, which is a part of the INR 760 billion-budget Program for Development of Semiconductors and Display Manufacturing Ecosystem in India. The DLI Scheme aims to offer financial incentives as well as design infrastructure support across various stages of development and deployment of semiconductor design(s) for Integrated Circuits (ICs), Chipsets, System on Chips (SoCs), Systems & IP Cores and semiconductor linked design(s) over a period of 5 years.

14-Jul-23

Foxconn is now reportedly engaged in discussions with Taiwan Semiconductor Manufacturing Co (TSMC) and Japan's TMH Group to form new partnerships in order to establish semiconductor fabrication units in India. The discussion is with a focus on producing advanced as well as legacy node chips.

19-Jul-23

Shiv Nadar-led HCL Group is considering a foray into the semiconductor sector. ET reported that the HCL Group is on the verge of presenting a proposal to the Centre for the establishment of an assembly, testing, marking, and packaging (ATMP) unit for semiconductors at an estimated project cost between US$200-300 million.

20-Jul-23

Union Minister Ashwini Vaishnaw announced that India and Japan have formally agreed to establish a joint mechanism aimed at facilitating collaboration between their respective governments and industries in the field of semiconductors.

21-Jul-23

The Odisha Cabinet gave its approval on July 21 for the proposed Odisha Semiconductor Manufacturing & Fabless Policy. The proposed policy aims to attract investors and facilitate their entry into the manufacturing of semiconductor/electronic chips in the eastern state of Odisha.

Jul-23

Following Micron's announcement regarding the establishment of a packaging and testing unit in India, reliable industry sources speaking to BusinessLine indicate that at least 4 to 5 leading suppliers of components and materials to the semiconductor sector are also poised to take a similar course of action. Prominent industry suppliers, such as Simmtech and Air Liquide, which specialize in providing printed circuit boards and high-purity industrial gases for chip manufacturing, are currently engaged in discussions with the Indian government to initiate their operations in India. As per a source speaking to the media, it appears that Simmtech, a Micron supply chain partner, has likely obtained government approval for its venture.

Jul-23

Advanced Micro Devices (AMD), a major US semiconductor chip design company, has plans to invest up to US$400 million in India over the next five years, per its Chief Technology Office Mark Papermaster. AMD aims to establish its largest design facility in Bengaluru, expanding its office presence to 10 locations in the country. With already over 6,500 employees in India, the new campus is expected to create around 3,000 additional engineering roles by the end of 2028.

16-Aug-23

Rajasthan-based Sahasra Semiconductor, which is part of India's Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS), has stated that it will begin the commercial production of the first made-in-India memory chips at its Bhiwadi plant from September or early October 2023.

22-Sep-23

The government is planning for a Graphics Processing Unit (GPU) cluster as part of the India AI program to support the growth of startups focused on training artificial intelligence models within India

26-Oct-23

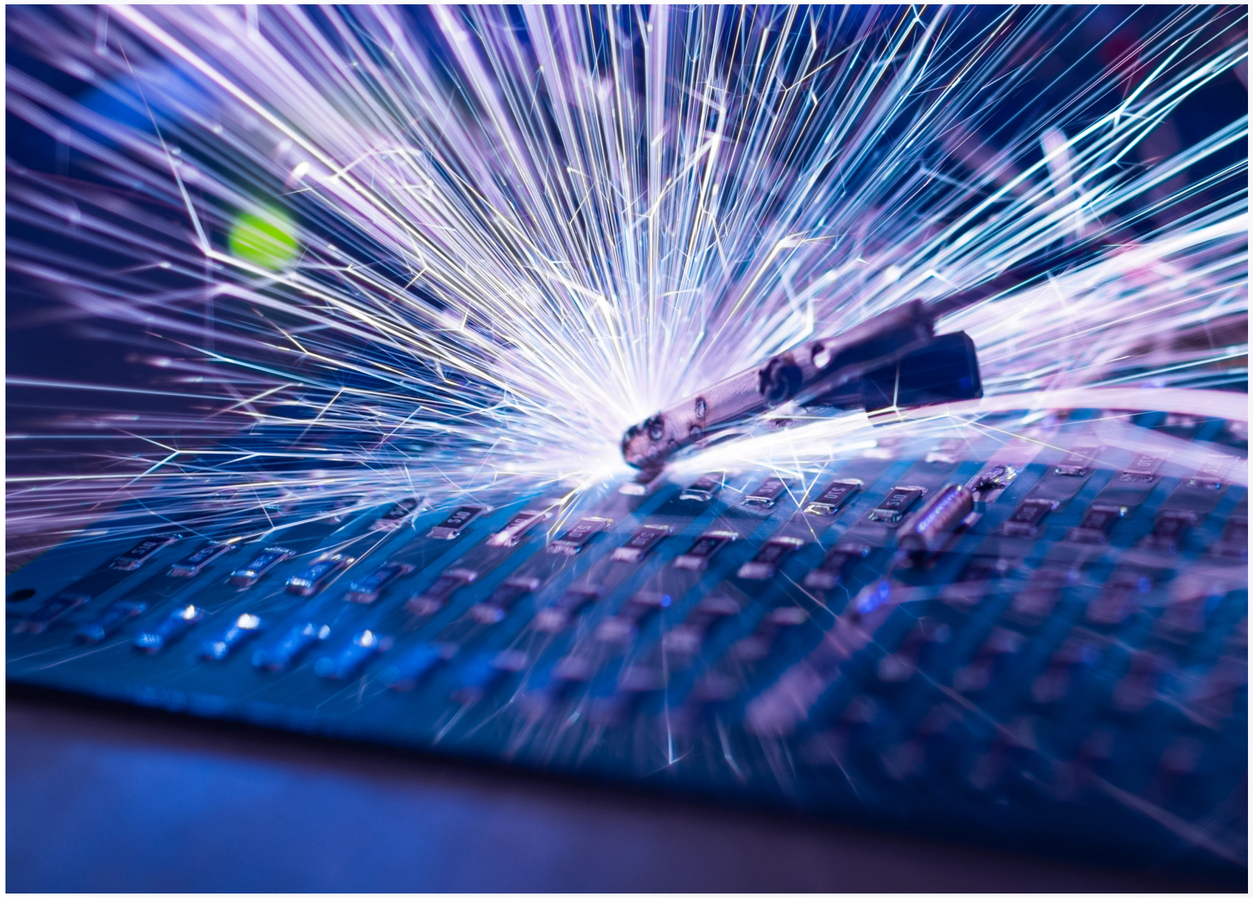
The Union Cabinet has approved a memorandum of cooperation between India and Japan on a Semiconductor Supply Chain Partnership

1-Nov-23

Qualcomm Inc told media that the technology giant will outsource manufacture of semiconductor chips to India when the country has set up its own fab plants and OSAT facilities. Qualcomm sees growth opportunities in the Indian market for mass-market 5G phones, in the EV automotive software industry [Tech Mahindra and TCS being key IT innovators in this domain], for implementation of WiFi-6 and WiFi-7 technologies, and wireless fixed broadband solutions [collaborating with HFCL and VVDN]

2.2 National Semiconductor Policy

In order to drive long-term strategies for developing a sustainable semiconductors and display ecosystem, a specialized and independent "India Semiconductor Mission (ISM)" will be set up by the government. The India Semiconductor Mission will be led by global experts in semiconductor and display industry and act as the nodal agency for efficient and smooth implementation of the schemes on Semiconductors and Display ecosystem. The India Semiconductor Mission (ISM) functions independently as a specialized Business Division within the Digital India Corporation with Ministry of Electronics & Information Technology (MEITY). Its core aim is to create a robust Semiconductor and Display ecosystem, elevating India's status as a significant worldwide center for electronics manufacturing and design. Led by prominent figures in the Semiconductor and Display sectors, the mission acts as a central hub for the successful execution of the Program for Development of Semiconductor and Display Ecosystem. It engages in partnerships with diverse Government ministries, departments, agencies, alongside industry and academic institutions, to ensure a holistic, streamlined, and effective strategy in pursuing its objectives. [6]



[6] https://ism.gov.in/about

a. About SemiconIndia Programme

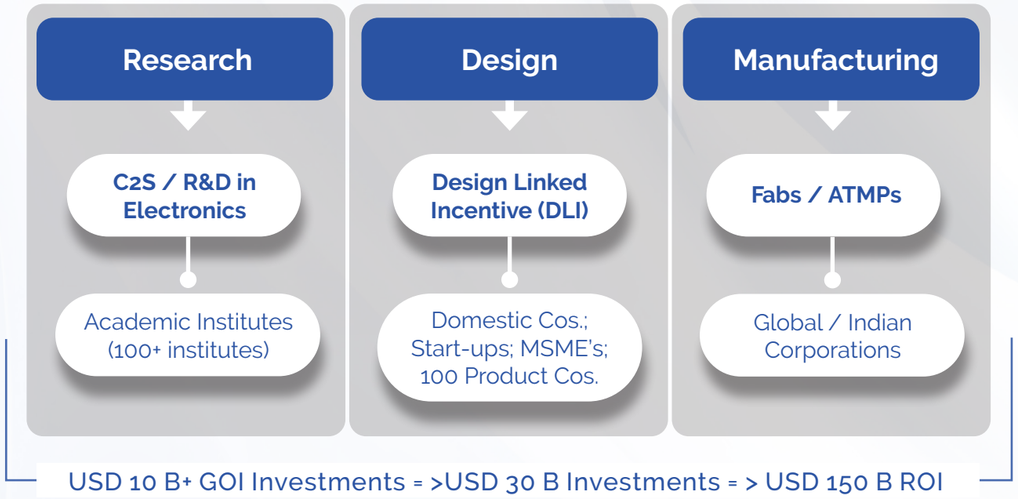
The SemiconIndia Program, aligned with the National Policy on Electronics 2019 (NPE 2019), envisions positioning India as a global hub for Electronics System Design and Manufacturing (ESDM). Central to NPE 2019 is the promotion of semiconductor wafer fabrication facilities and the development of a robust chip component design and fabrication ecosystem.

In 2021, the Union Cabinet approved the comprehensive SemiconIndia program, earmarking a substantial INR 76,000 crore (USD 10 billion) budget. This program's primary goal is to foster a sustainable semiconductor and display ecosystem.

The SemiconIndia Program offers compelling incentives to companies and consortia operating across diverse domains, including Silicon Semiconductor Fabs, Display Fabs, Compound Semiconductors, Silicon Photonics, Sensors (including MEMS) Fabs, Semiconductor Packaging (ATMP / OSAT), and Semiconductor Design.

The India Semiconductor Strategy is outlined below:

India Semiconductor Strategy



Through this initiative, the semiconductor and display manufacturing sector is poised to receive a notable impetus, benefitting from capital support and opportunities for technological collaborations, thus reinforcing India's global standing in the semiconductor industry.

b. Manufacturing Strategy

With the aim of establishing India as a prominent Electronics System Design and Manufacturing hub and advancing the vision of Atmanirbhar Bharat (self-reliant India), the Union Cabinet sanctioned a comprehensive program (Semicon India Program) dedicated to cultivating a sustainable semiconductor and display ecosystem within the nation. This initiative holds pivotal significance in propelling the rapid expansion of India's electronics manufacturing and innovation landscape.[7]

[7] https://pib.gov.in/PressReleasePage.aspx?PRID=1808676

The program's primary objective revolves around incentivizing enterprises to invest in semiconductors, display manufacturing, and design by providing financial support and incentives. This strategic move lays the groundwork for India's heightened global presence in the electronics value chains, fostering enhanced economic self-sufficiency.

Inherent in the semiconductor and display manufacturing sector are complexities and technology-driven intensity, entailing notable risks, substantial capital infusion, extended gestation periods, and rapid technological progress. In light of these challenges, the program's focal point is to offer compelling incentive support to companies, consortia, and joint ventures engaged in areas including Silicon Semiconductor Fabs, Display Fabs, Compound Semiconductors, Silicon Photonics, Sensors (including MEMS) Fabs, Semiconductor Packaging (ATMP/OSAT), and Semiconductor Design.[8]

The establishment of semiconductor wafer fabrication facilities in India through significant investments serves to fortify the electronics manufacturing ecosystem and cultivate a dependable value chain. Alongside financial incentives, the program ensures infrastructure backing via the EMC 2.0 scheme, demand aggregation, research and development assistance, and comprehensive skill development and training initiatives. State governments are actively encouraged to extend their backing to further elevate the overall ecosystem.

Key elements of the Semicon India Program policy is highlighted below:

- The disbursement of funds will span six years, anticipating the setup of approximately 20 units across diverse technology domains within the upcoming two years.
- Projections indicate that this scheme is poised to attract investments totalling INR 1,70,000 crore (~USD 22 billion) to India.
- Under the modified program, a uniform fiscal support of 50% of the project cost on a Pari Passu basis will be extended for the establishment of Semiconductor Fabs across all technology nodes.
- Recognizing the specialized nature of compound semiconductors and advanced packaging, the revised program extends fiscal support of 50% of Capital Expenditure in a pari-passu manner for the establishment of compound semiconductors, silicon photonics, sensors, Discrete semiconductors fabs, and ATMP/OSAT facilities.

c. Design Strategy

The Government of India, under the auspices of the Ministry of Electronics and Information Technology (MeitY), is actively addressing the crucial requirements of the Indian Semiconductor Design Ecosystem through a series of well-crafted and exemplary policy initiatives. These key policies are carefully curated and stand out as compared to other existing policies. The initiatives include:

[8] https://www.meity.gov.in/esdm/Semiconductors-and-Display-Fab-Ecosystem
[9] https://pib.gov.in/PressReleasePage.aspx?PRID=1861132

1. Design Linked Incentive Scheme (DLI)
2. Chips to Startup Program (C2S)
3. Microprocessor Development Programme (MDP)
4. Modernisation of Semiconductor Complex Ltd. in Mohali
5. Setting up of an India Semiconductor Research Center

The programs mentioned above are explained below:

1. Design Linked Incentive Program

The Design Linked Incentive (DLI) Scheme is designed to provide financial incentives and design infrastructure support to various stages of semiconductor design development and deployment, including Integrated Circuits (ICs), Chipsets, System on Chips (SoCs), Systems & IP Cores, and semiconductor linked design. The primary objectives of the scheme are as follows:

- To foster the growth and development of domestic companies engaged in semiconductor design, thereby facilitating their expansion.
- To promote substantial indigenization of semiconductor content and Intellectual Property (IPs) used in electronic products deployed within the country, thereby encouraging import substitution and value addition in the electronics sector.
- To strengthen the design infrastructure for semiconductor design and facilitate access to startups and Micro, Small, and Medium Enterprises (MSMEs).

2. Chip To Startup (C2S) Program

Aligned with the goals and vision of NPE-2019, the comprehensive "Chips to Startup (C2S)" Programme has been introduced to foster the growth of specialized VLSI/Embedded System Design expertise. This program is designed to benefit every component of the Electronics value chain by offering specialized manpower training, establishing a repository of reusable IPs, and facilitating the design and deployment of application-oriented Systems/ ASICs/FPGAs. Leveraging the expertise available at Startups and MSMEs, academia and R&D organizations can effectively utilize these resources to advance their projects.

The main objectives of the Chips to Startup Programme (C2S) are:

- Generating Industry-ready manpower in System/ SoC Design area for creating vibrant fabless chip design ecosystem in the country.
- Promoting industry-led R&D, translational research and strengthening Industry-Academia collaboration.
- Leapfrogging in ESDM space by way of inculcating the culture of developing reusable IP Cores & developing ASIC/ SoC/ Systems for societal/ strategic sectors.
- Broaden the base of ASIC / IC design in the Country by accommodating more academic institutions, start-ups for design of IPs / ASICs / Systems/ SoCs.
- Protection of Intellectual Property generated etc.
- To inculcate the culture of entrepreneurship among students & researchers by way of incubating startups

Under the Programme, it is proposed to include about 100 Institutions (including IITs / NITs / IIITs / Government/Private Institutions) spread across the country based on their interest and expertise in VLSI and Embedded System Design area.

3. Microprocessor Development Programme (MDP)

The Microprocessor Development Programme (MDP) is an initiative funded and initiated by the Ministry of Electronics and Information Technology (MeitY), Government of India. Its mission is to achieve the indigenous design and development of a family of Microprocessors, related Intellectual Properties (IPs), and a complete ecosystem. This comprehensive effort aims to foster fully indigenous product development that caters to strategic, industrial, and commercial needs.

The MDP project is driven by the imperative for India to attain self-sufficiency in various sectors, particularly in electronics. It encompasses the creation of a family of 32-bit/64-bit Microprocessors and associated software tool-chain & IP Cores, employing Open-Source Instruction Set Architecture (ISA). These Microprocessors will be fabricated both at the SCL foundry and foundries abroad to meet the strategic and commercial requirements of the nation. Through the MDP, India endeavours to strengthen its capabilities in microprocessor technology and foster indigenous innovation in critical sectors.

4. Modernisation Semiconductor Complex Ltd (SCL), Mohali

The modernization program of SCL, Mohali, is set to be a significant advantage for Chip Design companies in India, facilitating faster and cost-effective chip tape-out processes.

SCL Mohali has been transferred from the Department of Space to MeitY and is now being established as a commercial fab, encouraging broader participation from Indian semiconductor design companies. This move aligns with India's pursuit of self-reliance in the semiconductor sector under the AtmaNirbhar Bharat initiative. With an investment of approximately $1.2 billion[10], the 30-year-old facility will undergo modernization to enhance its capabilities, primarily focused on producing 8-inch CMOS microchip wafers, fulfilling critical needs such as space programs.

SCL boasts integrated facilities and supporting infrastructure, catering to various activities like Design, Development, Fabrication, Assembly & Packaging, Testing, and Quality Assurance of microdevices. Equipped with tools capable of processing 200mm-sized wafers, the upgraded SCL will serve as a boon to chip design companies, empowering them to tape out chips more efficiently and cost-effectively within India[11].

- The modernized SCL facility will have the capability to produce 28-nm chips, representing the leading-edge technology in the semiconductor industry[12].
- SCL has initiated a Request for Proposal (RfP) for increasing the capacity of its existing CMOS wafer fab from 700 wspm to 1,000-1,100 wspm by upgrading its current equipment[13].
- The upgrade will also include the addition of NVM (non-volatile memory) technology to the existing 180nm CMOS platform and the incorporation of GaN on silicon technology to its suite of technological capabilities.
- With these enhancements, SCL will expand its offerings in the domain of power electronics, encompassing PMIC, low power RF, and memory devices.
- In pursuit of technological advancements, SCL has secured a contract with IMEC Belgium to acquire GaN on Silicon Power HEMT technology for E-node 200V and 650V devices.

The modernization and commercialization of the SCL facility are integral components of the government's $10 billion India Semiconductor Mission unveiled in 2021. In July 2022, the Union Cabinet granted approval for the modernization plan, which involves exploring the potential of establishing a Joint Venture (JV) between the Semi-Conductor Laboratory (SCL) and one or more commercial fab partners.

Following the upgrade, the fab will play a pivotal role in facilitating research and prototyping capacities for semiconductors, further enhancing India's position in the semiconductor ecosystem.

5. Setting up of India Semiconductor Research Center

India Semiconductor Research Centre (ISRC) signifies India's commitment to drive innovation and strategy, propelling India to be at the forefront of the global semiconductor landscape. ISRC is part of a graded approach that the Government is taking to make India a global semiconductor research and innovation hub. This institution will be a core institution in India's growing capabilities in semiconductors. It will be the Indian equivalent of IMEC, Nano Tech, ITRI and the MIT Micro-electronic labs which have been the pioneers of every cutting-edge technology in the world .

The ISRC envisions the establishment of a world-class research institution focusing on semiconductor processes, advanced packaging, compound semiconductors and Fabless design and EDA tools. By fostering collaboration between industry, academia, and government, ISRC aims to nurture a vibrant semiconductor ecosystem. It is expected to facilitate seamless transfer from lab to fab, bridging the gap between research and manufacturing. The ISRC plans to invest strategically, focusing on achievable technology nodes and fostering collaborations with global research centres, academia and industry. The initiative aims to transform the centres of Excellence in India's academic institutions into globally competitive entities, attracting global companies to India.

It aims to establish India as a global foundry supplier for semiconductors, packaging, and integrated systems, from design to products. By investing in cutting-edge research, education, and collaboration, India is poised to transform its semiconductor landscape and secure a prominent position on the semiconductor map of the world.

A committee under the Ministry of Electronics and Information Technology (MeitY) has recommended the government to set up the India Semiconductor Research Centre (ISRC) at a cost of $2.5-3 billion , with the aim to make India a global foundry supplier

[10] https://www.business-standard.com/technology/tech-news/govt-to-spend-1-2-billion-on-modernising-semiconductor-lab-in-mohali-123051200931_1.html

[11] https://swarajyamag.com/news-brief/scl-commercialisation-under-india-semiconductor-mission-meity-invites-proposal-for-asset-valuation-of-fab-facilities

[12] https://economictimes.indiatimes.com/tech/technology/govt-to-spend-1-30-billion-to-modernise-semiconductor-laboratory-in-mohali/articleshow/94625738.cms?from=mdr

[13] https://www.eetindia.co.in/scl-mohali-modernization-to-help-advance-indias-semiconductor-goals/

for semiconductors, packagers and integrated systems from design to products. The committee estimates the annual operating expense for maintaining the research centre to be around $250 million - $ 500 million.

It estimates setting up a 1-1.5 lakh sq ft clean room for Si fab and 20,000-30,000 sq ft for advanced packaging.

In the 2-5 years' horizon, the theme for the ISRC will have to also incorporate completion of establishment of new R&D and education infrastructure, and implementation of technologies that will provide a wider range of capabilities and research offerings for the ISRC including potential for integrated packaging and system pilots.

