CTIER CENTRE FOR TECHNOLOGY, INNOVATION AND ECONOMIC RESEARCH

Building Skill in Silicon: India's Path to Semiconductor Excellence

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CTIER Research
Article 13

Suggested citation: Joshi, S., Misra, S., Nabar, J. (2025), "Building Skill in Silicon: India's Path to Semiconductor Excellence (CTIER Research Article 13)", Centre for Technology, Innovation and Economic Research

Cover: Sameer Karmarkar
Typesetting and design: Satisifice Designs Pvt. Ltd., Pune

We are grateful to the participants of the CTIER Ananta roundtable discussion on India's R&D Ambitions: Challenges and Imperatives, India's Potential in Semiconductors, held in November 2024.

Globally, the need for semiconductors has intensified in recent years due to their indispensable role in emerging technologies like artificial intelligence, machine learning and the Internet of Things. The varied use of semiconductors across sectors like automotive, electronics, defence and space adds to its strategic relevance in the global market. India seeks to position herself as one of the emerging semiconductor hubs of the world.

The focus of this essay is to outline how India's existing strengths can propel her to become a worthy contender in the global semiconductor value chain.[1,2] The first section looks at various policy initiatives at the national level, state level and in the form of bilateral agreements, followed by a description of the current presence of semiconductor firms and startups in India. The last section looks at different priority areas that India can focus on to grow the domestic semiconductor ecosystem.

Policy Resolve and a Multipronged Approach

There have been a number of initiatives introduced at the national level, state level and in the form of bilateral Memorandums of Understanding (MoU) to build the semiconductor ecosystem in India. These initiatives are a significant step in the right direction. Building on these and providing the necessary policy implementation support would contribute to building a comprehensive semiconductor ecosystem that plays to the country's strengths.

While the national measures are a start, the scale of funding would need to be increased and sustained over a longer period. The state government initiatives on talent would need to be supplemented with an explicit focus on talent development through research in the higher education sector. Lastly, the bilateral initiatives need to be actioned urgently to address the various lacunae the nation faces when it comes to talent and infrastructure development.

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1 While our focus in this essay on the semiconductor value chain, it is important that India also focus separately and urgently on growing EMS. This will not only contribute to the growth of the semiconductor industry but a broader EMS industry will play a huge role in job creation and bring immediate benefits to the wider economy.

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At the national level, the Government of India launched the India Semiconductor Mission in 2021 and has allocated USD 10 billion for various schemes. The mission includes a design linked incentive scheme that offers financial support of up to 50 percent of eligible expenditure. The mission also provides for a product deployment linked incentive on net sales for five years covering different stages of semiconductor design. It proposes fiscal support for establishing fabrication units for semiconductors, display, compound semiconductors, silicon photonics, sensors and discrete semiconductors. The government plans to provide incentives for ATMP/ OSAT facilities under the mission (Press Information Bureau, 2024).

Furthermore, around USD 1 billion has been set aside to modernise the Semiconductor Laboratory (SCL) in Mohali. SCL is an autonomous body under the Ministry of Electronics and Information Technology (MeitY), Government of India. The Ministry intends to do this through a joint venture with the private sector (Aryan & Agarwal, 2024).

A review of state policies is telling. 13 states have introduced dedicated semiconductor policies or integrated semiconductor-related measures within their electronics policies. The timeline of introduction of some of these policies predates the current national focus on semiconductors.

Table 1 highlights the focus areas covered under each of the policies. All policies focus on infrastructure development. While most policies have a mix of different areas of focus, Gujarat is an exception where the policy is entirely focused towards infrastructure for the semiconductor sector.

Different states are adopting varied initiatives for talent development. For example, Odisha is focusing on updating electronics curriculum with a special focus on VLSI Design at both undergraduate and graduate levels and emphasising on skill development through industry-academia collaborations. Tamil Nadu has a target of creating a talent pool of 200,000 within the Semiconductor sector by 2030 through training incentives and by facilitating high-end electronics design research. Uttar Pradesh is providing fiscal incentives for developing industrial housing along with curriculum upgrades and skill development workshops.