6. Digital India FutureLABS program

The Digital India FutureLABS, coordinated by C-DAC, aims to tap into the trillion-dollar opportunity presented by the Electronics System Design and Manufacturing (ESDM) sector. The initiative seeks to move up the value chain, fortify domestic R&D, and create a collaborative ecosystem for the development of IPs, standards, and the next-generation Electronics System Design in the country. Focusing on key growth areas such as Compute, Communication, Automotive & Mobility, Strategic Electronics, and Industrial IoT, the FutureLABS initiative is strategically positioned to leverage futuristic technologies, including AI, Big Data, and Quantum Computing, marking a transformative phase in Indian research.

The Programme was launched with an announcement of 22 MoUs of C-DAC with Industry for implementation of the futureLABS. Companies like NXP Semiconductors, Tenstorrent and Qualcomm India have signed MoUs in areas like High Performance Computing space, Design & Innovation in Compute space and Indian Telecom Stack.

Over the last ten years, India's journey has transformed from being a consumer of technologies and a provider of talent for large technology companies worldwide to becoming a country where talent is certainly available. India continues to support global companies and enterprises with high talent, while also taking the lead in developing technologies, intellectual properties, and solutions for ourselves and the world. India's tech & innovation ecosystem is expanding and growing while catalyzing the next wave of startups in AI to Semiconductors, Electronics System Design & Innovation starting at Digital India futureLABS. The Digital India futureLABS is the final piece in architecture for innovation being built by PM Narendra Modi ji since the Digital India programme in 2015. It represents an opportunity for Indian startups at the forefront of developing NextGen Electronics in Automotive, Compute, Telecom, Industrial and Strategic Electronics. Digital India futureLABS will act as a catalyst for this and in rounding off our ambitions of ensuring the Indian flag on every segment of emerging Tech Innovation.

These high-performance systems will be globally competitive, affordable, low-cost and trusted. Openness, safety, and trust are principles we want to build broadly into our digital ecosystem.

2.3 Analysis of key states active in attracting Semiconductor investments and their key policies

In conjunction with the endeavours of the Central Government, several State Governments within India are actively engaged in efforts to attract investments in the Electronics System Design and Manufacturing (ESDM) sector, which encompasses the semiconductor industry. Approximately 8 to 10 states have taken proactive measures to lure ESDM investments and have devised policies to bolster this sector. Noteworthy progress has been observed in Odisha, Gujarat, and Uttar Pradesh, where significant strides have been taken in semiconductor investments, leading to the formulation of dedicated State Semiconductor Policies.

2.4 Comparative analysis of key state policies for Semiconductors & ESDM industry

Comparison between State Government Policies

- **Capital subsidy offered by states for Semiconductor investment.**

An attempt was made to compare the Capital Subsidy provided by these states. Below is a display of the states that offer a 'Capital Subsidy' for Semiconductor Projects.

Gujarat	Uttar Pradesh & Tamil Nadu	Odisha
		
40% of additional capex incentive given by the GOI Incentive (i.e. 20% Capex Subsidy by the state)	50% additional Capital Subsidy on the capital subsidy approved by GOI. (i.e. 25% Capex Subsidy by the state)	50% additional Capital Subsidy on the capital subsidy approved by GOI for Projects going through the ISM route (i.e. 25% Capex Subsidy by the state) 30% Capital Subsidy by the State for Projects NOT going through the ISM route

Source: Feedback Advisory Analysis, reference of State Policy documents

In addition to Gujarat, Uttar Pradesh, Tamil Nadu and Odisha, several other states have included Semiconductors within their Electronics System Design and Manufacturing (ESDM) framework or categorized them under Mega Projects. In the context of these significant endeavors, these states have outlined a process wherein all proposals related to such mega projects will be individually assessed by their respective high-powered committees. These committees, constituted periodically, are entrusted with the responsibility of extending supplementary support as required.

- **States' Land-Related Subsidies for Semiconductor Investments**

Numerous states have incorporated provisions for explicit land subsidies, while others extend advantages tied to Electronics System Design and Manufacturing (ESDM) Parks, readily available infrastructure, and manufacturing clusters. A multitude of states have also delineated particular measures for Mega Semiconductor Fabs, treating them individually and according preferential treatment based on specific circumstances. Furthermore, all states furnish other incentives related to land, encompassing complete exemption from Stamp Duty and subsidies pertaining to land conversion charges.

Table 1: overview of the land-related subsidies extended by these states

States	Land related subsidies offered by states
Gujarat	• 75% subsidy on the first 200 Acres of land required for a FAB project; 100% Stamp Duty exemption
Uttar Pradesh	• For Semiconductor projects - 75% subsidy on the first 200 acres of land; 100% Stamp Duty exemption. • For other protects in ESDM - 25% to 50% of the land cost based on the Location; 100% Stamp Duty exemption
Odisha	• For the first 5 projects where the investment is in excess of INR 500 crores, the government will provide land at 25% discount over the prevailing IPR rate. • For each Mega Project investment subsequent to the first 5, 10% subsidy for first 200 acres on the prevailing IPR rate will be considered. • For each non-mega Project investments, 5% subsidy for first 200 acres on the prevailing IPR Rate will be considered • 100% Stamp Duty exemption
Tamil Nadu	• 50% subsidy up to 20% EFA; Stamp Duty Exemption - 50% in A&B districts and 100% in C districts
Telangana	• Special incentives shall be provided to the Semiconductors sector; to be discussed on a case to case basis; 60% rebate for others; 100% Stamp Duty exemption on first and 50% on second transaction
Karnataka	• 25% subsidy only in areas other than Bengaluru Urban and Bengaluru Rural districts up to an extent of 50 acres and 100% Stamp Duty exemption
Andhra Pradesh	• No mention but assured of a special concessions for Mega Fab Projects; 100% Stamp Duty exemption
Chhattisgarh	• 80% of the land premium/100% exemption in land registration cost
Haryana	• 100% Stamp Duty exemption and 50% of the project cost with a maximum of INR 25 Cr. Project cost to include development of basic infrastructure, support services such as Centre of Excellence (R&D, incubation and consultancy services), Training Facility, IT infrastructure etc.
Kerala	• No mention of any land related subsidies but offers Electronic parks
Rajasthan	• 100% of Land Tax and 100% Stamp Duty exemption
Madhya Pradesh	• 100% Stamp Duty exemption; For ESDM, Maximum area that can be allotted at concessional rates is 1 acre per every 50 people employed in core operations capped at 25 acres. Land would be allotted on a lease up to 99 years with provision for renewal.
Punjab	• 100% Stamp Duty exemption; would offer ready built Industrial Parks at concessional rates
Maharashtra	• 100% Stamp Duty exemption

Source: Feedback Advisory Analysis, reference of State Policy documents

- **Electricity Supply and Associated Incentives**

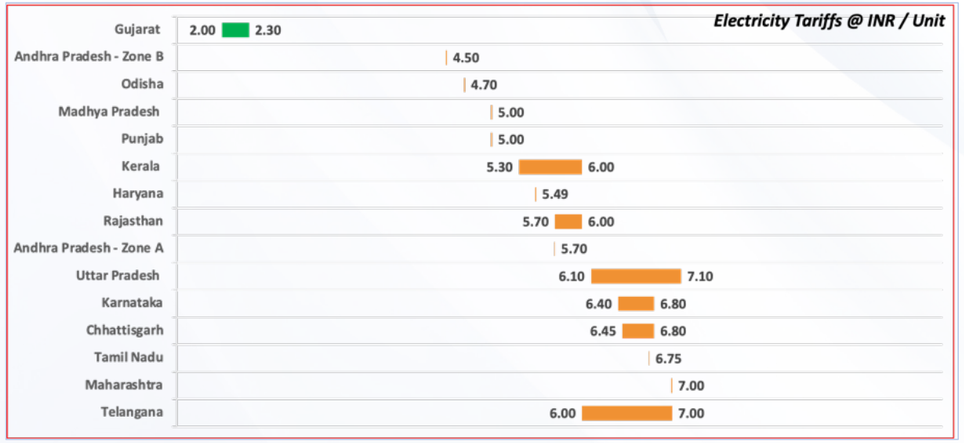
Uninterrupted and dependable power supply, coupled with access to ample water resources, stand as pivotal considerations when evaluating the suitability of locations for Semiconductor projects. These aspects significantly impact the competitiveness of such endeavors.

Numerous states, among them being Gujarat, Karnataka, Tamil Nadu, Maharashtra, Andhra Pradesh, Telangana, Rajasthan, Madhya Pradesh, and Uttar Pradesh, commit to offer stable power supply commitments tailored to accommodate expansive or mega Semiconductor projects. Given the substantial nature of Semiconductor initiatives, maintaining a consistent power availability is imperative for their prosperous realization.

Across most states, a notable subsidy of 100% for Electricity Duty is commonplace.

The industrial electricity tariffs for all states have been meticulously compiled from the most recent 'Tariff Orders of 2022-23.' The specific tariff concessions mentioned earlier have been duly taken into consideration. Utilizing these inputs, the ultimate Electricity Tariffs within these states have been graphically illustrated and are presented in Chart 3 below.

Chart 3: Electricity Tariffs in the states considering the specific incentives for Semiconductor / Large / Mega Projects.

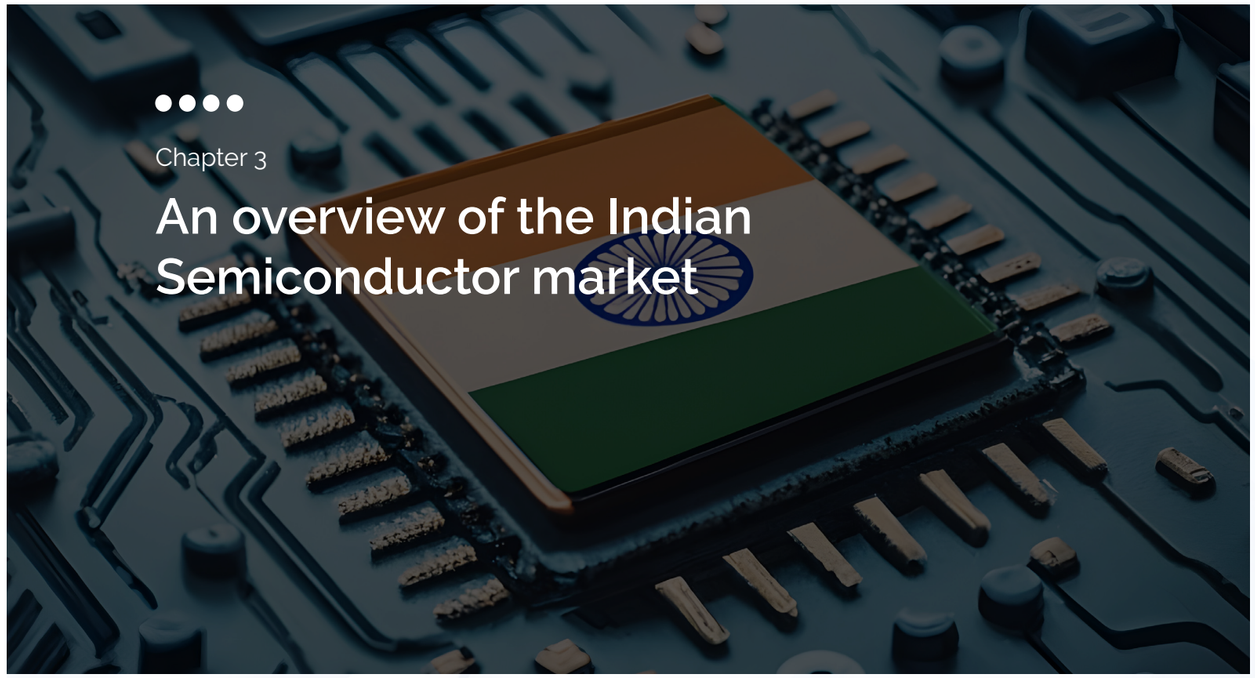


Source: Feedback Advisory Analysis, reference of State DISCOMS ARR's reports / documents

- **Other incentives and factors.**

There are a host of other factors / parameters, on which there are no uniform offerings from states, These include Production Linked incentive (~1%) in some states, Subsidies for Effluent / Water Treatment Facilities / Incentives for Human Capital / Training and many other incentives.

Chart 3: Electricity Tariffs in the states considering the specific incentives for Semiconductor / Large / Mega Projects.



Chapter 3

An overview of the Indian Semiconductor market

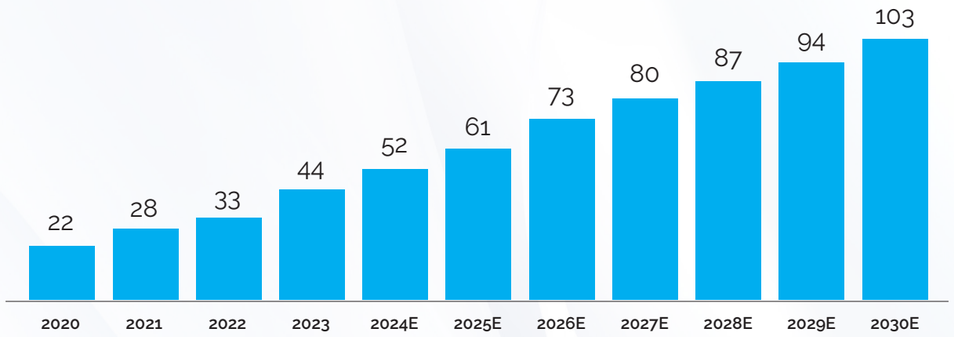
Abstract:
An overview of the Indian Semiconductors market is set out in this chapter. It includes the broader electronics sector overview and the estimated Semiconductor market size in India for the current and the next 3 years by various application segments. It also includes the key factors driving the Semiconductor market in India.

3.1 Semiconductors Market in India

The Indian semiconductor market was valued at $43.9 billion in 2023 and is expected to grow at a healthy CAGR of 13% from 2023 to 2030. Semiconductors play a crucial role in India's electronics manufacturing, digital transformation, mobile, defense, aerospace, renewable energy, Internet of Things (IoT), healthcare, automobiles, research, and various other sectors.[16]

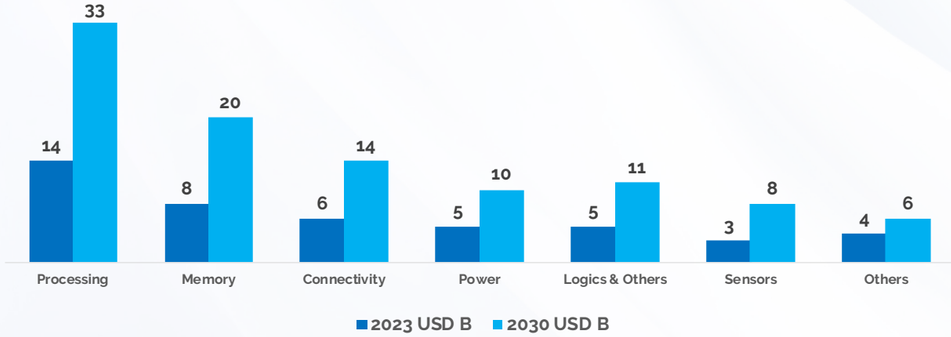
[16] IESA - 2023 Semicon Market Report

Chart 4: Semiconductors market size in India



This growth trajectory highlights the increasing importance of semiconductors in various industries within India. Factors such as technological advancements, expanding digitalization, investment in establishing manufacturing units and the rising demand for electronic devices contribute to the market's upward momentum. As the semiconductor sector continues to evolve and innovate, it plays a pivotal role in driving the country's technological landscape and economic progress.

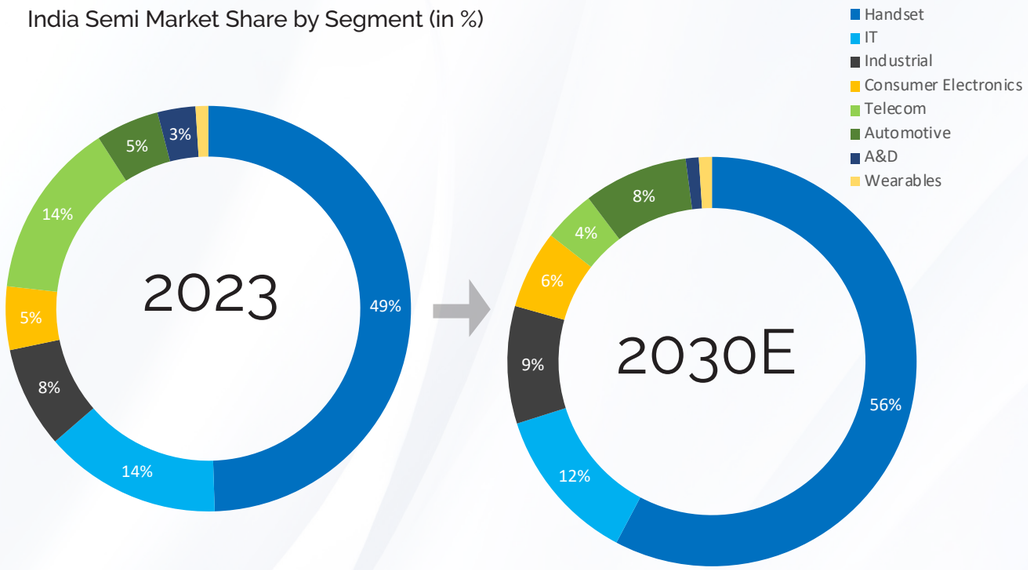
Chart 5: Semiconductors Market by Types of Semiconductors



3.2 Semiconductor market by key applications and types

The Indian semiconductor market is experiencing significant growth and transformation. Over the past few years, the Electronics System Design and Manufacturing (ESDM) sector in India has witnessed remarkable expansion, driven by the surge in mobile manufacturing and other electronics industries. This growth is evident from the more than 18.5% increase in ESDM manufacturing in the last 8 years, resulting in a market size of approximately USD 103 billion. However, despite this impressive growth, a substantial portion of the semiconductor demand is still met through imports, accounting for more than 90% of the total supply.

Chart 6: Semiconductors market by Key application segments



The key factors driving the Indian semiconductor market include:[17]

- **Consumer Electronics Demand:** The surging demand for semiconductors in consumer electronics like smartphones, laptops, tablets, and TVs is a primary driver, fueled by the growing Indian middle class and increasing digitalization.
- **Automotive Industry Growth:** The expanding automotive industry requires semiconductors for applications like ECUs, sensors, and infotainment systems, driven by rising vehicle production and the adoption of electric and connected vehicles.
- **Industrial Sector Advancements:** Increasing automation, robotics, and machine vision in industries lead to higher demand for semiconductors, supporting manufacturing efficiency and innovation.
- **Adoption of New Technologies:** The adoption of 5G, IoT, AI, and ML fuels semiconductor demand, as these technologies rely on chip-intensive applications for connectivity, processing power, and data analysis.
- **Government Initiatives:** Government incentives and policies, such as the $10 billion incentive package, encourage semiconductor manufacturing and attract global players to invest in the Indian market.

[17] IESA - 2021 Semicon Market Report

- **Electric Vehicle Revolution:** The shift toward electric vehicles necessitates advanced semiconductors for EV control systems and battery management, contributing to market expansion.
- **IoT Market Expansion:** The proliferation of IoT devices in various sectors increases semiconductor demand for connectivity and data processing, as devices become interconnected and generate vast amounts of data.
- **Emerging Semiconductor Technologies:** The development of innovative semiconductor technologies, such as 3D chips and quantum computing, showcases India's potential to be at the forefront of technological advancements.
- **Talent Pool and Research Ecosystem:** India's skilled workforce, substantial research output, and strong semiconductor design ecosystem position the country as an attractive destination for semiconductor companies.

3.5 The growing Indian ESDM sector and its impact on Semiconductor requirements

The Indian Electronics manufacturing sector has reached USD 102 billions in 2022-23[18], it comprises of Mobile Phones (43%), Consumer Electronics (12%), Industrial Electronics (11%), Auto Electronics (9%), Electronic components (10%), Strategic Electronics (5%), IT H/w (4%), LEDs (3%) and others (Telecom, Wearables & PCBA @ 3%) as shown in Table 3 below:

Table 3

Product Segments	2020-21	2021-22	2022-23
Mobile Phones	30	38	44
IT H/w (Laptops / Tablets)	3.0	4.0	4.0
Consumer Electronics (TV / Audio / Accessories)	10	10	12
Strategic Electronics	4.0	4.3	4.8
Industrial Electronics	11	11	12
Wearables & Hearables	0.0	0.3	1.0
PCBA	0.5	0.6	1.0
Auto Electronics	6.0	7.0	10
LED Lighting	2.2	2.5	3.0
Telecom Equipment	0.0	0.3	1.0
Electronic Components	9	10	11
Total Production (USD Bn)	**75**	**87**	**103**

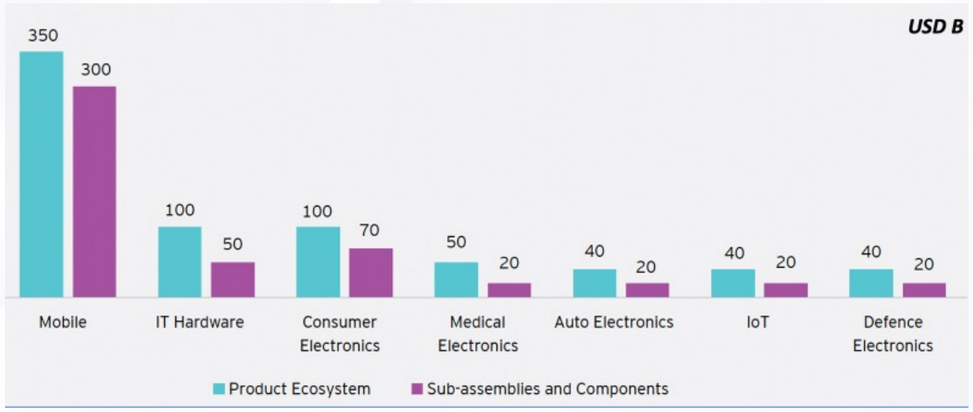
[18] Source: https://economictimes.indiatimes.com/industry/cons-products/electronics/domestic-electronic-manufacturing-rises-to-rs-8-25-lakh-crore-semicon-import-at-rs-1-29-lakh-crore-in-2022-23/articleshow/102576654.cms?from=mdr

India's electronics manufacturing has seen a sharp rise in Mobile manufacturing in the last 4-5 years. India represents one of the largest- and fastest-growing electronics market in Asia, and the Indian government plans to boost this growth to take it to USD 300 billion by the year 2026[19]. The recently released Vision Document states that:

"For India to be the global electronics manufacturing hub of the future, there needs to be a clear long-term vision which must be achieved by means of the short-term goals. In order to become a US$ 5 trillion economy by 2025-26, (or 2027-28 considering allowance for the two year loss on account of the pandemic), India shall strive to be a US$1 trillion digital economy given its omnipresence across all spectrums of life. Moreover, a special emphasis shall be laid on exports to achieve this objective."

The long-term vision is to create a USD 1 Trillion Electronic ecosystem in India in the next 10 years as given below in Chart 7 below:

The long-term vision is to create a USD 1 Trillion Electronic ecosystem in India in the next 10 years as given below in Chart 7 below:



But this long-term vision needs a very strong immediate / short term goal of USD 300 B of Electronics manufacturing to be created in India by 2026 and that is what the Government of India is working towards:

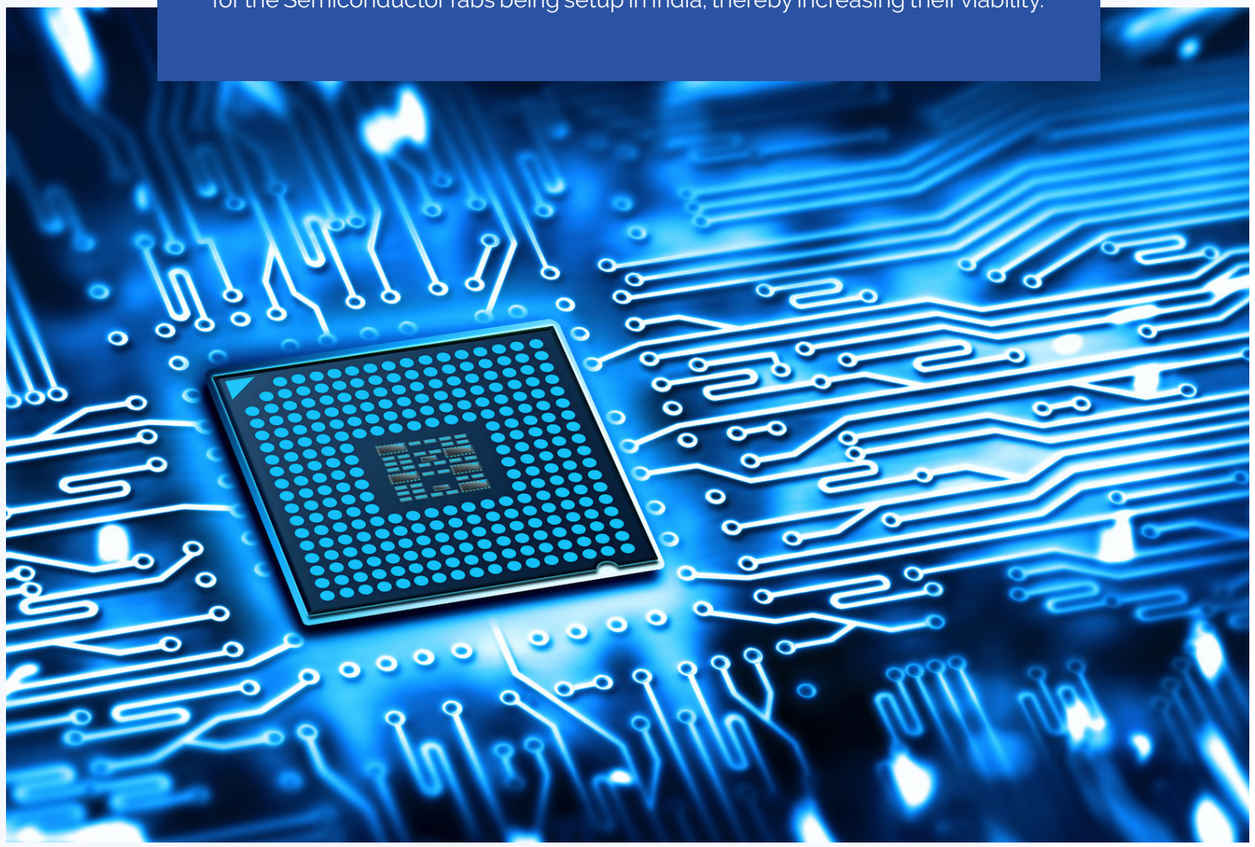
- Build competitiveness and scale
- Shift and develop sub-assemblies and components ecosystem
- Build design ecosystem
- Nurture Indian champions

[19] ICEA Vision Document released by Minister of State, Electronics Shri Rajeev Chandrasekhar in Feb 2022

The growing Electronics manufacturing is driving demand for Semiconductors for India:

The current manufacturing of USD 102 B would translate to a Semiconductor requirement of USD 25 to USD 30 B, going by a typical norm of 25% to 30% of Semiconductor components in any Electronics Product BOM (Bill Of Materials). With the rise in electronics production, this number is set to rise substantially.

Therefore, the key task before all the stakeholders is how to translate the burgeoning Semiconductors requirement to be in India and not depend on Imports as it is being done now. This will then translate to Semiconductors procurement to happen in India and will also translate as a "Domestic market" for the Semiconductor fabs being setup in India, thereby increasing their viability.



Chapter 4

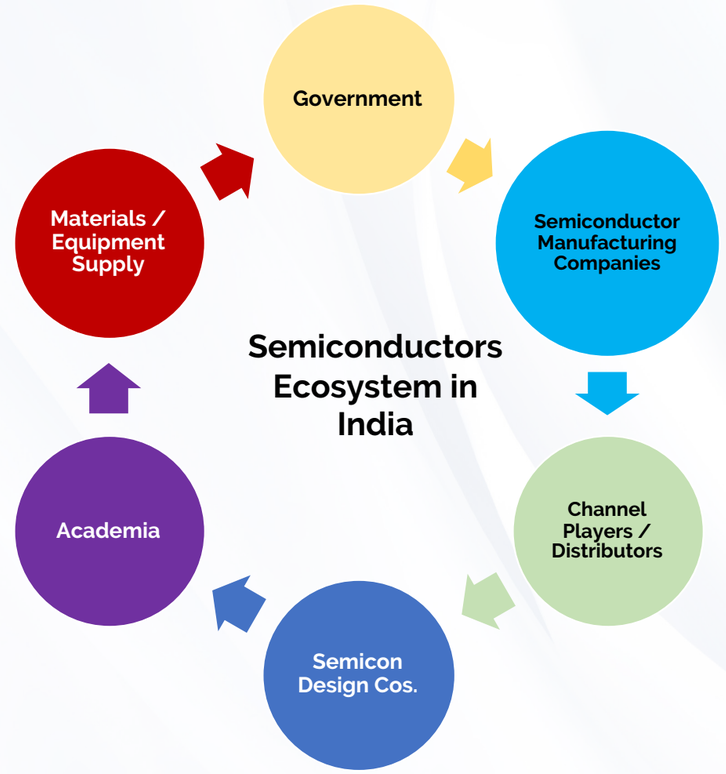
Stakeholder Mapping the Indian Semiconductor landscape

Abstract:
This chapter sets out a detailed landscape of the Indian Semiconductors Ecosystems. It sets out the key stakeholders in India related to Semiconductors and also a brief overview of key players and the current state of the Stakeholder segment in India. It also sets out the potential opportunities in Materials Supply and Equipment Spares Supply

4.1 Industry stakeholders in the Indian Semiconductor Industry – key players in each category

The Indian semiconductor industry is still in its early stages of development, but it has the potential to become a major player in the global market. A serious initiative to attract and make Semiconductors in India has been started and is likely to gain traction in the near future.

The overview of the key stakeholders in the Indian Semiconductor Ecosystem is as shown below in Chart 8:



4.2 Government

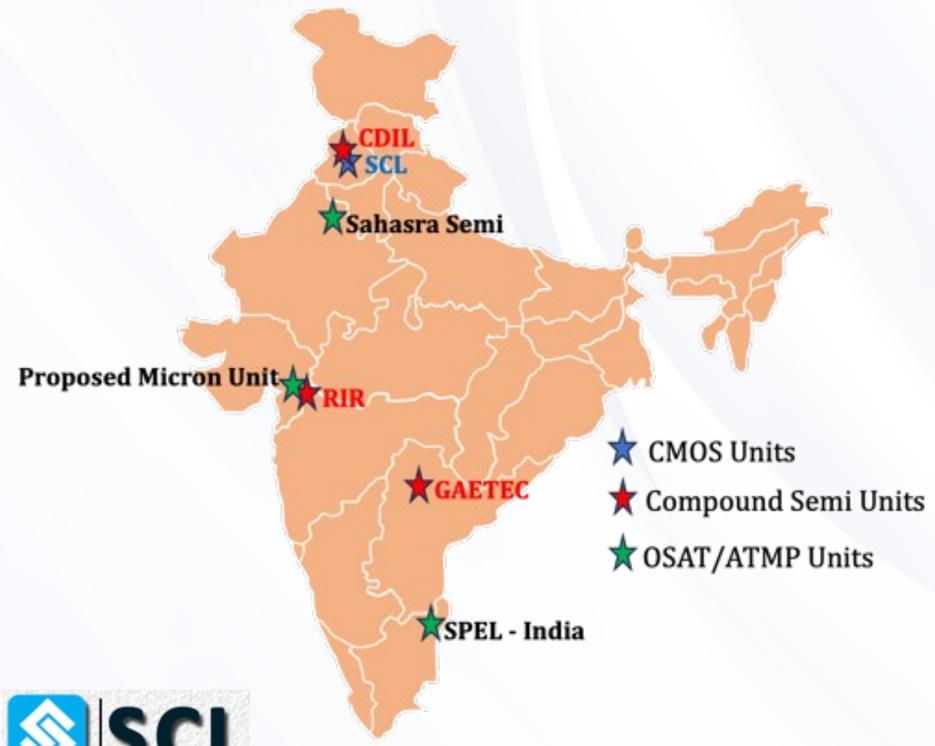
The Government of India and several State Governments involved in the Semiconductor ecosystem are listed below in Table 4:

Sr. No	Key agency	Role in the Semiconductor Industry
1	Ministry of Electronics & Information Technology (MEITY)	Key Nodal Ministry for Electronics & Semiconductors
2	India Semiconductor Mission (ISM)	Specialized and independent Business Division within the Digital India Corporation with MEITY - Executive Body for facilitating Semiconductor investments and policies
3	Department for Promotion of Industry and Internal Trade - Invest India (DPIIT)	Role of DPIIT is to promote industrial Development of the Country by facilitating investment in new and upcoming technology, accelerate & foreign direct investment and support a balanced development of industries & trade.
4	Ministry of Education (MOE)	MOE has been given a specific role of imparting Semiconductor related curriculum in Engineering Colleges in India. Forms the Policies and sets out the implementation targets for various Departments.

Sr. No	Key agency	Role in the Semiconductor Industry
5	All India Council for Technical Education (AICTE)	Statutory body, and a national-level council for technical education, under the Department of Higher Education. They have been given the mandate to implement the new Semiconductor curriculum in India.
6	Ministry of Skill Development and Entrepreneurship (MSDE)	Responsible for co-ordination of all Skill Development efforts across the country, removal of disconnect between demand and supply of skilled manpower, building the vocational and technical training framework, skill up-gradation, building of new skills and innovative thinking not only for existing jobs but also jobs that are to be created. Overall mandate to form Policies for Skill Development across sectors including Semiconductors.
7	National Skill Development Corporation (NSDC)	NSDC aims to promote skill development by catalyzing creation of large, quality and for-profit vocational institutions. the organisation provides funding to build scalable and profitable vocational training initiatives. Its mandate is also to enable support system which focuses on quality assurance, information systems and train the trainer academies either directly or through partnerships. It has around 35+ Specific Sector Skill Councils for addressing the needs of various Sectors
8	Electronics Sector Skills Council of India (ESSCI)	ESSCI's focus is on establishing an effective and efficient ecosystem for developing and imparting of outcome-oriented skills for the Electronics Systems, Design and Manufacturing Industry (ESDM). ESSCI's mandate comprises plethora of deliverables including development of curriculum, courses, information database, delivery system. ESSCI is responsible for standardization, accreditation and certification processes to enhance the employability of the Indian workforce globally. It has introduced 21 specific Semiconductor related Skill Development Courses.
9	Department of Science & Technology (DST)	Its objective is for promoting new areas of Science & Technology and to play the role of a nodal department for organizing, coordinating and promoting S&T activities in the country. Matters relating to institutional Science and Technology capacity building including setting up of new institutions and institutional infrastructure. Key body for fostering and growing R&D programs in India
10	Department of Chemicals and Petrochemicals (DCPC)	DCPC aims to formulate and implement policy and programmes for achieving growth and development of the chemical and petrochemical sectors in the country; and to foster the spirit of public-private partnership for overall development of above mentioned sectors of the industry. DCPC is now keen on developing the Chemical ecosystem required for the Semicon Industry.

4.3 Semiconductor companies

Semiconductors Manufacturing in India is at a very small scale in India. There is one Traditional CMOS Fab and some Compound Semiconductor Fabs and a few small scale OSAT/ATMP Units in India currently. The geographical locations of these units are shown below in the Indian Map below in Chart 9:



a. Semiconductors Complex Laboratory (SCL): It is an autonomous body under Ministry of Electronics & Information Technology (MeitY), Government of India; It is engaged in Research & Development in the area of Microelectronics to meet the strategic needs of the country and is located in Chandigarh, Mohali in the state of Punjab in North India. SCL has integrated facilities / supporting infrastructure all under one roof and undertakes activities focused on Design, Development, Fabrication, Assembly & Packaging, Testing and Quality Assurance of CMOS and MEMS Devices for various applications. SCL is also engaged in Fabrication of Hi-Rel Boards, Radio Sonde Systems and indigenisation of electronic sub systems.

• It has an 8" Wafer Fabrication Facility with a 180 nanometer CMOS Process for Fabrication of products in Digital, Mixed Signal and Analog domains. The facility meets international standards in terms of design, process equipment, in-line inspection & metrology tools, and support utilities. Fab has cleanrooms of class 1, 10, 100, and 1000 with controlled environmental conditions. SCL process is qualified as per JP-001A standard

• It also has 6" Wafer Fab Line for fabrication of MEMS devices. It is is expanding it to include a compound semiconductor fabrication facility for the production of optoelectronic and high-power devices. The line is equipped with in-line metrology and inspection tools, as well as a scanning electron microscope for analysis during the process and product development activities

• SCL can make 90 types of products and ASICs, produced in the domain of Analog, Digital, Mixed-Signal, Memory, Optoelectronics and MEMS Devices

With an investment of approximately $1.2 billion[21], the 30-year-old facility will undergo modernization to enhance its capabilities, primarily focused on producing 8-inch CMOS

b. SPEL – India: SPEL-India is a IC Assembly & Test Company located in Chennai, India. SPEL is India's first OSAT company & 100% export oriented. SPEL India is part of Natronix Pte of Singapore. Natronix is a member of the Valingro Group of Singapore. SPEL supplies to Global Customers across US, Europe, India & APAC inclusive of Companies with in Top 10 Semiconductor ranking. It has products serving wide range of application segments like 3Cs, Automotive, Medical, Industrial, Military & Aerospace. It has ISO 9001, ISO 14001, IATF 16949 certifications.

The existing capacity of the Unit is about 1,7 million units month of Leaded Package (20 lead equivalent) and 3.3 million units / month of QFN / DFN packages (3 sq. mm equivalent)

c. GAETEC: The Gallium Arsenide Enabling Technology Centre (GAETEC) at Hyderabad, is a vertically integrated foundry with design, fabrication, assembly, testing, packaging and module making facilities. GAETEC was established in 1996. At present GAETEC is running 0.7 and 0.5 micron MESFET-based microwave circuit technologies at different frequency ranges. GAETEC has productionised several indigenous R&D efforts carried out at Solid State Physics Laboratory (SSPL), DRDO, Delhi, and delivered several critical MMICs and application specific RF modules for Defence applications and ISRO satellite space missions.

d. Continental Devices India Ltd (CDIL): Continental Device India Ltd., (CDIL) is an ISO 9001, IATF 16949, and ISO 14001 certified company that pioneered the manufacturing of Silicon Semiconductor Chips and Devices in India in 1964. It launched its Electronic Manufacturing Services (EMS) division (Deltron) in 1982.

CDIL's comprehensive range a wide variety of Lead Free RoHS Compliant surface mount and leaded packages. Their product range includes Transistors; Diode; Zener Diodes; Rectifiers; Bridges; Schottky; DIACs; Triacs; SCRs; Voltage Regulators; TVS; Chips/ Dice/ Wafers.

[21] https://www.business-standard.com/technology/tech-news/govt-to-spend-1-2-billion-on-modernising-semiconductor-lab-in-mohali-123051200931_1.html

It has a deep sales and distribution network, both locally and globally, reaches satisfied customers in over 35 countries across 45 locations. It also has an international office in Hong Kong manages international clients.

CDIL has recently inaugurated the new Surface Mount Semiconductor Packaging Line, at Continental Device India Private Limited's (CDIL) Mohali plant today. With the new versatile SMA and SMB package line, via the Government of India's SPECS, CDIL becomes India's first Silicon Carbide components manufacturer, scaled to make auto-grade devices, including Silicon Carbide MOSFETs, Silicon Carbide Schottky Diodes, Rectifiers, Zeners and TVS Diodes among others for the global as well as the domestic market. The expansion of assembly lines will increase CDIL's total capacity at the facility to 600 million units annually. CDIL has also established an advanced testing and reliability laboratory at the Mohali plant. The facility, a one-of-a-kind in India, is equipped to meticulously qualify the semiconductor products according to the stringent standards stipulated by the Automotive Electronics Council (AEC), ensuring they meet the rigorous demands of the automotive domain.

e. RIR Power Electronics (RIR): RIR is Promoted by the founder of Silicon Power Corporation, USA, Dr. Harshad Mehta. RIR is set to be the first Indian company to "Make in India" WBGS power devices. Leveraging Silicon Power's extensive expertise, RIR plans to set up a vertically integrated, SiC device manufacturing operation for power electronics (epitaxial deposition, device fabrication and packaging). When established, RIR's SiC device fabrication will be the first of its kind in India.

RIR has one of its kind vertically integrated facility located in Halo, Gujarat. It has capabilities to design and manufacture semiconductor products, starting from Silicon wafers to producing end finished products. They can design and manufacture wide range of high power semiconductor devices ranging from 9000 volts and 6000 amperes. They also have capabilities beyond discrete power semiconductors to manufacture Power equipment such as Industrial rectifiers Battery chargers, high power stacks etc. Its facility in Gujarat is spread over 15,000 sq. meters land with a built area of 4,500 sq. meters.

Apart from these existing firms, the new Semiconductors Policy by the Government of India has led to an increased interest in India as a destination for Semiconductors manufacturing. A few recent news highlights are given below:

Micron Inc.[22]: Micron plans to build India's first semiconductor ATMP unit with an investment of $2.75 billion. Of this, Micron will be investing $825 million (around ₹6,760 crore) and the balance will come from the government in two phases. The project encompasses the design and construction of a first-of-its-kind DRAM and NAND assembly and test facility in India.

[22] https://www.thehindubusinessline.com/companies/tata-projects-bags-contract-to-build-microns-275-billion-semiconductor-plant-in-gujarat/article67337571.ece

[23] https://www.indiatoday.in/business/story/foxconn-stmicroelectronics-partnership-semiconductor-chip-factory-in-india-2432444-2023-09-07

Foxconn[23]: Foxconn Technology Group is collaborating with STMicroelectronics NV to submit a joint bid for constructing a semiconductor manufacturing plant in India, with the aim of securing state support for this endeavor. The partnership seeks to establish a facility dedicated to manufacturing 40-nanometer chips, a mature chip technology used in a wide range of applications, including automobiles, cameras, printers, and various other devices.

Vedanta[24]: The Vedanta Group is expecting government approval for its semiconductor and display fabrication plant soon. The company was looking at 2027 for the commercial production of semiconductors, and 2026 for the display production in Dholera, Gujarat. Vedanta would be investing USD 8-10 billion in the semiconductor foundry and the display would require USD 3-4 billion.

Tarq Semiconductors[25]: Tarq Semiconductors, owned by real estate giant Hiranandani Group, has submitted revised proposals for an assembly, testing, marking and packaging (ATMP) facility and a compound semiconductor unit. It is expected to invest about Rs 2,500 crore initially for its proposed ATMP facility, which should be implemented within 24 months of receiving all approvals. The proposed facility will come up in Uttar Pradesh's Yamuna Expressway Industrial Development Authority (YEIDA).