As more of these policies roll out, consideration must be given to the idea that while it may not be possible for each state to embed itself in the semiconductor value chain, given differences in resources, infrastructure and logistics, every state could at least contribute to building the talent pool.

With respect to the bilateral initiatives, India needs to urgently action the

Table 1 Focus Areas under State Policies

State	Policy	Year	Infrastructure	Talent	R&D	Startup Support	IPR Support
Andhra Pradesh	Electronics Manufacturing Policy	2024 - 2029	✓	✓	✓	✓	
Assam	Electronics (Semiconductor etc.) Policy	2023	✓	✓			✓
Gujarat	Semiconductor Policy	2022 - 2027	✓				
Haryana	Draft ESDM Policy	2024	✓	✓	✓	✓	✓
Karnataka	Engineering Research and Development Policy	2021			✓		✓
	Semiconductor Policy	2010	✓	✓	✓	✓	✓
Madhya Pradesh	IT, ITeS & ESDM Investment Promotion Policy	2023					✓
	Semiconductor Policy	2025	✓	✓	✓	✓	✓
Maharashtra	Industrial Policy	2019	✓	✓	✓	✓	✓
Odisha	Semiconductor Manufacturing and Fabless Policy	2023	✓	✓	✓	✓	✓
Rajasthan	Electronics Manufacturing Policy	2021	✓	✓	✓	✓	
Tamil Nadu	Semiconductor and Advanced Electronics Policy	2024	✓	✓	✓	✓	✓
Uttar Pradesh	Semiconductor Policy	2024	✓	✓	✓		✓
West Bengal	Information & Communication Technology	2012	✓	✓			✓

Source: CTIER Analysis, various state government websites

intentions laid out in MoUs with Singapore, Taiwan, the USA and Japan. The MoU with Singapore (ANI, 2024) aims to create a semiconductor cluster and focus on talent development in semiconductor design and fabrication. Similarly, through our MoU with USA (U.S. Embassy and Consulates in India, 2023), we seek to build research opportunities, talent and upskill the semiconductor workforce. The National Science Foundation (NSF) of the US and the Department of Science and

Technology (DST) of India have announced joint research collaborations in applied research areas of emerging technologies which includes semiconductors (ibid). India's MoU with Taiwan (ANI, 2024) emphasises on person-to-person interactions with a focus on mitigating the shortfall of workforce in Taiwan's semiconductor industries, which we should leverage to benefit India's own semiconductor talent.

Semiconductor Presence: Where are we?

While India's policy initiatives and strategic collaborations captured above hint at positioning India as a desirable global hub across the semiconductor value chain, an analysis of the capabilities residing in India reveals a significant focus on design related activities at present. It has been reported that India contributes around 20 percent of the world's semiconductor design talent (Bansal, 2024; Varadarajan et al., 2024).

To better understand India's presence in the global semiconductor value chain, we mapped major firms by their activities in the value chain in Table 2. We then looked at how many of these firms have a presence in India. Nearly half of the major global companies with a semiconductor presence in India seem to be working on their design capabilities while others are working on ATMP and R&D for semiconductors. (See Table 3)

Table 2 Major Companies in the Global Semiconductor Value Chain

Activity	Firm Name
Design	Alphabet, Meta, Microsoft, Apple, Tencent, Qualcomm, Alibaba Group Holding, Nvidia, Stellantis, Cisco Systems, NTT, IBM, Siemens, Advanced Micro Devices, Broadcom, Nokia, Ericsson, Mediatek, Hon Hai, Baidu, Tesla, LG Electronics, ZTE, Hyundai Motor, Arm Holdings
Fabrication	Taiwan Semiconductor Manufacturing Company (TSMC)
Assembly, Testing, Marking and Packaging (ATMP)	ASML Holding, Applied Materials (AMAT), Hitachi
Integrated Device Manufacturer	Huawei Investment & Holding, Samsung Electronics, Intel, Toyota Motor, Robert Bosch, Sony, Denso, SK Hynix, Micron Technology, Hitachi, Western Digital, NXP Semiconductors