Tata Group[26]: Tata group is planning to invest Rs 200 crore for a semiconductor testing and packing unit at Narasapura in Kolar district, which is around 65 km from Bengaluru. With Wistron's iPhone manufacturing unit in Kolar being taken over by Tata group, it is likely to set up an Assembly, Testing, Marking and Packaging (ATMP) plant in Kolar.

Silicon Power Group[27]: Silicon Power would be investing USD 60 million to set up Sicion Carbide Fab and Packaging facility in India. They are in advanced stages of disccussions with the Government of India and other State Governments.

Sahasra Semiconductors Pvt. Ltd.: Sahasra has recently started NAND FLASH IC packaging and testing operations. The facility in Bhiwadi, Rajasthan has commenced its trials and sample production in March 2023. Building with required clean rooms spread over 8000 Square meters is ready and all high end technology equipments are installed.

[24] https://www.cnbctv18.com/business/vedanta-semiconductor-micron-foxconn-akarsh-hebbar-exclusive-18043701.htm

[25] https://economictimes.indiatimes.com/tech/technology/meity-reviewing-tarqs-revised-semicon-proposal/articleshow/103845222.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

[26] https://www.moneycontrol.com/news/business/karnataka-tata-group-to-invest-rs-200-crore-for-semiconductor-assembly-and-testing-unit-11380241.html

[27] https://www.newindianexpress.com/states/odisha/2023/jul/28/us-firm-to-set-up-silicon-carbide-unit-in-odisha-2599481.html

4.4 Channel Players & Distributors

India is the second largest electronics component importer in the world and has huge demand of electronics component in consumer electronics manufacturer. An increased demand in component has given birth to online component distribution and supply in the market. There are estimates of a presence of over 200+ Importers & Distributors of Semiconductor Products in India. However, the top 20 players would have a major market share of Semiconductors supplier in India. There are some major players in distribution industry which claims to have 5 million products available online from top manufacturers in worldwide. Mouser, Digi key and RS Components are the leading players which holds top position in the list of online electronics component supplier in India.

Table 5: Some key channel players in India are set out below

Company Name	Location	Website
Mouser Electronics India Pvt Ltd	Bangalore	www.mouser.com
Digi-Key Corporation	Bangalore	www.digikey.in
element 14 India Pvt Ltd	New Delhi	www.element14.com
Allied Devices (S) Pte Ltd	Singapore	www.adevices.com.sg
Arrow Electronics Inc	U.S.	www.arrowasia.com
Avnet Technology Solutions India Pvt Ltd	Bangalore	www.ats.avnet.co.in
Arihant Electricals	Delhi	www.arihantelectricals.com
Cirkit Electro Components Pvt Ltd	Mumbai	www.cirkitelectro.com
Componix India	Mumbai	www.componixindia.com
Electromark Devices (Bombay) Ltd	Mumbai	www.electromarkindia.com
Elektronika Sales Pvt Ltd	Delhi	www.elektronikasales.com
Emaar Impex Pvt Ltd	Mumbai	www.emaarindia.com
Elepin Tradex Pvt Ltd	Bangalore	www.elepintradex.com
Future Electronics	New Delhi	www.futureelectronics.com
Indus Technotronics Pvt Ltd	Bangalore	www.industechno.com
Integrated Industrial Electronics	Haryana	www.iielectronic.com
LWI Electronics Inc	Bangalore	www.livewireinfo.com
Millennium Semiconductors	Delhi	www.millenniumsemi.com
Network Electro Devices Pvt Ltd	Mumbai	www.network-india.com
Power Palazzo Pvt Ltd	AHMEDABAD	www.powerpalazzo.co.in
Precious Electronics Pvt Ltd	Mumbai	www.preciouselectronics.com
Rabyte Electronics Pvt Ltd	Noida	www.rabyte.com
Ramakrishna Electro Components Pvt Ltd	Delhi	www.rkelectro.com
RS Components and Controls (India) Ltd	New Delhi	www.in.rsdelivers.com

4.5 Semiconductor Design Companies / Fabless Companies

The state of Semiconductor Design ecosystem in India is summarized below:

- India possesses a significant competitive advantage in Semiconductor Design, with **approximately 20%**[28] of the world's Semiconductor Design Engineers based in the country.
- Each year, these engineers contribute to the design of **nearly 2000**[29] chips in India.
- India remains **an attractive destination for global semiconductor design companies,** hosting major players such as T1, Broadcom, Intel, Qualcomm, Western Digital, Samsung, and Huawei, who have established fabless Intellectual Property (IP) and System-on-Chip (SoC) design houses in the country.
- The **design domain in India is robust,** with expertise in networking, microprocessors, analog chip design, and memory subsystems, supported by several multinational corporations, design centers, service houses, and local chip designing companies, catering to government requirements.
- The semiconductor industry in India is vibrant, with **over 100 design startups and 250+ semiconductor design companies** actively engaged in chip design and verification.
- The country boasts 5-10 domestically owned small **Indian fabless startups with chipsets in production,** and another 20-25 companies **are in the prototype/pre-proto stage[30].**
- According to **Table 6** below, the Electronics Design Sector is projected to experience a Compound Annual Growth Rate (CAGR) of 20%[31] in the next 5 years.

Table 6

Market forecast by Revenue (USD Bn)						
	2020	**2021**	**2022**	**2023**	**2024**	**2025**
VLSI Design	1.7	1.8	2.15	2.34	2.84	3.35
H/W Board Design	1.5	1.7	1.9	2.15	2.52	2.98
Embedded S/W	20.8	25.5	31.95	38.51	45.64	53.67
Total Design Market	24	29	36	43	51	60

Source: Semicon India Future Skills Talent Committee Report

Some of the major Indian players in Semiconductor Design Services are Tessolve Semiconductors, Tech Mahindra Cerium, Mirafra SW Technologies, MosChip Technologies, InSemi Technology, SoCtronics Technologies, SmartSoC Solutions, Adept Chip Services, Ignitarium Technology Solutions, SeviTech Systems and Digicomm Semiconductors. These firms have 300+ employees.[32]

Apart from these Indian firms, most prominent MNC firms in Semiconductors have their Design Operations in India.

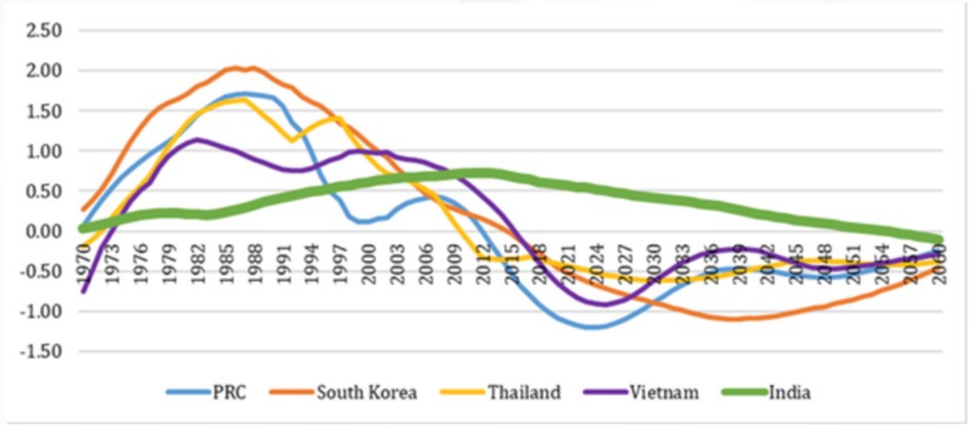
[28] https://c2s.gov.in/about_c2s.jsp
[29] Ibid
[30] https://www.dqindia.com/government-has-recognized-tremendous-opportunity-semiconductor-industry-opens-up-for-india-saankhya-labs/
[31] Semicon India Future Skills Talent Committee Report
[32] A brief profile of these firms are elaborated in Annexure @@.

4.6 India's Talent Supply and Education Programs

India talent supply

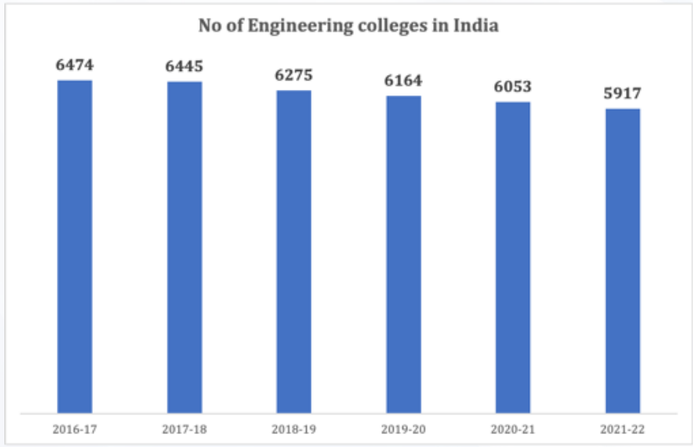
India possesses one of the most significant demographic advantages globally, with an estimated 1.04 billion individuals in the working-age category expected by the year 2030[33]. Over the next decade, approximately 25% of the world's new workforce is projected to emerge from India. When compared with other key countries in Asia, **Chart 10**[34] (Below) clearly illustrates India's clear demographic edge.

Chart 10



Source: https://www.ey.com/en_in/india-at-100/reaping-the-demographic-dividend

India also has one of the highest number of Engineering colleges in the world as **shown here in Chart 11**[35]**:**



Source: https://www.indiatoday.in/education-today/news/story/over-550-engineering-colleges-affiliated-with-aicte-shut-shop-in-last-6-years-1855266-2021-09-21; Feedback Analysis

[33] https://www.ey.com/en_in/india-at-100/reaping-the-demographic-dividend
[34] https://india.unfpa.org/en/news/reaping-indias-demographic-dividend; Prof. Sang-Hyop Lee, East West Centre, Hawaii, Honolulu, USA
[35] https://www.indiatoday.in/education-today/news/story/over-550-engineering-colleges-affiliated-with-aicte-shut-shop-in-last-6-years-1855266-2021-09-21; Feedback Analysis

India has a huge supply of a STEM / Engineering Talent [36] as shown in the Chart 12 below:

	Stream	Enrolment			Pass-out
		No. of Students	Male Students	Female Students	No. of Students
Under-Graduate	Electronics Engineering	611,442	365,509	254,933	134,600
	Electrical Engineering	373,300	271,455	101,845	85,505
	Computer Engineering	935,270	578,877	356,303	172,327
Graduate	Physics	76,382	31,409	4,473	30,785
	Electronics	3,862	2,057	1,805	1,618
	Electronics Engineering	24,228	11,640	12,588	11,209
	Electrical Engineering	19,928	13,320	6,608	6,931
	Computer Engineering	29,065	13,756	15,309	13,909
	IT & Computer (Non-Engineering)	197,395	100,986	96,409	67,189
Post-Graduate	Physics	7,439	4,632	2,807	1,398
	Electronics	382	205	177	93
	Electronics Engineering	5,674	3,526	2,148	763
	Electrical Engineering	5,309	3,835	1,474	655
	Computer Engineering	7,682	4,436	3,246	849
	IT & Computer	3,512	1,629	1,883	626

Actual students pass-out ~530 K per year

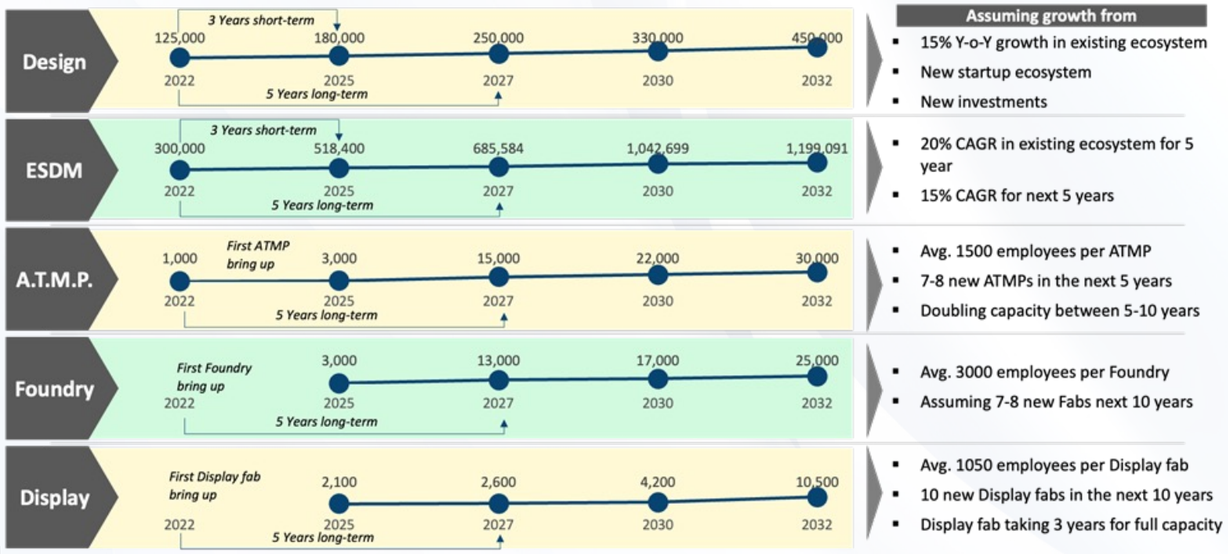
Source: Semicon India Future Skills Talent Committee Report

[36] Semicon India Future Skills Talent Committee Report

Aiming to become the Semiconductor Workforce for the World:

According to the 'Talent Demand Assessment for the ESDM and Semiconductor Sector for 2032[37] conducted by the Skill Development Committee, there will be a substantial requirement for a workforce, totaling 1.7 million individuals by the year 2032. This demand is four times higher than the existing workforce base of 0.42 million, as depicted in Chart 13.

Chart 13



Source: Semicon India Future Skills Talent Committee Report

The Semiconductors Talent development plan of India is summarized below[38]:

- Short term goal of training 85,000 Semi Professionals in the next 5 years
- Long term goal of training about 1.2 to 1.7 million professionals by 2032. To achieve this, an additional 275,000 skilled professionals are required in chip design, 25,000 in semiconductor fabrication, and 29,000 in assembly, testing, marking, and packaging (ATMP) operations .
- Programs to address all major spectrums of Semiconductor value chain – Fabs/ ATMPs/Design and R&D
- Hence, the need to have SemiCon professionals across various levels of industry requirements starting from Technicians, Diploma Holders, Engineers and PHDs/ Doctorates in Semiconductors
- Involves a mix of Formal / College based educational programs and Informal and Vocational Training Programs by Indian / International institutes.

[37] Ibid

[38] Feedback analysis of various GOI and Industry programs

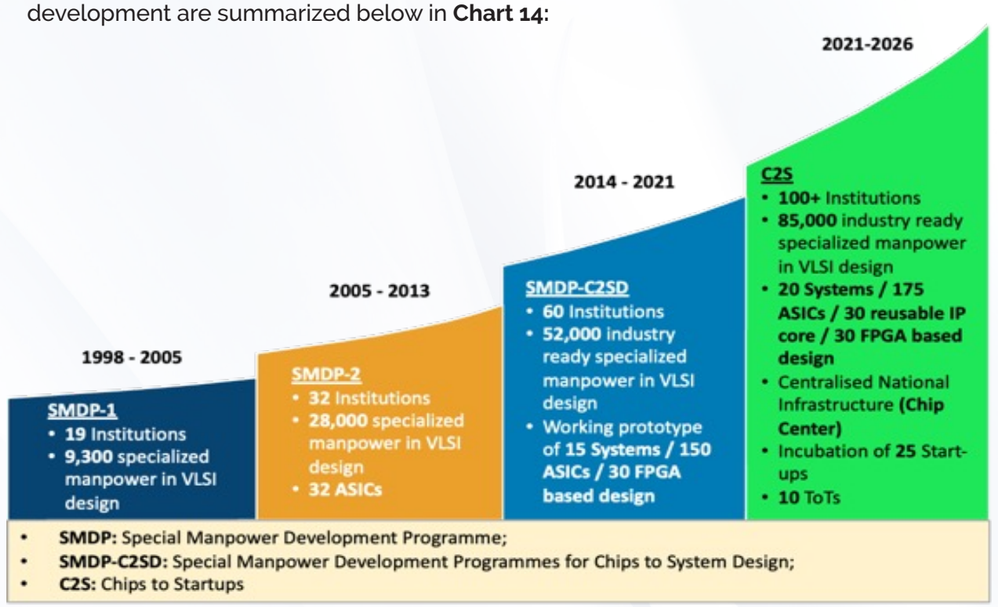
Key skill development activities being undertaken in the Semiconductor areas in India

- **Academic Collaborations and Programs:** The Indian government, along with academic institutions, is promoting collaborative projects focused on semiconductors. Institutes like IIT Hyderabad and IIT Roorkee offer specialized B.Tech programs in IC Design and Technology, IC Manufacturing, and VLSI Design. Tier-I and Tier-II institutes also provide undergraduate courses in the semiconductor field.
- **Chips to Startup (C2S) Program:** The All-India Council for Technical Education (AICTE) has launched the C2S program to train a total of 85,000 engineers in ESDM (Electronics System Design and Manufacturing) over five years. The program spans across Bachelors, Masters, and Research levels and collaborates with 82 technical education institutes to ensure successful implementation.
- **Curriculum Enhancement:** The AICTE has introduced a comprehensive curriculum for B.Tech Electronics (VLSI Design & Technology) and Diploma in IC Manufacturing. These programs equip students with expertise in various semiconductor disciplines, including VLSI Designing, IC Integrated Chip Designing, Semiconductor Management, and Silicon Chemical Extraction.
- **Industry-Academia Partnerships:** Collaborations between academia, R&D organizations, startups, MSMEs, and industries play a pivotal role in developing IPs, ASICs, SoCs, and Systems for targeted semiconductor applications. Such partnerships provide real-world exposure and hands-on experience to students.
- **Diploma Programs for Semiconductor Fabrication:** In response to the industry's demand for skilled professionals in semiconductor fabrication, the Indian government has introduced a Diploma in IC Manufacturing. This program provides specialized knowledge and skills required for intricate processes in semiconductor fabrication.
- **Emphasis on VLSI and Embedded Systems:** The growth of the Indian software sector relies on VLSI and embedded design professionals. The government's focus on fostering a skilled workforce in VLSI design and embedded systems aligns with the National Policy on Electronics 2019 (NPE-2019) vision and mission.

OTHER TRAINING PROGRAMS:

- Electronics Sector Skills Council of India and the Electronic Industries Association of India have jointly launched SEMI University, an online platform offering 360 courses covering manufacturing, chip design, artificial intelligence, and workplace safety.
- U.S.-based LAM Research will introduce virtual nanofabrication through its simulation platform Semiverse, training 60,000 engineers in the next decade.
- Purdue University, jointly with ISM, will offer certificate courses in circuit and system design and advanced packaging and manufacturing beginning in 2024.
- **Minor Specializations:** The curriculum allows students pursuing core engineering branches to opt for a minor specialization in semiconductors. This opens doors for students interested in entering the semiconductor industry, even if their primary focus is on other engineering disciplines.

The efforts of the Government of the India programme for Semiconductors Manpower development are summarized below in **Chart 14:**



Specific semiconductors education programmes in India:

The All-India Council for Technical Education (AICTE) has unveiled a comprehensive curriculum for B. Tech Electronics (VLSI Design & Technology) and Diploma in IC Manufacturing, with a primary focus on creating a skilled workforce in the semiconductor domain. The courses aim to equip students with expertise in various semiconductor disciplines, including VLSI Designing, IC Integrated Chip Designing, Semiconductor Management, and Silicon Chemical Extraction.

With the Semicon India program in mind, AICTE has initiated the Chips to Startup (C2S) program, intending to train a total of 85,000 engineers at the Bachelors, Masters, and Research levels combined, specializing in ESDM (Electronics System Design and Manufacturing), over a span of five years. In collaboration with 82 technical education institutes, AICTE has established necessary partnerships to ensure the successful implementation of this ambitious program.

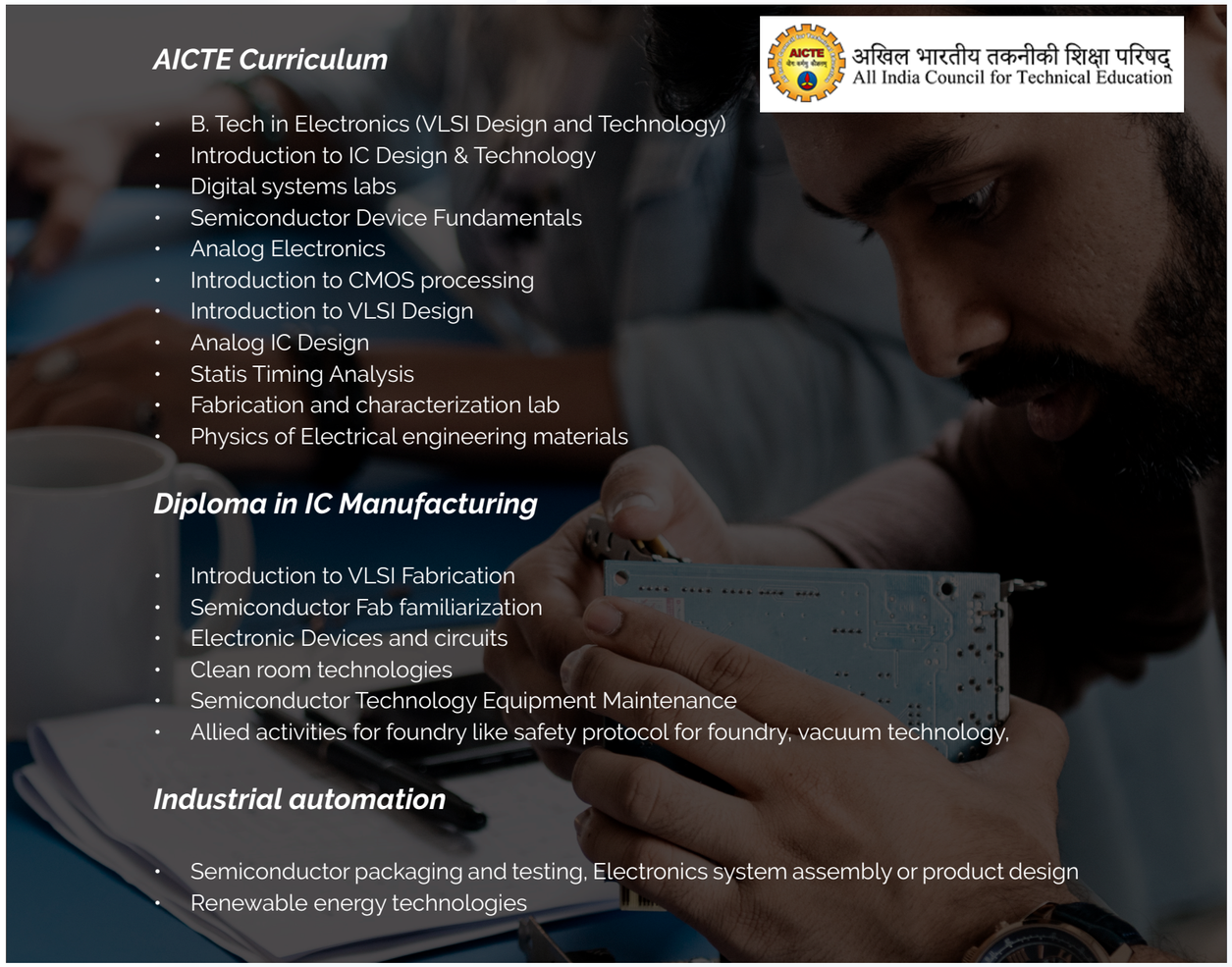
The introduction of these courses marks a significant step in cultivating a skilled workforce that can contribute to the thriving semiconductor industry in India. Graduates will find numerous employment opportunities with attractive salary incentives, both in global companies and domestic firms. Notably, the VLSI sector, being high-paying and resistant to automation, presents a promising avenue for career growth and stability.

The curriculum opens doors for students pursuing core engineering branches to opt for a minor specialization in semiconductors within their engineering colleges. Additionally, working professionals keen on upgrading their skills to enter the semiconductor industry can also enrol in these courses.

Conventional technical institutes included some semiconductor courses in programs like BTech-Electronics Engineering, Electronics and Communication Engineering, etc.

- IIT Hyderabad introduced a specialized B. Tech program in IC Design and Technology recently.
- IIT Roorkee provides a comprehensive program focusing on IC manufacturing and VLSI Design.
- Many Tier-I and II institutes offer undergraduate courses in the field of semiconductors.

In addition to engineering courses, diploma programs are being introduced to meet the genuine demand for rapid growth in the semiconductor domain, encompassing both fabrication and design. The industry seeks skilled professionals capable of handling intricate processes in semiconductor fabrication. To address this need, the government conceived the idea of a dedicated Diploma in IC Manufacturing, providing a structured curriculum to equip individuals with specialized knowledge and skills required in this critical field[40].



[36] https://www.educationtimes.com/article/higher-education-subject-wise/98440606/aicte-launches-courses-in-semiconductor-to-make-india-self-reliant-in-chip-manufacturing

A brief profile of key Academic Institutions in India in Semiconductors

a. Indian Institute of Technology, Delhi (IIT-D)

Indian Institute of Technology Delhi, established in 1961, is one of the 23 IITs created to be Centres of Excellence for training, research and development in science, engineering and technology in India.

Since its inception, over 48000 have graduated from IIT Delhi in various disciplines including Engineering, Physical Sciences, Management and Humanities & Social Sciences. Of these, nearly 5070 received Ph.D. degrees.

EE department of IIT-D has a dedicated faculty group called the IECD group (Integrated Electronic Circuits and Devices group) that has expert faculty looking into all aspects of semiconductors.

- There is a dedicated semiconductor design program called the VDTT (VLSI Design Tools & Technology) program - which traditionally is sponsored by tier 1 Semi Design industry. The VDTT is a highly customizable master's level fully sponsored programme, where the sponsoring company is offered end-to-end involvement, right from the selection of students and all the way up to deciding elective courses and the master's degree project.
- There is CARE (Centre for Applied Research on Electronics) which is also active in areas of Semiconductors.
- IIT-D also has an IEC M.Tech program.
- Infrastructure wise, there are two Research Facilities - Nano Research Facilities and Central Research Facilities. EE-IEC faculty are doing globally cutting edge research in semi areas like - quantum computing, neuromorphic hardware, sensors, MEMS, non-volatile memory technology, wearable electronics, power electronics, analog/digital circuit design, photonics and plasmonics.
- There are also some international programs ongoing in IIT-D,
    1. IIT-D + NYCU Taiwan has a joint PhD program also running on semiconductors. Tsmc, Mediatek in past have participated in it. Entire NYCU top brass are visiting soon to IIT-D for renewing this program on Indo-Taiwan Semiconductors collaboration.
    2. IIT-D is also in discussion with Purdue university on Semiconductors collaboration programs.

b. Indian Institute of Technology, Bombay (IIT-B)

IIT Bombay Center for Semiconductor Technologies, SemiX was established in 2022.

- Semi stands for Semiconductors
- X represents the integration of various semiconductor solutions – materials, equipment, devices, circuits, packaging, and software
- SemiX enables semiconductor industry focussed R&D, workforce development, and entrepreneurship by serving as a common interdisciplinary platform to integrate the energies of (a) Multiple involved academic disciplines, (b) Indian semiconductor consumers and creators, (c) Academicians, entrepreneurs, investors, and government policymakers.
- SemiX has significant contributions
- **World Class Facilities & Investment**
  1. The microelectronics facility was instituted in the 1980s
  2. In 2006, funding was pioneered by O/o PSA & MeitY to fund integrated nanofabrication facilities at IIT Bombay and IISc, Bangalore. The Center of Excellence in Nanoelectronics (CEN) was born.
  3. The Infrastructure created was open access subject to policy, with IT-enabled online slot booking, billing, chemical safety audit, etc.
  4. Tremendous R&D Investment Attracted for Equipment Capex & Opex in 1.5 decades (~150M$)
  5. ~6M$ Industry engagement- Applied Materials, Semiconductor Research Corp, GlobalFoundries, Keysight, Synopsys, Intel, Renesas, TSMC, Micron, IMEC, IBM, etc.
  6. Synopsys Research Lab for Virtual Fab Solutions established in 2023
- **6+ Startups for Nationally/Globally relevant technologies**
- **Outreach & Training Impact:**
  1. Various training courses in association with industries have been launched as pioneering (e.g. Fab Training with Applied Materials, GlobalFoundries, and Synopsys)
  2. INUP Training for Nanoelectronics provided hands-on training, leading to research resulting in 400+ Ph.D. theses, 533 research papers, and 22 patent

c. Birla Institute of Technology Studies, Pilani

BITS PILANI has set up a Centre for Research Excellence in Semiconductor Technologies (CREST). The key vision of CREST is to make BITS Pilani as the leading academic institution for Semiconductor Research and Innovation in India. Its mission is to be on the forefront of India's Mission Level Programs (Semiconductors, Cyber Physical System, and Quantum Tech).

Critical infrastructure:

- Current 600 sft clean room (Class 100 & 1000)
- Sophisticated Instrument Labs in each campus
- Develop dedicated semiconductor lab infrastructure
- Material and device simulation / modelling, AI assisted methods, material optimization, reliability, and characterization

Collaborations:

- Industry players for guiding PhD scholars, providing access to infrastructure, targeted Internships
- International Universities for Twinning / Semester Exchange
- TBIs, Venture Centers for Entrepreneurship focused projects /course

CREST's academic plan:

- Start an UG level minor program in Semiconductor domain
- Semiconductor related courses (Design, Modelling, Simulation,
- Processing, Characterization, Testing, Validation, AI/ML) for Engineering Students
- Setting up curriculum Labs
- Industry Oriented Projects
- Entrepreneurship focused projects / course mandatory

Further strengthen the current Master's program in Microelectronics with a focus on contemporary semiconductor areas

- Upgrading the current program and Labs
- Including more hands-on courses and Lab work
- Targeted Internships with collaborating Industries
- Improve the Student : Faculty ratio
- Achieving 1:1 Equipment : Student Ratio

Build and nurture cross disciplinary PhD program in Semiconductor Domain

- To initially support 10-12 relevant strategic project (each with 2 faculty members, and 1 PhD scholar)
- Possibility to be guided by an Industry professional

4.7 Semi Supply Chain - Materials

India has availability of chemicals (Sulfuric Acid, Hydrochloric Acid, Nitric Acid, Hydrogen Peroxide, Ethanol, carbon etc.) minerals (Aluminum / Alumina / Bauxite, Titanium, Zinc, gypsum, etc.) and gases (oxygen, nitrogen, argon, carbon-di-oxide etc.) which can be supplied to semiconductor manufacturers across globe. Moreover, India is the 6th largest country in chemical sales globally.

India can supply chemicals, minerals and gases to semiconductor manufacturers across globe, especially to countries who are re-assessing their import partners due to geopolitical reasons. However, India may have to look into few aspects to be a supplier of chemical, mineral and gases to SC manufacturers, such as:

1. Spreading industry-wide awareness of SC related application of chemical, mineral and gases
2. Bringing government policies to assist/promote production of SC grade chemical, mineral and gases
3. Investment in expansion of capacities
4. Investment in SC scale packaging requirements for chemicals, minerals, and gases

Major gas companies Air Liquide, Linde, and INOX are the largest gas companies in India who holds the capability to upgrade the existing gas producing facilities and supply to several semiconductor manufacturing companies.

Furthermore, there are few materials and gases which India produces but not of that level of purity which is required for SC manufacturing. Through suitable funding, governmental backing, and education initiatives, it's possible to elevate the production of chemicals like Hydrofluoric Acid, Phosphoric Acid, acetic acid, acetone, as well as minerals such as Silicon/Quartz, Magnesium, and gases like hydrogen and helium to a point where they can be readily supplied to semiconductor manufacturers worldwide.

India has many of the chemicals, minerals, gases used in semiconductor manufacturing which have been used by different segments of the Indian industry such as Pharmaceuticals, Paints, Automotive, etc. The Indian materials industry will have to improve the quality and purity of these materials (Chemicals, minerals, and gases) to be of semiconductor manufacturing grade.

Therefore, it can be said that **India has an appropriate ecosystem for becoming an integral part of the global semiconductor manufacturing supply chain.** While India has the base resources available, but these need to be made specific to adhere to the Global Semiconductor Manufacturing standards and specifications. This would require significant investment and time to qualify for Semiconductor Market requirement and hence one of the important approaches would be to get established international firms which are part of the existing ecosystem to invest in India and leverage the local suppliers to support as

4.8 Semi Supply Chain - Equipment

4.8.1 Introductions

Global Semiconductor Manufacturing Equipment segment is expected to reach ~US$ 115 bn in 2023; MSMEs can be a major contributor in making India the supplier of spare parts for equipment to semiconductor equipment manufacturers

Multiple countries including U.S., Japan, Taiwan, South Korea, China, Netherlands, Germany, Austria, UK, Switzerland, France, Italy, and Israel among others, have presence across equipment segment. However, **no single country dominates in all the equipment sub-segments, different countries have prominence in the different equipment category.** This is the segment which has scope for other countries to enter in the market, especially in areas such as electrical instruments, microscopy, and structural inspection & repair where not more than two countries are present. **Applied Materials, ASML, Lam Research, Tokyo Electron, and KLA continue as top suppliers of semiconductor equipment.** COVID-19 turned out to be a strong driver as well as a huge logistical challenge for semiconductor manufacturing, resulting with the top 15 companies growing 18%. 2020 was a prominent Logic/Foundry year for semiconductor capital equipment, with surging demand in 5G and Datacenter chips as well as 7 & 5nm processors driving strategic investments.

Semiconductor manufacturing includes several processes, and each process requires a large number of equipment. To break it down further, each equipment is made of several small parts and spares. These equipment companies have contracts with sub-contractors across globe to get the supply of components/parts/spares for producing semiconductor manufacturing equipment. These sub-contractors can be in in the same country as of the equipment manufacturing facility or can be outsourced from other parts of globe. Therefore, it can be an opportunity of India to be a sub-contractor of these equipment manufacturing companies to enter semiconductor manufacturing supply chain.

4.8.2 Global Semiconductor Equipment Manufacturers in India

Table 7

Name of the Company	Country	India Presence	Focus
Applied Materials	US	Yes	Engineering Support
Lam Research	US	Yes	Engineering Support
ASML	Netherlands	Yes	Marketing
Hitachi	Japan	Yes	Marketing
Tokyo Electron	Japan	Yes	Marketing
ASM Int.	Netherlands	Yes	Marketing
KlA	US	Yes	Marketing
Advantest	Japan	Yes	Marketing & Software Development

Source: Secondary Research, Feedback Analysis

Key semiconductor market ecosystem players in India for materials and equipment:

Applied Materials: Applied Materials is a global leader in the supply of semiconductor manufacturing equipment. The company has a strong presence in India, with offices in Bangalore, Chennai, and Mumbai.

Lam Research: Lam Research is another major supplier of semiconductor manufacturing equipment. The company has a research and development center in Bangalore, and it also provides training and support to customers in India.

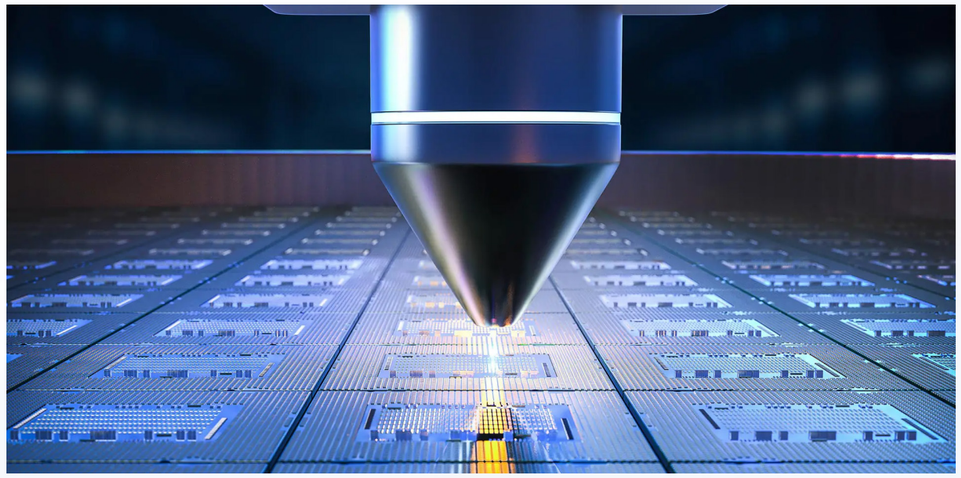
KLA Tencor: KLA Tencor is a supplier of semiconductor inspection and metrology equipment. The company has a strong presence in India, with offices in Bangalore, Chennai, and Hyderabad.

ASML: ASML is a Dutch company that is the world's leading supplier of extreme ultraviolet (EUV) lithography systems. The company has a service center in Bangalore, and it also provides training and support to customers in India.

Tokyo Electron: Tokyo Electron is a Japanese company that is a major supplier of semiconductor manufacturing equipment. The company has a strong presence in India, with offices in Bangalore, Chennai, and Mumbai.

Hitachi High-Technologies: Hitachi High-Technologies is a Japanese company that is a major supplier of semiconductor manufacturing equipment. The company has a strong presence in India, with offices in Bangalore and Chennai.

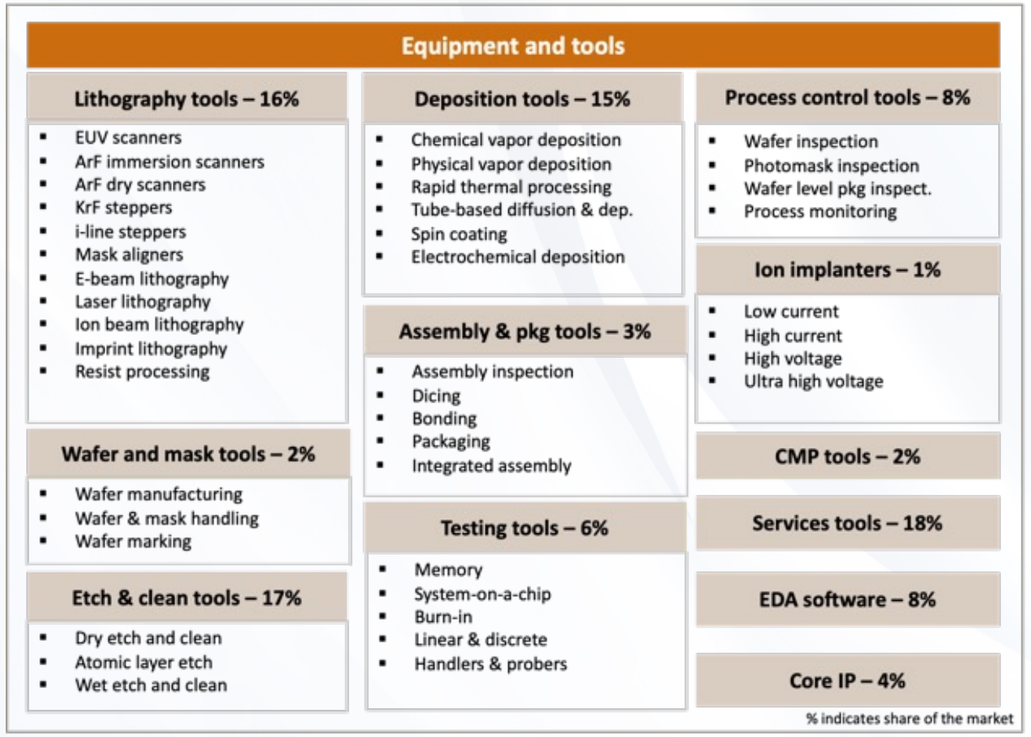
- In addition to these major players, there are a number of other smaller companies that are active in the semiconductor materials and equipment market in India. These companies are providing a variety of products and services, including wafers, gases, chemicals, and process control equipment.
- The presence of these key players is a positive sign for the growth of the semiconductor industry in India. The availability of high-quality materials and equipment is essential for the development of a vibrant semiconductor manufacturing ecosystem.
- India is already manufacturing some of the important parts required for semiconductor manufacturing equipment which are being utilized in different industries. Some of the major opportunities at India's doorstep are cleaning equipment, spares, refurbishment, ancillary tools, clean room set-up and maintenance.
- A list of major equipment spares given in the Annexure – A.2.



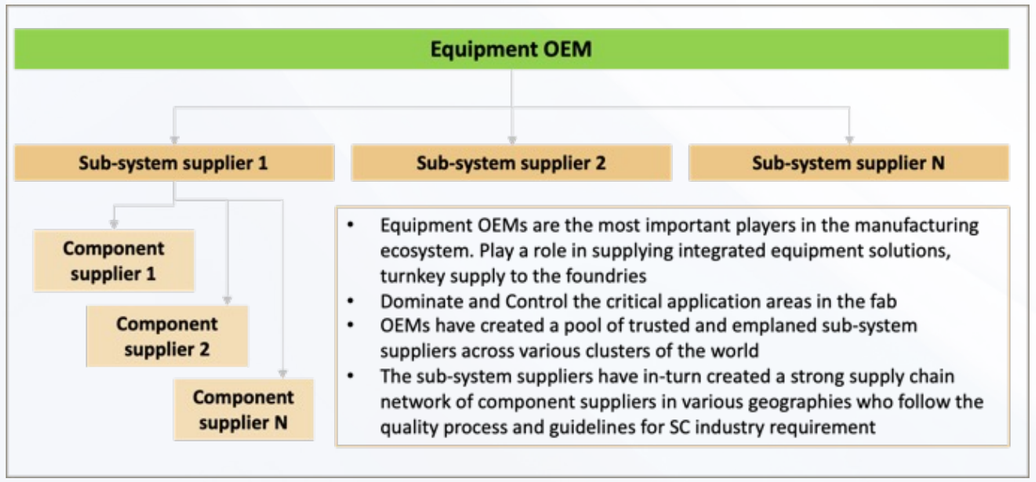
4.8.3 Global Semiconductor Equipment demand and India Opportunity

Global Semiconductor Manufacturing Equipment demand estimated to be US$ 200 Bn by 2030

Chart 15: Semiconductor manufacturing includes several processes, and each process requires a large number of equipment.