Source: CTIER Analysis, various news reports and company websites

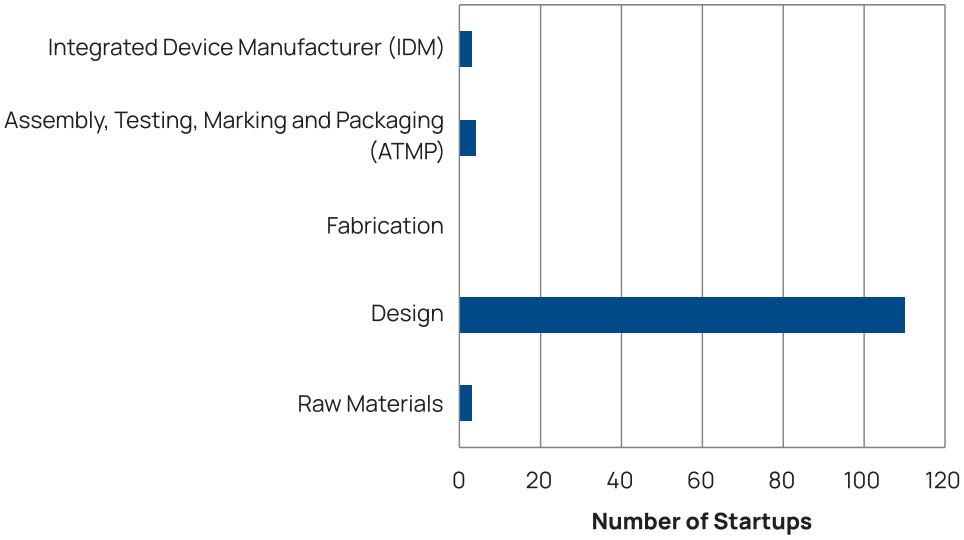
Table 3 Major Global Companies with Semiconductor Presence in India

Semiconductor Work Done in India	Firm Name
Design	Qualcomm, Advanced Micro Devices, Intel, Nvidia, Meta, NXP Semiconductors
Assembly, Testing, Marking and Packaging (ATMP)	Micron Technology, Foxconn (Hon Hai)
R&D	Samsung Electronics, Mediatek, Applied Materials (AMAT), Broadcom

Source: CTIER Analysis, various news reports and company websites

There seems to be a similar phenomenon with startups working in the semiconductor space in India. Of the 120 Indian startups that we identified in the semiconductor value chain, around 90 percent are carrying out design related activities. (See Figure 1)

Figure 1 Semiconductor Startups In India



Source: CTIER Analysis, Tracxn

Priority Areas for Growing India's Semiconductor Industry

In this section we outline priority areas for growing India's semiconductor industry that policy should focus on. We look at how India's current design and fabrication capabilities can be adapted to gain advantage. We highlight the various ways in which India's talent can become the defining factor in the success of India's semiconductor industry.

Making India the Global Design Centre for Chips

Design is a crucial part of the semiconductor value chain. It is foundational to defining the functionality, performance and efficiency of a chip (Palma et al., 2022).

A potential area within chip design that India should capitalise on and challenge global competitors in, would be in developing specialised chips designed for Generative AI (GenAI), Large Language Models (LLMs) and Diffusion Models. Given the disruptive nature of such technologies in the current global landscape, India should focus on R&D and design of these specialised chips in order to gain an edge over others in the global semiconductor value chain.

India should focus on developing Application-Specific Integrated Circuits (ASICs) or sensors. Sensor chips have varied usage in IoT, gas sensing, security and diagnostics. India can gain comparative advantage in such high design and low volume chip manufacturing which have a significant market potential in intelligent electronics. Currently, Indian academia is carrying out research in sensors which can be used by industry.