To break it down further, each equipment is made of several sub-systems which consists of small component parts and spares as shown in Chart 16:



These equipment companies have contracts with vendors across globe to get their supply of sub-systems for semiconductor manufacturing equipment. **Equipment companies reliance on a limited group of suppliers involves several risks, including a potential inability to obtain an adequate supply of required components, reduced control over pricing and the risk of untimely delivery of the components and subassemblies.**

The sub-system manufacturers have multiple manufacturing footprint and source their component parts from different vendors across the globe. This is very similar to the Automotive industry which follows a Tier led manufacturing approach. **The maturity and success levels of the Indian Automotive Industry is very well know and could be leveraged to replicate a similar success for the semiconductor equipment component/ parts industry as well.**

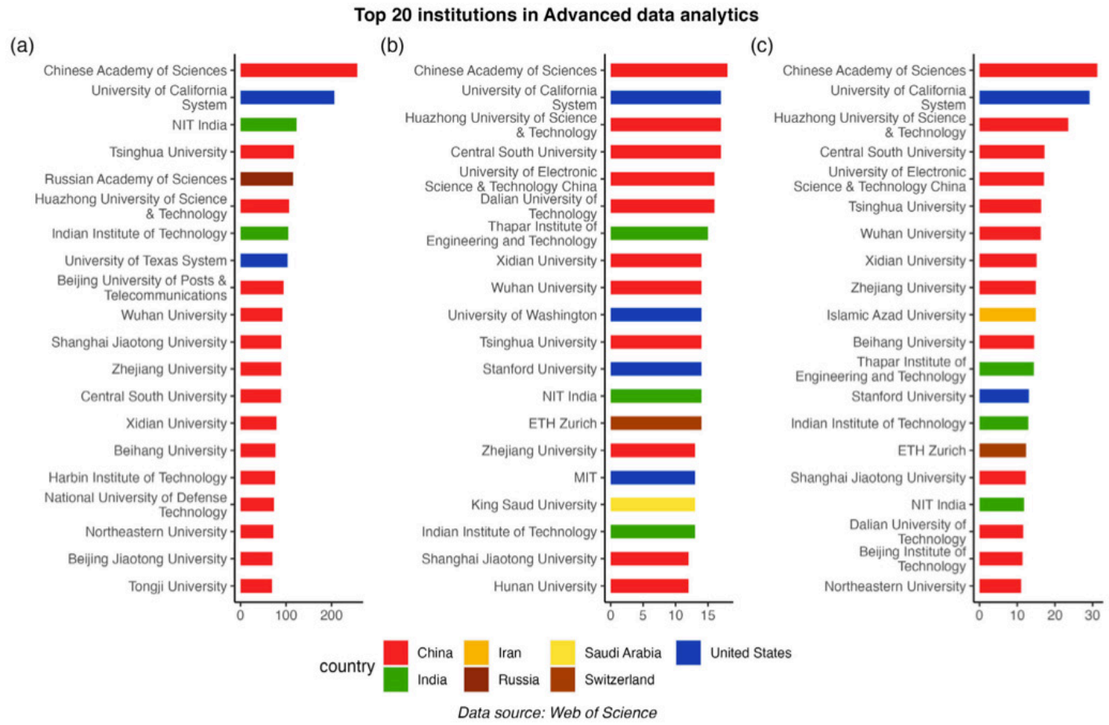
The semiconductor manufacturing equipment follows a stringent cycle of preventive and break down maintenance. Preventive maintenance is carried out in periodic intervals as a fixed cycle which demands the need for change in spares and consumables, even if they are not worn out. **This implies that the maintenance spends per equipment is fairly fixed, this is a great opportunity to be serviced from the Indian region.**

India is already manufacturing some of the important parts along with precision components required for semiconductor manufacturing equipment / sub-systems which are being utilized in different industries such as Aerospace, Automotive, Medical Devices, etc. Some of the major opportunities at India's doorstep are electrical products such as power control panels, rectifiers, etc. stainless steel plated. India has a strong MSME base which is into manufacturing some of the spare parts such as bellows, valves, Ball Bearing, actuator, washers, C-parts etc. which is being consumed in almost all the industries with machinery and are supplied to Global markets as well.

The leading firms in the equipment manufacturing space such as Advanced Materials and LAM Research have presence in India in the form of Technology/Engineering centre while others have presence by way of Marketing offices. Clearly, these firms have started to look at India and leverage the available capabilities. **Therefore with the right capabilities and existing infrastructure for manufacturing of some of the common parts of semiconductor manufacturing equipment, the MSMEs in India are ideally suited to partner with the sub-system suppliers of these Global Equipment Manufacturers. This opportunity will enable the MSME growth in line with the Governments vision of upscaling the MSME industry in India.**

According to the Australian Strategic Policy Institute latest study report, India performs very well in high-specification machining processes and smart materials and is the second ranked country in these technologies in the quality metrics (top 10% of highly cited papers). India's Indian Institute of Technology is the top ranked institution in high-specification machining processes, and National Institute of Technology comes close behind ranking third or fourth. India's strong performance is mirrored in its share of global talent training and working in the field, holding an equal standing to China and the US in this respect. This is shown below in the following Chart 17.

Chart 17: Top 20 institutions in high-specification machining processes by (a) the weighted number of publications (b) H-index and (c) the weighted number of publications within the top 10% of highly cited publications.



Source: Australian Strategic Policy Institute, Policy Brief: Report No. 69/2023 - The global race for future power

The Global Equipment OEMs are also keen to work towards setting up R&D Labs in India with the scope for prototyping, testing, measurements, characterisation, etc. They are keen to work with, and develop the local talent to be able to work in these Labs. However, seek strong policy support from the Government to make this a viable value proposition to set up Labs and service the Domestic and Global market requirement. India has one of the best human resources available for design which can be further leveraged to set up the Semiconductor engineering and equipment designing labs. Through this approach there is scope to create IP in this space as well.

[41] Australian Strategic Policy Institute, Policy Brief: Report No. 69/2023 - The global race for future power

Chapter 5

Opportunities for Dutch firms in India

Abstract:
This Chapter summarizes the potential opportunities for Dutch firms in India in terms of investment opportunities, potential partnership opportunities for R&D and joint development programs and potential partnership opportunities in academia. It sets out the key drivers for each of these opportunities and the broader risks involved in India and its mitigating factors.

5.1 Pull-factors for the Semiconductor sector in India

There are some compelling reasons now for the Netherlands to evaluate and build partnerships with India in the semiconductor sector as shown below in Chart 18:

1. Large Electronics Market

India is a large and one of the fastest growing Electronics markets in the world. Electronics manufacturing has been growing at a very high pace (>17%) over the past few years. This will indirectly be feeding into a large Semiconductors market as explained in Chapter 4 in this report. Secondly, there are very aggressive plans to triple the Electronics manufacturing in the coming years. A growing ESDM nation with aspirations to build a Semiconductors ecosystem would be ideal for a mature Semi Nation such as The Netherlands to build a lasting relationship. This report provides for a roadmap to begin this journey.

2. Young Population

India has one of the youngest populations in an aging world. In 2020, the median age in India was 28, compared to 37 in China and the US, 45 in Western Europe, and 49 in Japan. Since 2018, India's working-age population (people between 15 and 64 years of age) has grown larger than the dependent population — children aged 14 or below as well as people above 65 years of age. This bulge in the working-age population is going to last till 2055, or 37 years from its beginning. India's literacy rate is about 77% - male literacy rate is more than 84% and female literacy rate is around 70%. India is expected to achieve universal primary education in 2050, universal lower secondary education in 2060 and universal upper secondary education in 2085. A study on demographic dividend in India by United Nations Population Fund (UNFPA) throws up two interesting facts:

- The window of demographic dividend opportunity in India is available for five decades from 2005-06 to 2055-56, longer than any other country in the world.
- This demographic dividend window is available at different times in different states because of differential behavior of the population parameters.

In this report, we further elaborate on the plans of Government of India on development of the Semiconductor Workforce for the World, which could be a potential for The Netherlands to look at to meet the growing gap in Semiconductors workforce.

3. Semiconductor Talent

India is also known as the Semiconductor Design Capital of the world with nearly 20%[42] of the worlds Semiconductors Design engineers being in India. The fact that this was achieved without a major focus on the Government of India on Semiconductors proves the inherent strengths / pivot of Indian Engineering education towards Semiconductors. Now, with a major focus driven top down by the Government and a focused effort to educate and train 85,000 Semiconductor Professionals[43] in the next 5 years, India could be a major source of Design Partnerships, R&D collaboration, Educational Partnerships and Training for Netherlands.

4. India's Semiconductor Design capabilities

The semiconductor industry offers a broad spectrum of opportunities for Dutch institutes and firms to collaborate with Indian counterparts in various areas of R&D. The synergy between the Netherlands' expertise in fabrication and equipment and India's strengths in design, innovation, and a skilled workforce can lead to mutually beneficial partnerships and advancements in the semiconductor field. The key advantages which the country provides are highlighted below:

- India's is the **world's largest Semiconductor Design Hub** with nearly 20% of the world Semiconductors Designers based in India. Most Global firms have a base in India for their back end design operations.

[42] https://www.investindia.gov.in/team-india-blogs/indias-emerging-prominence-semiconductor-superpower
[43] https://www.businesstoday.in/technology/news/story/meity-democratising-chip-designing-to-train-over-85000-engineers-in-next-5-yrs-332339-2022-05-04

- India offers a **variety of Semiconductor Design firms with diverse skills / scale / certifications** who can be base for Dutch firms to collaborate with.
- This is further made attractive by the **strong push for incentives by the Government of India and other State Governments** to facilitate Semiconductor Design in India.

5. Engineering & Manufacturing Capabilities

The engineering sector is the largest of the industrial sectors in India. It accounts for 27% of the total factories in the industrial sector and represents 63% of the overall foreign collaborations.[44] India has a competitive advantage in terms of manufacturing costs, market knowledge, technology, and innovation in various engineering sub-sectors. India's engineering sector has witnessed a remarkable growth over the last few years, driven by increased investment in infrastructure and industrial production. The engineering sector, being closely associated with the manufacturing and infrastructure sectors, is of huge strategic importance to India's economy. The engineering industry has been de-licensed and allows 100% foreign direct investment (FDI). Additionally, it has grown to be the biggest contributor to the nation's overall merchandise exports.

India became a permanent member of the Washington Accord (WA) in June 2014. it is now a part of an exclusive group of 17 countries who are permanent signatories of the WA, an elite international agreement on engineering studies and mobility of engineers.

Netherlands main strength in Semiconductor Equipment Manufacturing has the opportunity to expand and derisk their Suppliers base by sourcing from India.

6. Aggressive Government Policies in Semiconductors

The Government of India as recognised the need to create a Semiconductor Manufacturing ecosystem in the country and has come out with very aggressive policies to invite Semiconductor manufacturing and its associate ecosystem firms. Many nations and international firms / institutions have already taken up the initiative and are in advanced stages of forging partnerships with Indian Stakeholders. Netherlands stakeholders also need to evaluate this opportunity closely now.

7. Rising Geopolitical Power

India is one of the fastest growing major economy and is the fifth largest economy in the world. It is said to become the 3rd largest economy by 2030. Recent global occurrences, including the Covid-19 pandemic and the conflict in Ukraine, have highlighted the vulnerabilities inherent in traditional business practices. These events also make a compelling argument for India to emerge as a pivotal alternative in global supply chains. Indian Government is recognised of this fact and is already

[44] https://www.ibef.org/industry/engineering-india

making a case for becoming a key player in the Global Semiconductor Supply Chain and has signed up international agreements with key nations such as USA, Japan and are already in talks with other key nations of Taiwan and Korea.

5.2 Potential areas for collaboration with Indian companies in research and development for Dutch institutes and businesses.

There are several potential opportunity areas for Dutch institutes and firms to partner with Indian counterparts in research and development (R&D) within the semiconductor industry:

1. Semiconductor Design Collaborations: Indian firms have a mature semiconductor design industry. Dutch firms and institutes could collaborate with Indian design companies to jointly develop innovative chip designs, leveraging India's design expertise and the Netherlands' strengths in fabrication and equipment.

2. Innovation Ecosystem Enhancement: Dutch firms / institutes can offer guidance and support to Indian firms in building a strong innovation ecosystem. Joint innovation programs can be established to help Indian firms improve their innovation cycles and develop cutting-edge products.

3. Joint Research Programs: Dutch and Indian institutes can collaborate on joint research initiatives focused on emerging semiconductor technologies, such as photonics and quantum technologies. Research partnerships could explore novel applications and solutions in these fields.

4. Technology Transfer and Licensing: Dutch firms with advanced technologies could explore opportunities to transfer technology or license their innovations to Indian firms. This can accelerate technology adoption in India and foster mutual growth.

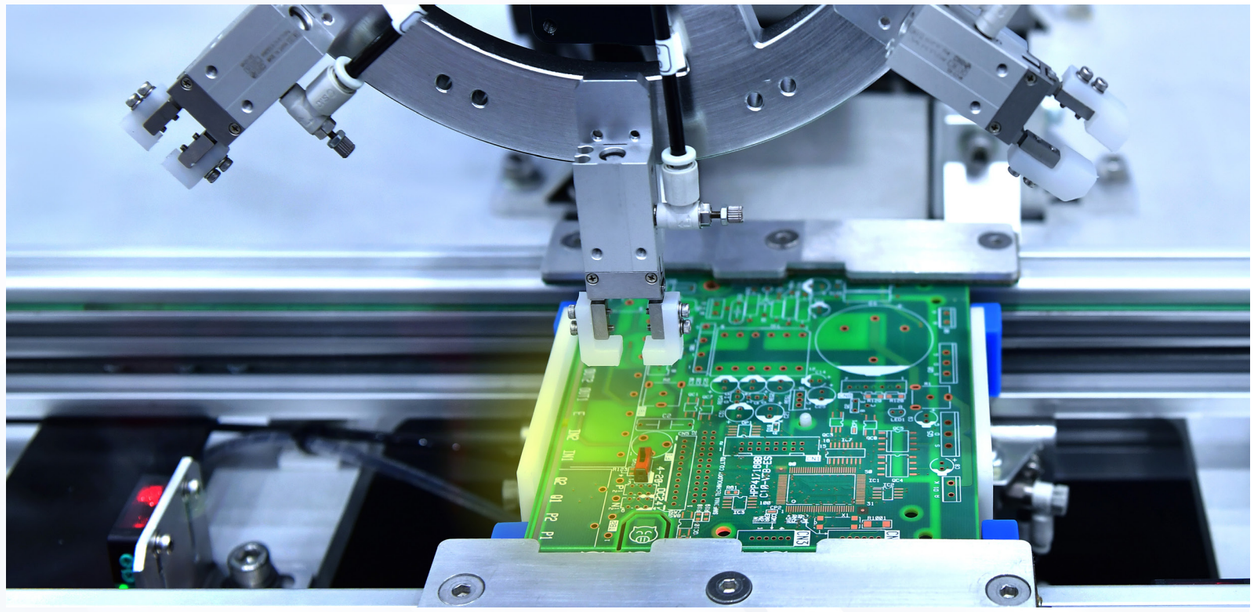
5. Collaborative Start-up Incubation: Institutes and firms from both countries can collaborate to support semiconductor-related start-ups. Incubation programs can provide mentoring, resources, and funding to nurture innovative ideas.

6. Joint Participation in Government Initiatives: Both countries can jointly participate in Indian government initiatives, such as the Design Linked Incentive Programs. Dutch firms and institutes can offer their expertise and resources to assist Indian companies in leveraging these initiatives.

7. Market-Specific Solutions: Collaborations can focus on developing semiconductor solutions tailored to specific market needs, such as automotive, healthcare, and telecom sectors. Indian firms' domain knowledge and Dutch technical expertise can result in valuable market-specific products.

8. Cross-Border Technology Transfer: Dutch firms can partner with Indian companies to facilitate the transfer of semiconductor technologies across borders, enabling both parties to benefit from each other's strengths.

9. Resource Sharing: Collaborative projects can involve sharing resources such as research data, testing facilities, and specialized equipment. This can lead to cost savings and improved efficiency in R&D efforts.



5.3 Potential areas for collaboration with Indian academic institutions

India produces over 1.5 million engineering graduates annually, making it one of the largest sources of engineering talent in the world. India also presents an opportunity having a very good cost effective workforce. India's progress in the Innovation Index CAGR of 20% in Semicon sector especially due to the rising demand for Evs.

India's ambitious aim of training 85,000 Semiconductor professionals over the next 5 years provides for a large market for Dutch academic institutes to participate. This is further made attractive by the strong push for incentives by the Government of India and other State Governments to facilitate Semiconductor education in India. The large interest in setting up a Semiconductor ecosystem in India by various firms provides for a large base of absorbing the Semiconductors professionals and India is also looking at exporting Semiconductor Professionals to the world. There is a huge interest in academia world-wide (discussions in advanced stages with Georgia Tech and Purdue University) to partner with Indian educational institutes and participate in the semiconductor opportunity.

Partnering with Indian academic institutions in the semiconductor field offers numerous opportunity areas for Dutch institutes and firms.

1. ***Joint Research Projects:*** Collaborative research projects between Dutch and Indian academic institutions can focus on emerging semiconductor technologies, materials science, fabrication processes, and innovative device designs.
2. ***Faculty and Student Exchange Programs:*** Establishing exchange programs for faculty and students promotes knowledge sharing and cross-cultural learning. Dutch institutes can offer expertise, while Indian students gain exposure to advanced research facilities.

3. **Ph.D. Programs and Co-supervision:** Co-supervision of Ph.D. students can combine the strengths of both institutions, leading to interdisciplinary research and comprehensive outcomes.
4. **Skill Development Workshops and Training:** Organizing workshops, seminars, and training sessions can enhance the skills of students and researchers in areas like semiconductor design, fabrication, characterization, and packaging.
5. **Technology Transfer and Commercialization:** Collaborations can result in technology transfer from academic research to practical applications. Dutch firms can support Indian institutions in bringing their innovations to market.
6. **Access to Advanced Facilities:** Dutch institutes can provide access to their cutting-edge research infrastructure, clean rooms, and labs, enabling Indian researchers to conduct high-quality experiments.
7. **Joint Publications and Patents:** Collaborative research can lead to joint publications, patents, and intellectual property, contributing to the academic reputation of both institutions.
8. **Talent Development and Training:** Dutch firms / institutes can collaborate with Indian educational institutions to design joint training programs for semiconductor professionals. This can help meet India's ambitious goal of training a large number of semiconductor professionals and create a skilled workforce for both nations.

5.4 Potential areas for Investing in India for Dutch firms

The opportunities for Dutch firms to invest in India could be summarised as given below:

1. Investment in Semicon Equipment Parts – Green field Unit in India
2. Investment in Semicon Design Firms – Acquisitions
3. Investment in OSATs / ATMPs & Fabs

1. Investment in Semicon Equipment Parts – Green field Unit in India

Opportunity for India to be part of Global Semicon Equipment Parts Supplier base is very high given the twin factors of :

- India's strong presence in Engineering Manufacturing / Auto Components Ecosystem providing the Dutch firms with local cost quality manufacturing and workforce advantages
- Netherlands strong presence in Equipment Manufacturing Ecosystem and having a Global Supply Chain Base

Dutch firms could look at the following options in investing in India:

- **Encourage their Tier 1 / 2 Component suppliers to set up a Green field Unit** in India and derisk their global supply chains
- **Develop and Source Components / Spares** from Existing Indian firms

A detailed list of spares which could be localised in India.

2. Investment in Semicon Design Firms – Acquisitions

India is a Semiconductor Design Capital of the world and firms in India contribute at a very high end spectrum of Design needs of the Semiconductor Industry.

Dutch firms have the opportunity to invest / acquire niche and strategic Indian Design firms in India. Brief profiles of key Indian design firms.

Given the unsuccessful joint venture (JV) between Adani Group and Vedanta, where Vedanta has now partnered with Foxconn for a 13.6 billion JV, Adani Group is actively exploring new collaborations in the semiconductor industry. With its strong infrastructure and funding capabilities, Adani Group presents an enticing opportunity for Dutch companies to establish a JV.

This also gives an opportunity for Dutch Semicon companies to explore brownfield expansion to India. Potential partners could be – Reliance Industries, Tata Electronics, STL, HCL Tech, Wipro (Private) and BEL, ISRO (Public), Keltron (State Government PSU).

3. Investment in OSATs / ATMPs

Semiconductor Firms in Netherlands, strong in many areas of the Semiconductors specifically in **Photonics, Sensors, Micro controllers and MEMS** could look at investing in India as an alternate destination to derisk their manufacturing activities. These products could be made in India and exported to global markets.

The key advantages which the country provides are highlighted below:

- India has proven its credentials as a **strong contender for firms to diversify their Supply Chain activities,** in the current geopolitically sensitive environment. This is already demonstrated by the Mobile / Wearables Manufacturing business which is now in the process of creating a Mobile / Wearables GVC in India.
- This is further made attractive by the **strong push for incentives by the Government of India and other State Governments** to attract Semiconductor manufacturing in India. Micron has shown its commitment by starting on its large ATMP facility in India and many more are in pipeline.
- The talent available in India and a **large pool of highly skilled workforce** at a very reasonable cost would be an added advantage.
- Many **manufacturing disabilities are now taken care by many Governmental initiatives** such as creation of Electronic Manufacturing Clusters, heavy infrastructure investments, ease of doing business and lower taxes.

5.5 Opportunity qualifiers – key risks and its mitigation

The key risks and mitigating factors concerning India would be:

Change of political leadership in India in 2024 elections.
Politics are always uncertain, and could pose a risk for the semiconductor industry. The current political situation, the political commentary in the Country aided by the reforms / positive governance in the last 10 years, indicate that this is not a major concern in India.

India's economic growth taking a major hit.
Even during the major catastrophic events period, such as Covid-19 and the Ukraine war, India is seen as the fastest growing large economy, which has stable growth aspects. The growth prospects in India are significantly of low-risk, supported by a variety of factors, and do not pose a major threat.

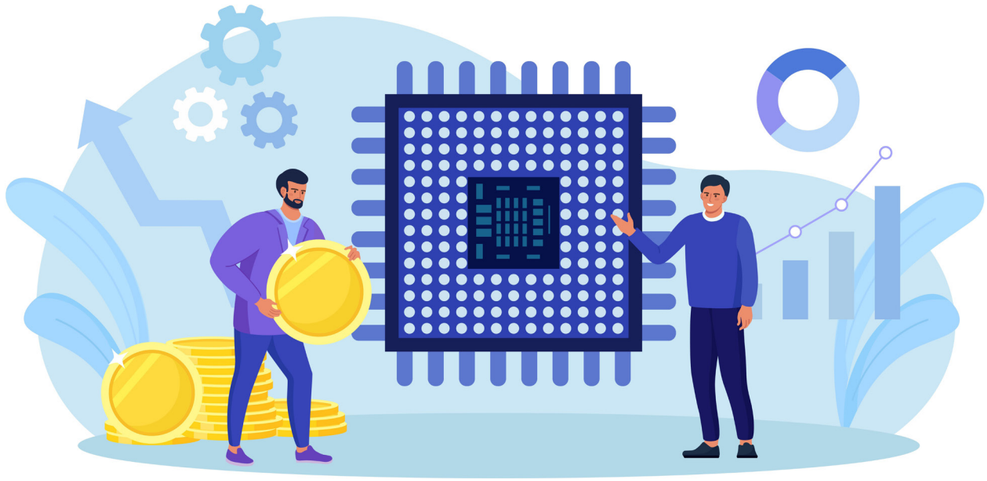
Bureaucratic hurdles impacting new projects and investments in India
The past few years have shown that the Government machinery (both at the Center and in several states) has seen a major transformation in terms of attracting new businesses and investments.

Regulatory Alignment
This can be mitigated by having a collaboration on regulatory standards and certifications to streamline the process for Dutch semiconductor companies to enter the Indian market with Indian Regulatory Authorities such as the Bureau of Indian Standards (BIS).

Chapter 6

Recommendations

IESA recommends the following strategic actions



A. First step: Strategic Partnership between the Governments of India and The Kingdom of Netherlands.

Prime Minister Modi of India and Prime Minister Rutte of the Netherlands agreed to form a strategic partnership in 2023. This would be an overarching framework for collaborating on a myriad of topics. This could be important to deepen the existing relationship and strengthen ties on topics such as semiconductors. To set up the strategic partnership in the field of semiconductors, similar agreements signed by India with nations such as USA (ICET agreement) and Japan. The agreement should cover a wide range of subjects, such as governance of the strategic partnership trade relations and investment frameworks, research and innovation collaboration & talent development and technology transfer.

1. Facilitating Technology transfer agreements between companies
2. Invest in semiconductor R&D and Science under bilateral knowledge and innovation agenda
3. Opening up the key strategic areas of Space for Dutch Semicon Companies.

B. Stepping up trade activities between the two nations

1. In the roundtables we organized we understood there is a lack of knowledge of Dutch businesses and other stakeholders about the Indian semiconductor field.
    - Therefore it is necessary to set up inbound and outbound missions to India.
        - » Innovation missions to bring in scientists and innovators.
        - » Arrange and facilitate Government delegation visit to NL and IND.
        - » Trade mission to IND with leading players like ASML
2. It is advisable to have a formal association / MOU between key trade bodies such as Semiconductors, Holland Hightech and IESA.
3. There are opportunities for Dutch firms / Institutions to have formal agreements with several State Governments in India.
4. There is a specific need to encourage
    - Tier 1 and Tier 2 Component firms of the Equipment Supply Chain to evaluate investments in India
    - Investigate setting up logistics and distribution facilities by leveraging the geographical advantage of India,
    - Explore collaborations in the Indian Chemical industry ecosystem and forming Joint Ventures for a robust supply chain management
5. Mapping database of hardware startups and exploration of joint opportunities together

C. Talent Development and Research & Development initiatives

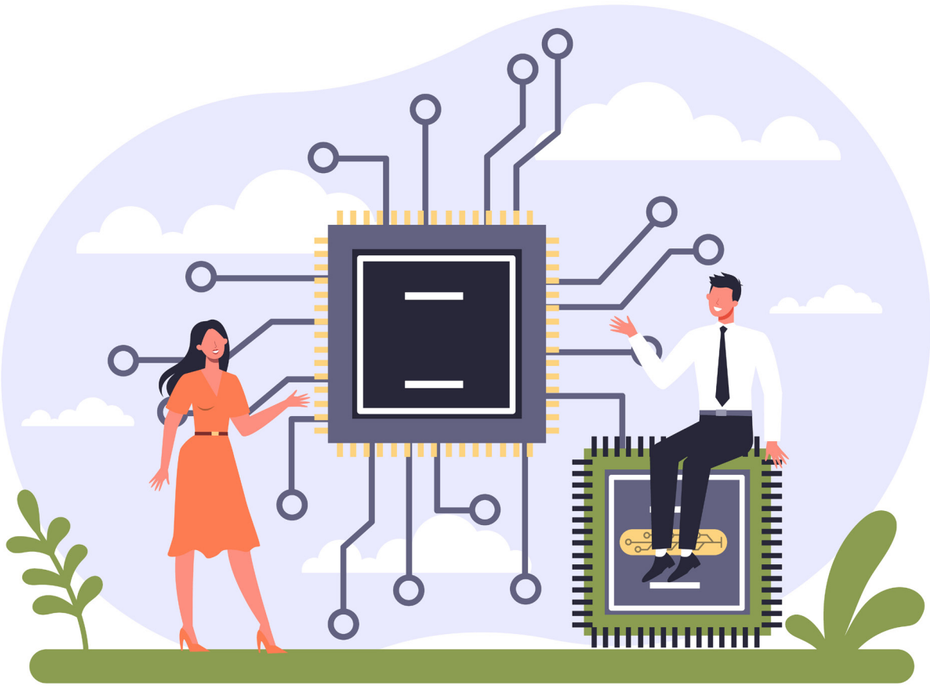
Talent Development initiatives are the low hanging fruit for a meaningful co-operation between India and the Netherlands. Various academic institutions we spoke to in Netherlands would like to have a structured working relationship with Indian Institutions and encourage critical PHD programmes and joint R&D and training programmes.

- The indian government invites Dutch insitutes to be part of Semiconductor Research Center, as there are already talks with other International institutes such as The Purdue University and MIT.
- It is advisable to set up a longterm research&development program on semiconductors under the existing knowledge and innovation agenda WAH!. NXP India and MEITY have made their desire to collaborate on such a program explicit and this could build ties between the Dutch and INdian research community for years to come.

India could be a source of Skilled Manpower for the Netherlands Semicon Industry. Plans are in the implementation phase to train and educate 85,000 Semicon Professionals over the next 5 years in India. Involvement of Dutch institutions in this initiative could assist in tailoring the skilled workforce to meet specific needs. This involves training to cultivate a vast pool of technicians and support personnel, in addition to engineers and specialists, tailored to meet specific requirements.:

1. Process management and floor experience
2. Joint certification courses in semiconductor research and design
3. Academic Collaborations and Exchange programmes on mutually beneficial levels of academic courses
4. Assist in curating joint curriculum with the industry

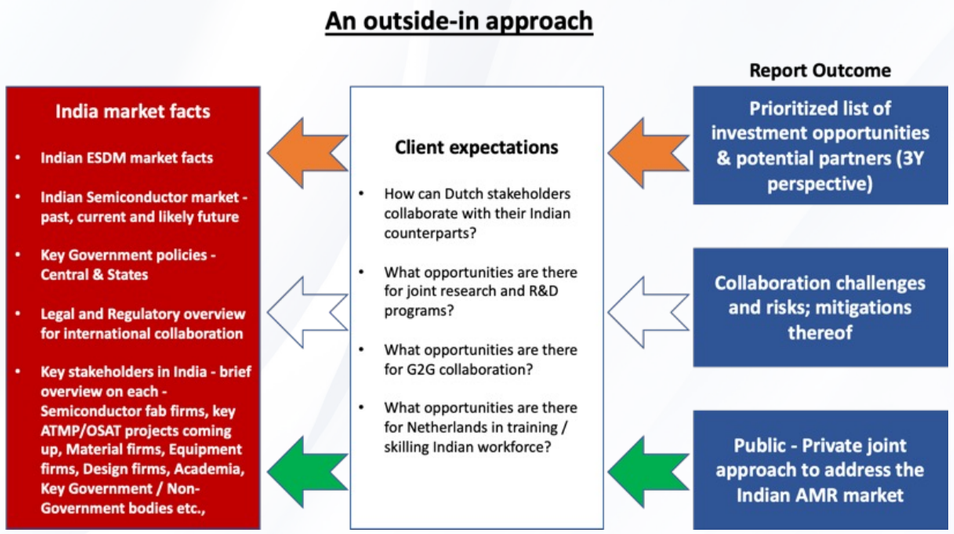
- I-to-I relationships / MOUs needs to be formed. IESA & the Embassy of the Kingdom of Netherlands could help in this endeavour.
- It is advisable to work closely together with semiconductor companies (such as NXP India) and government bodies to set up programs on talent development and research.
  - » Like the program that was set up between Philips and the Dutch State in the past to accomodate 75 PhD-Candidates from India in the Netherlands.
  - » Funding of R&D projects and laboratories by existing companies of the Netherlands in India
  - » Leverage alumni connects and CSR to create research facilities in future materials and green processes
- Through PhD funding initiated by both governments at institute level mobilize student exchange, knowledge sharing, deepen research bonding
- Some of the identified topics of research in the roundtables are the following: e.g. applications of semiconductor technology in the automotive sector, ultra-low-power... etc



Netherlands	India
Hugo Westerveld, Analog ASIC Design Service	Jitendra Cheddah, Global Foundries
Tom van der Dussen, Holland Hightech	Hitesh Garg, NXP
Francesco Pagliano, NanoPhab BV	Sanjay Gupta, Spark Minda
Paul van Ulsen, Salland Engineering BV	Rangesh Raghavan, Lam Research
Rogier Verberk, TNO semicon equipment	Vivek Tyagi, RP Tech
Sathish kumar Ganesan, Cyient	K Krishnamoorthy, President IESA
Roy Paulissen, RVO/NL	Col. Anurag Awasthi, Vice President, IESA
Dhoya Snijders / Vikas Kohli, Embassy of Netherlands	A M Devendranath, CEO, Feedback Advisory

Annexures

A-1 Research methodology and approach
The above TOR was delivered using the framework shown below in Chart A1:



To meet the above mentioned objectives, and apropos the approach set out above, the research methodology included having three virtual roundtables as set out below:

1. Round Table 1 – Industry discussions
2. Round Table 2 – Academia discussions
3. Round Table 3 – Government discussions

The round tables were conducted virtually and was organized by the Dept. of Innovation at the Embassy of the Netherlands in India. The Dutch speakers were invited by the organisers and the Indian speakers by India Electronics and Semiconductor Association - IESA.

This was proposed as a "closed network of speakers" who were invited to participate in this Round Table and it was not an "Open-to-all" Webinar.

The details of the RT and the list of participants from these three Round Tables are given below:

Key Questions for Speakers from Netherlands for RT 1 and RT 2
1. A brief introduction about your firm / organisation
2. What role does your firm provide for in the Semiconductor value-chain?
3. Does your firm have any business connects in India? Kindly explain your presence in India.
4. How can Netherlands Semi industry and your firm contribute for a mutual beneficial Semi ecosystem development in India?
   - Collaboration opportunities in the areas of Research & Development, Design, Engineering, Product development and Sourcing (if any).
5. What are your key expectations from the Indian market / stakeholders from India?

Key Questions for Speakers from India for RT 1 and RT 2
1. A brief background about your firm / organisation
2. What role does your firm provide for in the Semiconductor value-chain?
3. Does your firm have any business connects in Netherlands? Kindly explain your presence in Netherlands.
4. Which are the promising Market segments and areas where Indian market strengths could be leveraged?
   - Collaboration opportunities in the areas of Research & Development, Design, Engineering, Product development and Sourcing (if any).
5. What are your key expectations from the Netherlands Semi Industry / stakeholders from Netherlands?

Key Questions for Speakers from Netherlands & India for RT 3

1. How do you view India as a Semiconductor nation?
2. What potential areas do you consider are ideal to partner with India for NL firms?

- Collaboration opportunities in the areas of:
- Research & Development,
- Design, Engineering,
- Product development
- Manufacturing
- Sourcing (if any)

3. What are your key expectations? (from Indian government, policy, other stakeholders, partnerships?)
4. Does the Government of NL view India as a possibe partner in Semiconductors?

The List of Participants in the First Round Table were:

Netherlands	India
Hugo Westerveld, Analog ASIC Design Service	Jitendra Cheddah, Global Foundries
Tom van der Dussen, Holland Hightech	Hitesh Garg, NXP
Francesco Pagliano, NanoPhab BV	Sanjay Gupta, Spark Minda
Paul van Ulsen, Salland Engineering BV	Rangesh Raghavan, Lam Research
Rogier Verberk, TNO semicon equipment	Vivek Tyagi, RP Tech
Sathish kumar Ganesan, Cyient	K Krishnamoorthy, President IESA
Mr. Roy Paulissen, RVO/NL	Col. Anurag Awasthi, Vice President, IESA
Mr. Dhoya Snijders / Mr. Vikas Kohli, Department of Innovation, Embassy of Netherlands	A M Devendranath, CEO, Feedback Advisory

The List of Participants in the Second Round Table were:

Netherlands	India
Prof. Erwin Kessels, TuE Eindhoven	Dr.Ramesh Unnikrishnan, Advisor, AICTE
Prof Paddy French – TU Delft	Prof Udayan Ganguly, IIT Bombay
	Prof Siva Vanjari, IIT Hyderabad
Prof Harijot Singh Bindra - Universiteit Twente	Prof Srikanth Mutnuri, Dean BITS Pilani
Prof Marcelo Ackerman – Universiteit Twente	K Krishnamoorthy, President IESA
Mr. Dhoya Snijders / Mr. Vikas Kohli, Department of Innovation, Embassy of Netherlands	Col. Anurag Awasthi, Vice President, IESA
	A M Devendranath, CEO, Feedback Advisory

A.2 Key stakeholders of relevance for the Dutch firms / entities

The key stakeholders of relevance for Dutch firms/entities seeking partnerships and collaborations in India's semiconductor industry include:

1. **Embassy of the Netherlands in India:** The embassy plays a pivotal role in fostering international relationships and facilitating collaborations between Dutch firms/entities and Indian stakeholders.

2. **Holland Hightech (Industry Association):** As the industry association, HollandSemicon is instrumental in representing the interests of the Dutch semiconductor sector and facilitating connections with Indian counterparts.

3. **NXP (Major Dutch Firm with Indian Presence):** NXP already has a significant presence in India, including engineering/R&D bases and sales offices. They can serve as potential partners for collaboration and engagement between Dutch and Indian firms.

4. **Private Companies (NXP, ASML, Global Foundries, etc.):** Dutch firms with R&D expertise and resources can partner with Indian semiconductor companies seeking advanced technological collaborations, joint research, and innovation projects.

5. **Indian Electronics and Semiconductor Association (IESA):** As the Indian semiconductor industry association, IESA can play a significant role in connecting Dutch firms/entities with relevant stakeholders in India and promoting collaboration.

6. **GOI – India Semiconductor Mission:** The Indian government's policies and initiatives to boost the semiconductor industry, such as the plan to train a large number of semiconductor professionals, provide a supportive environment for Dutch firms/entities seeking to collaborate in India. India Semiconductor Mission (https://www.ism.gov.in/), part of Ministry of Electronics and Information Technology could be a starting point as well.

7. **Academic Institutions (Indian and Dutch Universities):** Institutes like TU/e, TUDelft, Indian Institutes of Technology (IITs), and other technical universities in both countries can directly collaborate on joint research projects, faculty exchanges, and skill development initiatives.

8. **Electronics Sector Skill Council of India (ESSCI):** Responsible for undertaking Skill Development activities in Semiconductors from a Vocational Courses perspective. They have over 23 approved (By NSDC) Qualifications in the Semiconductor Design & Packaging domains.

9. **Research and Innovation Centers (IMEC, TNO, CITC, etc.):** Dutch research and innovation centers can engage with Indian counterparts, such as research institutes, technology centers, and innovation hubs, for collaborative semiconductor R&D projects.

10. **Technology Parks and Incubators:** Both countries have technology parks and incubators that can provide infrastructure, resources, and support for collaborative R&D projects between Dutch and Indian entities.

11. **Venture Capital and Funding Organizations:** Investment firms with a focus on technology and innovation can facilitate funding for joint R&D projects between Dutch and Indian entities.

12. **Innovation Networks and Clusters:** Participating in innovation networks, clusters, and forums related to semiconductor R&D can help Dutch firms connect with potential Indian partners.

13. **Professional Networks and Conferences:** Attending industry conferences, workshops, and seminars can provide opportunities for Dutch firms to network with potential Indian collaborators and showcase their R&D capabilities.

14. **Technology Transfer Offices (TTOs):** Universities and research centers often have TTOs that facilitate technology transfer and partnerships between academia and industry.

15. **Start-up Ecosystem:** Engaging with start-ups can lead to innovative collaborations and technology transfer between Dutch and Indian firms.

By engaging with these key stakeholders, Dutch institutes and firms can identify, establish, and foster productive R&D partnerships with Indian firms in the semiconductor industry, contributing to technological advancements and mutual growth.

A.3 A brief profile of the top Design firms in India

TESSOLVE
A HERO ELECTRONIX VENTURE

Tessolve Semiconductor Private Limited (A Hero Electronix Venture) (https://www.tessolve.com/)

- Location: Bengaluru, Chennai, Hyderabad and major Indian cities
- Founded: 2005
- Employee strength: 3000
- Company founders has held senior positions in companies like Cirrus Logic and Centillium, Tata Elxsi Communications, HCL, Wipro, GE, Texas Instruments.
- Areas of Service offerings:

Chip design

- Analog & Mixed Signal Design
- RTL Design
- Design Verification
- Design for Test
- Physical Design
- FPGA Emulation
- Foundry Porting Services
- Test Engineering
- Product Engineering

- Company counts Global Foundries, Techworks, Teradyne, NI, Silicon Catalyst, Ismosys, Advantest, Siemens, Synopsys, Cadence as engineering solutions provider and NXP Semiconductors, Qualcomm, DynamoEdge, Mediatek, Renesas, SGeT, STMicroelectronics, Infineon, Texas Instruments and AWS as embedded solution partners.

Tech Mahindra Cerium Private Limited (https://www.cerium-systems.com/)

- Location: Bengaluru, Kochi, Vishakhapatnam, Ahmedabad
- Founded: 2013
- Employee strength: 2000
- Areas of Service offerings:
  - » ASIC Design and Verification
  - » Physical Design (PD)
  - » Analog Design
  - » FPGA
  - » Embedded Software
- One of India's fastest growing technology companies, Mahindra Cerium Systems is a global design services company for the VLSI and Embedded Software sector. Company delivers cutting edge solutions across a diverse portfolio of services including ASIC Design, Verification, Physical Design, DFT, Circuit Design & Layout FPGA and Emulation.
- Company focuses on end-to-end customised turnkey solutions of the highest quality with the shortest development cycle to the global semiconductor industry.

Mirafra SW Technologies Pvt. Ltd (https://mirafra.com/)

- Location: HQ at Bangalore and design or business centres at Houston, Austin, San Jose, San Diego, New Jersey, Sweden and Singapore
- Founded: 2004
- Employee strength: 1200
- Company founders have held senior positions in companies like Synopsys, Nokia, ITC Infotech
- Areas of Service offerings:
  - » Semiconductor design and embedded software development including applications
  - » End to end product engineering and SW services
  - » Chip / SoC design to new edge enterprise application development with cutting edge AI/ML features, including firmware and embedded software
  - » ASIC/SoC design and software development end to end
- Count leading Fortune 500 companies as their client. Many of the Mirafra's clients are engaged as strategic partners for long term business association. Works with 11 out of top 20 semiconductor companies, several leaders in data communication, Telecommunication, Networking and Automotive domain.

MosChip Technologies Limited (https://moschip.com/)

- Location: Hyderbad, Bengaluru, Ahmedabad, Pune
- Founded: 1999
- Employee strength: 1200
- Company founders have held senior positions in companies like Gigacom, Cyient, Invecas, NVIDIA
- Areas of Service offerings:
  - » Analog, digital and mixed-signal ASIC and IP design services
  - » Electronic Design Services for Networking, High Speed and High Capacity Storage, Computing, Semiconductor, Defence, Aerospace, Industrial, and Wireless domains
  - » Developing embedded platform solutions for Analog, Digital, Mixed Signal, and Power Electronics domains
  - » Experience in developing M2M and IoT and has delivered end-to-end solutions
- Only publicly traded semiconductor and system design services company
- MosChip has been building its own digital IP and analog IP over the years. MosChip has expertise in Serdes designs and its 6G and 10G Serdes designs are production ready.
- With an overall unparalleled tape out expertise on more than 200 multi-million gate ASICs with stringent power and speed requirements, taping out designs in all leading foundries in process nodes all the way from 500nm to 7nm, and with time tested and proven methodologies/flows using leading EDA tools, MosChip has emerged a leading semiconductor design services house providing expert Spec to GDSII services for customers globally.

InSemi Technology Services Pvt Ltd (https://insemitech.com/)

- Location: Bengaluru
- Founded: 2013
- Employee strength: 1000
- Company founders has held senior positions in companies like Infineon, TI, Magma Design, and Intel, AMD India, Interra Systems, TSMC USA, Virage Logic USA.
- Areas of Service offerings:
- End-to-end semiconductor design services including:
  - » RTL & ASIC Design,
  - » Physical Design,
  - » STA,
  - » Verification,
  - » DFT,
  - » Circuit Design & Layout,
  - » FPGA,
  - » Foundation IP design,
  - » PSV and Emulation
- InSemi has been growing expeditiously and with a team of 1000+ technology specialists.