Typically, critical semiconductor IPs are developed by the major firms (See Table 1) and licensed out to chipmakers. Given that there is an ongoing movement of open source chip architecture, India can also consider using this to her advantage. (Kotasthane & Sahu, 2024)

Strengthening Fabrication Capabilities

For India to become a notable player in the fabrication space, India will either need to bring a dominant player like TSMC to the country to capitalise on a significant portion of the semiconductor value chain or develop similar fabrication capabilities. To build fabrication capabilities of this scale, attention would need to be paid to ensuring clear air, ultrapure water (James, 2024), continuous power supply (Galbrun-Noel, 2021) and a well developed logistics infrastructure.

As India strives to attract or develop its high fabrication capabilities, there are three immediate areas policymakers could focus on: leverage its strategic partnerships to improve fabrication capabilities, tap into relatively niche areas of fabrication and scale up low value added processes within the semiconductor value chain.

Recently there have been efforts to establish fabrication capabilities in India. For instance, Tata Electronics and PSMC have signed an agreement worth USD 11 billion to set up a chip fabrication unit in Dholera, Gujarat (Press Trust of India, 2024). India should also leverage its strategic partnerships to fabricate chips designed in India in these partner countries.

India should tap into the relatively niche areas of fabrication like manufacturing compound semiconductors. Indichip Semiconductors Limited and Yitoa Micro Technology Limited (YMTL) of Japan signing an MoU with the Andhra Pradesh government to set up a Silicon Carbide (SiC) fabrication facility in the state is a welcome step in this direction (Rao M., 2025). Other ongoing efforts include the manufacturing of compound semiconductors like Gallium Nitride which are more energy efficient compared to their Silicon counterparts by startups like Agnit Semiconductors (Sur, 2024).

Lastly, India should also focus on scaling up the low value added processes within the semiconductor value chain like ATMP. Recent efforts of firms like Micron Technology and Tata Electronics to set up ATMP facilities in Gujarat (Press Trust of India, 2025) and Assam (Financial Express, 2024) respectively are a right step in this direction.

Doubling Down on Talent

India will need to devise strategies for talent development. To begin with, SCL can act as a training centre to build India's in-house talent capabilities for her semiconductor ecosystem.

India's academic programs must be reoriented to offer hands-on exposure and foster an innovation mindset. It would be important to introduce programs like specialised degrees in VLSI and semiconductor technology, along with expanded laboratory facilities where students get hands-on exposure. Embedding these cutting-edge training programmes within academic institutions would ensure that students are well prepared to contribute to the industry in an innovative capacity. Initiatives such as industry mentored PhD programs should also be introduced to align research efforts with industry needs.

Every effort should also be made to bring advanced talent from the diaspora back to India. There should be attractive enough incentives for Indians working abroad in the semiconductor industry to return. Countries like Malaysia, that are facing similar manpower shortage have introduced policies to attract its semiconductor talent back to their respective counties (Lin, 2025). Policies like these would need to be studied. Other opportunities to provide international exposure to Indian professionals through programs under the India-Taiwan MoU should also be taken advantage of as a route to talent development.

In Conclusion

In the current geopolitical context, India has a window of opportunity to become a worthy contender in the global semiconductor race. Government support can help — instead of a one time investment effort, there is a need to continuously invest a yearly amount of USD 10 to 20 billion for the next 10 years to meaningfully develop the ecosystem. Industry will have to play its part and amp up on capabilities across the value chain.

Building design capabilities will be pivotal to India's progress in this industry. These capabilities will require to be developed over not just chip design, but could also be extended to the design of fab facilities.

India can strengthen fabrication capabilities through tapping into niche areas of fabrication, scaling up the low value added processes within the

semiconductor value chain like ATMP besides ramping up existing efforts on building fabrication capabilities.

Projections suggest that the Indian semiconductor sector may face a shortfall of approximately 300,000 professionals over the next five years (Singh, 2024). India will need to devise strategies to counter this outward talent loss. We will need to double down on talent development.

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