SoCtronics Technologies Pvt. Ltd
(https://www.linkedin.com/company/soctronics/?originalSubdomain=in)

- Location: Hyderabad
- Founded: 2000
- Employee strength: 800
- Areas of Service offerings:
  - » VLSI design and embedded software services
  - » Complete spec-to-silicon turnkey solutions that include embedded systems and software/firmware co-development
  - » SoC/Subsystem Integration
  - » SoC or Subsystem Verification

  - » DFT Services
  - » FPGA Prototyping
- SoCtronics is not an average engineering services outsourcing company. SoCtronics engineers routinely work on the most advanced CPU designs as well as the industry's leading edge multimedia technologies and applications using advanced process technology nodes such as 28nm process technology from TSMC.

SmartSoC Solutions Private Limited (https://www.smartsocs.com/)

- Location: Bengaluru
- Founded: 2016
- Employee strength: 750
- Company founders has held senior positions in companies like Qualcomm, Infineon Technologies, HARMAN International, Cerium Systems, SiCon Design Technologies
- Areas of Service offerings:
  - » Silicon Engineering
  - » Micro-architecture Planning
  - » RTL Implementation
  - » Design Verification
  - » DFT
  - » Physical Design
  - » Analog Layout
  - » Analog Design
  - » ATMP Services
  - » Product Engineering
- Backed by a $270 million angle invester
- 100+ Marquee clients – AMD, Analog Devices, Canon, Broadcom, Cadence, Infinera, Microchip, Micron, NXP, Rambus, Saankhya Labs, Sasmsung, SiFive, SiTime, Synopsys, Infineon, Western Digital, Xilinx, Zebra, Google

Adept Chip Services Pvt. Ltd. (A Quest Global Company) (https://www.adeptchips.com/)

- Location: Bengaluru, Hyderabad, Vizag
- Founded: 2011
- Employee strength: 500
- Areas of Service offerings:
  - » RTL Design,
  - » FPGA/Silicon Implementation
  - » Foundry quality signoff
  - » Design for Test,
  - » Verification,
  - » Physical Implementation,
  - » Hardware Emulation
  - » Signoff
- Adept is a full service IC design firm that specializes in team augmentation, turnkey solutions for end-to-end chip design, and product lifecycle management. A flexible and reliable partner with more than 480 talented engineers, Adept brings a wealth of technical capabilities scalable to multinational corporations. As of September 2022, Adept is now part of the Quest Global family.

Ignitarium Technology Solutions Private Limited (https://ignitarium.com/)

- Location: Bengaluru, Kochi
- Founded: 2012
- Employee strength: 400
- Areas of Service offerings:
  - » Architecture consulting,
  - » Digital design and verification,
  - » FPGA design and emulation
  - » AMS Verification,
  - » DFT,
  - » Physical design
- Ignitarium specializes in Semiconductor design, Multimedia & Imaging, Connectivity, Cloud & Enterprise, Machine Learning & Deep Neural Networks. As an ISO 9001:2015 certified company, meet all standards for quality assurance and process compliance.
- NVIDIA® Jetson™ Ecosystem Partner and an early NVIDIA Inception program member. Ignitarium delivers highly optimized software solutions for engineers using Texas Instruments processors in robotics and other industrial systems.

SeviTech Systems Pvt Ltd (acquired by UST Global) (https://sevitechsystems.com/)

- Location: Bengaluru, Hyderabad
- Founded: 2013
- Employee strength: 350
- Areas of Service offerings:
  - » VLSI Design Services company
  - » design services expertise to Semiconductor Companies in VLSI RTL to GDS digital & analog flow, Post Silicon Validation, Systems & Board Design
  - » ASIC design covering entire Frontend, Backend and Mixed Signal Design aspects for both Semi custom and full custom designs
  - » VLSI Hardware solutions and services to a wide range of industry segments like Wireless, Networking, Enterprise, IoT, Telecom, Storage and other niche areas like AI / ML specific next generation products at sub-nanometer technologies
- UST - Sevitech provides extensive services for foundry collaterals. With expertise in developing foundation IPs like Standard Cells, Memories, IOs, PDKs, Library development etc. for all major EDA tools supplier on a wide range of nm and process technologies. Sevitech have partnership with leading foundries to target their new and old technologies based on the customer requirements.
- Business models offered are ODC, TurnKey, Fixed-price, KPI, Cluster, T&M

Digicomm Semiconductor Private Limited (https://www.digicommsemi.com/)

- Location: Bengaluru, Hyderabad, Noida, Hyderabad
- Founded: 2012
- Employee strength: 300
- Areas of Service offerings:
  - » professional, technical services to fasten SOC development life cycles.
  - » VLSI services and solutions covering the entire front end and back end of ASIC
  - » SoC, ASIC Full-chip, Sub-system and IP level Verification
  - » IP delivery – complete ownership and delivery of IP starting from Transistor level to Bump and ESD planning.

Experienced in leading and implementing complex algorithmic designs, including the design of chips up to 16FF technology with more than 12 million instances and upto 512Mb of embedded memory. Skilled in designing for timely closure, optimizing for speeds up to 1.2 GHz.

A.4 Case study of Select Indian firms in Equipment Spares / systems and Services:

SankhyaSutra Labs (https://sankhyasutralabs.com/

Incubated in 2015 in Bangalore, Sankhya Labs has quickly grown into a team of simulation and domain experts. In 2019, Reliance Industries Limited acquired a majority stake in SankhyaSutra Labs. Today, their team is working collaboratively with customers across the globe. Applications of their products span various industries including but not limited to Automotive, Aerospace & Defense, Chemical & Petrochemical, Semiconductor industries.

SankhyaSutra Labs provides highly reliable simulation results without needing unreasonably large computing power. They use the highly efficient Lattice Boltzmann Method, whose performance is enhanced through code optimisation and a custom-built cluster (6th largest in India).

Their flagship offering is fluid dynamics simulation. They provide packages for solving multi-physics models, where fluid simulations are coupled with aeroacoustics, chemical reaction, particle motion, and thermal solvers. For rarefied flows, we have developed a solver based on Direct Simulation Monte Carlo (DSMC) method. Apart from traditional licensing options, their products are available as a cloud-hosted solution in Software-as-a-Service (SaaS) mode to lower the entry barrier.

Fabrication labs and OEMs have been utilizing multi-physics modelling and simulation tools for years. Semiconductor industry operates with small margins for error. SankhyaSutra's LBM based solver provides accurate Multi-physics simulation results, even at very small characteristic lengths, which are often encountered in semiconductor industry. Their powerful Direct Simulation Monte Carlo (DSMC) solver can handle near-vacuum operating conditions efficiently.

Some applications of SankhyaSutra's technology in semiconductor Industry are:

- Temperature controller assembly
- Chemical Vapor Deposition
- Air flow in Clean room
- Rarefied gas flows

Atonarp Micro-Systems India Pvt. Ltd. (https://www.atonarp.com/)

Founded in 2009, the Atonarp team collaborates across locations in Japan, India, and the United States. The Company is led by a world-class team of experts in the development and commercialization of analytical instruments and medical devices.

For Semiconductors Industry, Atonarp provides fast, high sensitivity mass spectrometers for in-situ Metrology. Advancing semiconductor in situ metrology through digital molecular profiling. They have two The ASTON platform includes a portfolio of fast, high-sensitivity mass spectrometers with proprietary software that enable quantitative, rapid gas analysis required in complex in-situ semiconductor manufacturing processes. The ASTON platform delivers real-time, chemically specific actionable insights to maximize throughput and yield. One tool can replace multiple legacy tools.

Ultra-Compact Mass Spectrometers

ASTON Impact and ASTON Plasma combine high-sensitivity measurements with high-speed sampling to measure process gases and by-products to optimize processes, throughput and yield.

- Optimize advanced processes such as atomic layer deposition and etch with real-time control.
- Monitor sub-fab dry vacuum pumps, combustion abatement systems and bulk gas delivery and management to ensure safety, drive sustainability, and maximize savings.

ASM Technologies Limited (https://www.asmltd.com/)

Established in 1992, ASM Technologies Limited is a publicly listed company in India, with global presence in USA, Singapore, UK, Canada, Mexico and Japan. With over two decades of experience, ASM has been providing world class consulting and product development services in the areas of Engineering Services and Product R&D with successful Offshore Development & Support Centers in India and Overseas for its global clientele.

ASM specializes in the Design and Value Engineering, Complex Prototyping, Competitive Manufacturing in the capital process equipment for Semiconductor, Solar and Display verticals. Their key offerings are described below:

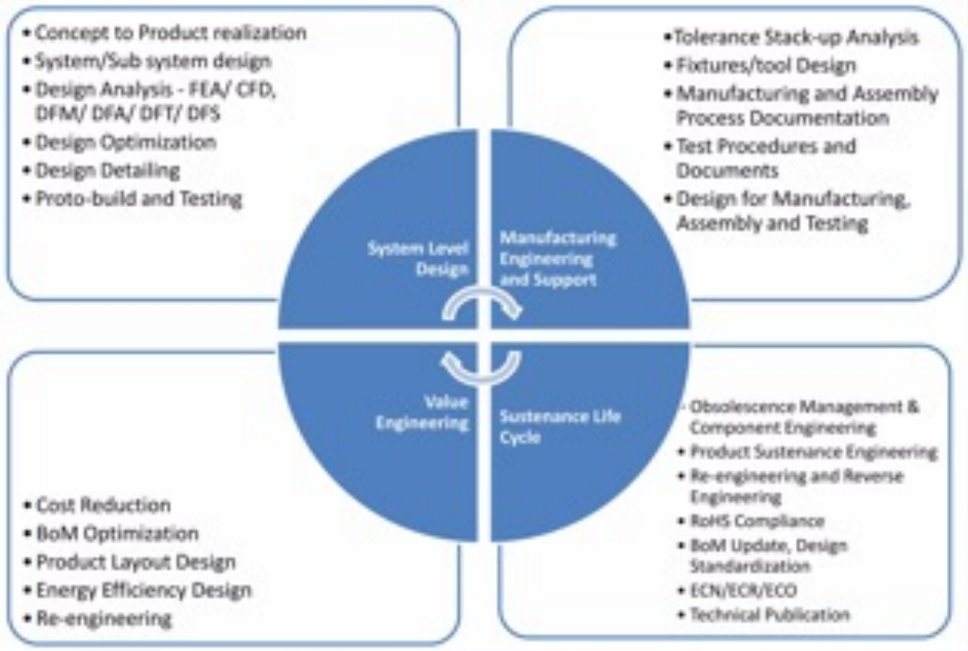
Center of Excellence in Semiconductor, Display & Solar

- Product and Value Engineering
- Electronic Hardware Design & Development
- Re Engineering, Reverse Engineering
- Automation
- Test Fixtures / Rigs / Automated Test Equipment
- IoT, VR / AR and edX
- Prototyping, Testing and Manufacturing
- Equipment / Tool Remanufacturing

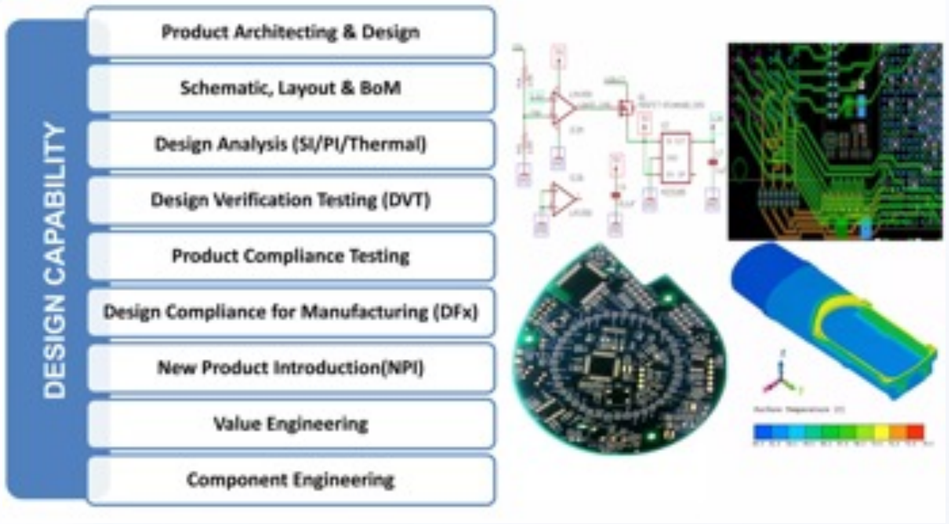
ASM Capability - Wafer Processing Tools, Precision Equipment:

- Design & Development of:
  - » Transfer Chambers / main frame design and vacuum chambers - Ultra High Vacuum, High Temperature environment
  - » Bakeout / Oven / Heated Chamber Design - Stand alone / in line
  - » Stand alone / Cluster tools for deposition / thin film coating, Glove Box Design and Substrate Polishers
  - » Precision Mechansims - Wafer Transfer Units, Foup Transfer Units, Micron level motion systems design, Components transfer mechanisms and related sub systems
  - » Liquid delivery units like slurry dispensing systems for CMP, Controlled chemical delivery units, Gas Panel Units and related items

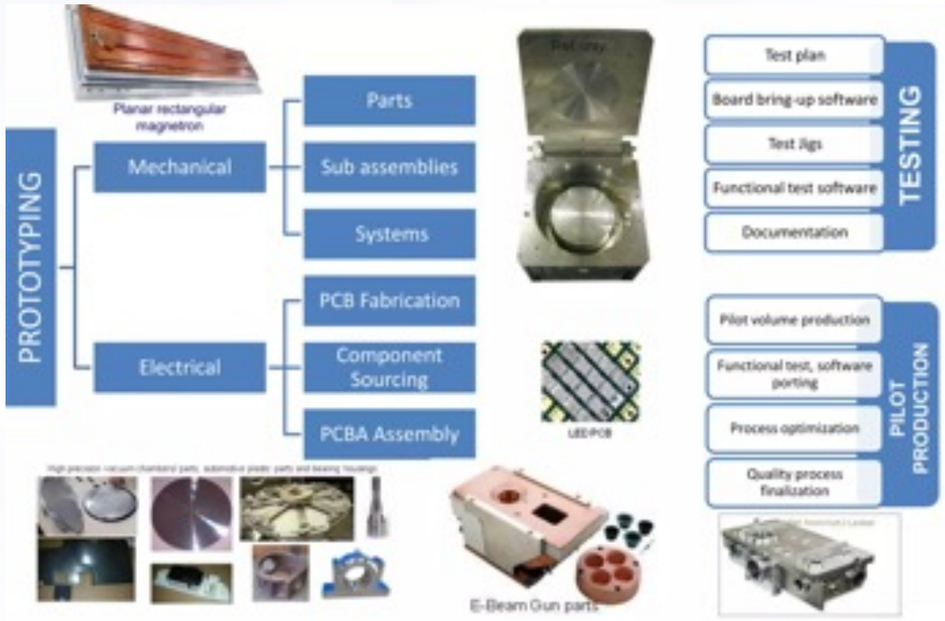
- System Design House



- Electronics Design Capability



- Prototyping, Testing and Manufacturing



A.5 Details on the Courses offered by Electronics Sector Skill Council of India.

Electronics Sector Skills Council of India (ESSCI) an apex body for Skilling in Electronics is a Not-for-Profit Organization, registered under the Indian Companies Act, 1956. The Council has been promoted by six Associations i.e., CEAMA, ELCINA, IESA (formerly ISA), IPCA, MAIT and ELCOMA. They have a dedicated Sub-Sector named as "Semiconductor & Components", where we have conducted various Market Research/ Skill Gap Studies which gives a comprehensive overview of the Semiconductor Sector.

They have developed 23 NSQF Aligned Qualifications in the Semiconductor Design & Packaging domains.

S.No.	Name of Qualification/ Standalone NOS	Qualification Code	Industry Classification/ Occupation	NSQF level	Notional Hours				
					Theory	Practical	OJT	ES	Total
1	Sr. Executive-Business Development	ELE/Q1101	After sales Service	5	210	300	210	0	720
2	Advanced Program on Nano Science & Technology	ELE/N6106	Design & Manufacturing	6.5	18	72	0	0	90
3	Foundation Program on Nano Science & Technology	ELE/N6105	Design & Manufacturing	6	60	0	0	0	60

S.No.	Name of Qualification/ Standalone NOS	Qualification Code	Industry Classification/ Occupation	NSQF level	Notional Hours				
					Theory	Practical	OJT	ES	Total
4	Laser Marking & Cutting Process Engineer	ELE/Q0118	Manufacturing/Process	5	220	300	200	0	720
5	Molding Process Engineer	ELE/Q0119	Manufacturing/Process	5	220	300	200	0	720
6	Saw Singulation - Process Engineer	ELE/Q0128	Manufacturing/Process	5	210	300	210	0	720
7	Solder Ball Attach - Process Engineer	ELE/Q0127	Manufacturing/Process	5	210	300	210	0	720
8	Wafer Back Grinding Engineer	ELE/Q0125	Manufacturing/Process	5	210	300	210	0	720
9	Wafer Dicing Engineer	ELE/Q0126	Manufacturing/Process	5	210	300	210	0	720
10	Wafer Test and Sort Engineer	ELE/Q0122	Manufacturing/Process	5	210	300	210	0	720
11	Welding Operator Electronics	ELE/Q0102	Manufacturing/Process	3	90	150	150	30	420
12	Winding Operator	ELE/Q0101	Manufacturing/Process	4	150	240	150	60	600
13	Die Attach and Wire Bonding Engineer	ELE/Q0117	Manufacturing/Production	5	220	300	200	0	720
14	IC Package Engineer	ELE/Q0124	Manufacturing/Production	5	210	300	210	0	720
15	Embedded Full Stack IoT Analyst	ELE/Q1404	Product Design	5	150	240	150	60	600
16	Embedded Product Design Engineer- Technical Lead	ELE/Q1403	Product Design	6	240	360	240	60	900
17	Embedded Software Engineer	ELE/Q1501	Product Design	5	240	360	240	60	900
18	IoT Hardware Analyst	ELE/Q1405	Product Design	5	90	120	210	30	450
19	Package Design Engineer	ELE/Q0123	Product Design	5	210	300	210	0	720
20	Semiconductor Process Technology Engineer - Upskilling	ELE/Q1406	Product Design	6	60	150	30	60	300
21	VLSI Design Engineer	ELE/Q1201	Product Design	5	210	300	210	60	780
22	Failure Analysis & Reliability Engineer	ELE/Q0121	Quality Assurance	5	210	300	210	0	720
23	Quality Analysis & Reliability Engineer	ELE/Q0120	Quality Assurance	5	220	300	200	0	720

(Link to access the courses: https://www.essc-india.org/qualification-packs.php)

Abbreviations

Sr. no.	Abbreviation	Full form
1	AI	Artificial Intelligence
2	AICTE	All India Council for Technical Education
3	ALD	Atomic Layer Deposition
4	AMD	Advanced Micro Devices
5	ATMP	Assembly, testing, marking, and packaging
6	BEL	Bharat Electronics Limited
7	BITS	Birla Institute of Technology Studies
8	C2S	Chips to Startup Program
9	CDIL	Continental Devices India Ltd
10	CITC	Chip Integration Technology Center
11	DCPC	Department of Chemicals and Petrochemicals
12	DLI	Design Linked Incentive
13	DPIIT	Department for Promotion of Industry and Internal Trade - Invest India
14	DST	Department of Science & Technology
15	ECU	Engine Control Unit
16	EMC 2.0	Electronic Manufacturing Cluster scheme 2.0
17	EMS	Electronic Manufacturing Services
18	ESDM	Electronics System Design and Manufacturing
19	ESSCI	Electronics Sector Skills Council of India
20	GAETEC	Gallium Arsenide Enabling Technology Centre
21	GDA	Gateway Design Automation
22	GOI	Government of India
23	GPU	Graphics Processing Unit
24	IC	Integrated Circuits
25	iCET	initiative on Critical and Emerging Technology
26	IDM	Integrated Document Management
27	IIT	Indian Institute of Technology
28	IP	Intellectual Property
29	ISM	India Semiconductor Mission
30	ISRC	India Semiconductor Research Centre
31	MDP	Microprocessor Development Programme
32	MEITY	Ministry of Electronics & Information Technology
33	ML	Meta Language
34	MOE	Ministry of Education
35	MOSFET	Metal-oxide-semiconductor field-effect transistor.
36	MoU	Memorandum of Understanding
37	MSDE	Ministry of Skill Development and Entrepreneurship
38	MSME	Medium & Small Scale Enterprises
39	NAND	Not AND
40	NWO	The Dutch Research Council
41	NPE 2019	National Policy on Electronics 2019
42	NSDC	National Skill Development Corporation
43	OEM	Original Equipment Manufacturer
44	OSAT	Outsourced Semiconductor Assembly & Test
45	SCL	Semiconductor Complex Limited
46	SIA	Semiconductor Industry Association
47	SMA	SubMiniature version A
48	SMB	SubMiniature version B
49	SME	Subject Matter Experts
50	SoC	System on Chips
51	SPECS	Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors
52	SSPL	Solid State Physics Laboratory
53	STEM	Science, technology, engineering, and mathematics
54	TEM	Transmission Electron Microscope
55	TNO	Netherlands Organisation for Applied Scientific Research
56	TU/e	Eindhoven University of Technology
57	TUDelft	Delft University of Technology
58	VLSI	Very Large Scale Integration

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