Bridging Innovation Gaps: India's Path to Nanoelectronics Dominance by 2047

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Introduction

As India ascends to its place as the world's most populous nation[1], it stands on the cusp of a technological revolution that could transform its economic landscape. By 2047, the centenary of India's independence, the country has the potential to emerge as a global powerhouse in nanoelectronics. However, to realise this vision, India must overcome significant challenges, including bridging the gap between research and innovation, fostering stronger academia-industry collaborations, and building a robust ecosystem for deep-tech startups.

Harnessing the Demographic Dividend

India's demographic advantage, with a working-age population of around 60% as per the recent economic survey[2], presents a tremendous opportunity. However, this potential remains largely untapped due to the socio-economic challenges in the country's poorest states. The lack of quality education and skills training in these regions hampers their contribution to the economy. While India has launched multiple science and technology missions, including biotechnology, nanotechnology, cyber-physical systems and AI, the impact of these scientific missions on job creation has been below expectations. It is primarily due to the disconnect between research, which generates new knowledge, and innovation, which transforms this knowledge into new products and services.

India ranks 3rd globally in knowledge generation but falls behind in innovation (40th) and academia-industry collaborations (66th).[3] This disconnect is a significant barrier to technological advancement. To achieve the status of a developed nation by 2047, India must address its lagging technological development in core areas like automated manufacturing, advanced materials, Internet of Things (IoT), and nanoelectronics. These technologies are crucial for driving the country's growth, especially in sectors beyond IT services. However, the key to bridging the gap between research and innovation lies in fostering stronger collaborations between academia and industry. Research thrives in academic institutions, while innovation primarily happens in deep-tech startups and high-tech industries. A more integrated approach is needed, where academia and industry work together to develop new technologies and create jobs. Establishing a supportive ecosystem for deep-tech startups is crucial, as these are the breeding grounds for future industries.[4]

The world is currently experiencing the sixth wave of innovation, focusing on sustainability and automation.[5] Each wave has demanded new skill sets, and this one is no different. To remain competitive, India's academic institutions must continuously evolve their curricula to meet the changing demands of the job market. McKinsey Global Institute highlights the rapid adoption of digital technologies in India, predicting a potential market valuation of USD 435 billion for core digital sectors by 2025.[6] This makes India fertile ground for new technology adoption, particularly in AI and semiconductor manufacturing.

Semiconductor Manufacturing: The Way Forward

Launched in 2021 with a substantial USD 10 billion investment, the India Semiconductor Mission (ISM) is a crucial initiative aimed at establishing India as a prominent global semiconductor manufacturing hub. This mission goes beyond merely boosting the economy; it encompasses national security, technological autonomy, and advancing India's digital future.[7] Encouragingly, early developments signal progress, with major players like Micron, Tata, and CG Power receiving government approvals to set up semiconductor manufacturing facilities in regions like Gujarat and Assam.[8] India is ambitiously targeting a 10% share of the global semiconductor market by 2030, a market expected to be worth USD 1.1 trillion, thus positioning itself as a key international player in this critical industry.[3]

Over the past two decades, India has made significant advancements in manufacturing, particularly in the automotive and pharmaceutical sectors, while cementing its status as a leading global provider of IT services. Projections suggest that the automotive sector could reach USD 300 billion by 2026[9] and the pharmaceutical industry might touch USD 130 billion by 2030.[10] However, these sectors have primarily focused on scaling production rather than pioneering new products. Despite being the third-largest producer of pharmaceuticals globally and a dominant force in IT, India still lags in groundbreaking drug innovations.

The primary barrier to innovation in these sectors is the limited collaboration between academia and industry. India ranks impressively high in research output, standing 3rd globally in publications, 6th in patent filings, and 9th in research quality as measured by citations. In cutting-edge fields like the IoT and sensor technology, Indian academic institutions rank among the top five globally. According to industry forecasts, IoT markets are anticipated to grow to a trillion dollars by 2032. However, despite these academic achievements, the potential for innovation remains largely untapped by both government and industry. Globally, India ranks 66th out of 130 countries in academia-industry partnerships, with academic institutions often viewed merely as talent pools rather than sources of innovative ideas or technologies. The lack of strong academia-industry collaborations stifles innovation, preventing the emergence of transformative products similar to Tesla in the automotive sector or disruptive technologies like ChatGPT in the IT industry.[3]

In addition to establishing manufacturing facilities, there must be a concerted effort to foster innovation through collaborations between academia and industry. Taiwan, for instance, boasts a highly integrated semiconductor supply chain, with Taiwan Semiconductor Manufacturing Company Limited (TSMC) leading the way in manufacturing. Taiwanese universities offer a comprehensive range of semiconductor-related courses, ensuring robust education, research, and skill development. They also regularly upgrade their semiconductor infrastructure, encouraging more public-private research partnerships and helping to bridge the talent gap in the semiconductor industry.[11] The United States, through the CHIPS Act, is similarly investing in academia, with the Biden administration allocating over USD 5 billion for research and development in collaboration with academic institutions.[12] To fully harness India's innovation potential, ISM must invest heavily in establishing academia-industry consortia and integrate academic institutions from the outset. India possesses a wealth of talent within its academic institutions, and tapping into this resource requires a unified effort from the government and industry. A strategic and coordinated approach is crucial for directing this talent toward nation-building initiatives rather than merely serving as a training ground for the workforce. Without such alignment, Indian research risks becoming a 'solution looking for a problem' rather than addressing real-world challenges.

A way forward for the country's semiconductor mission, therefore, is to distribute the investment of approximately USD 9 billion in cutting-edge technology areas, as highlighted in the figure below. Additionally, around USD 1 billion is needed for various R&D initiatives involving industry-academia partnerships across different scenarios. To achieve the vision of a developed India by the country's centenary year of independence in 2047, fostering entrepreneurship and creating jobs through collaborative efforts between industry and academic institutions is essential.

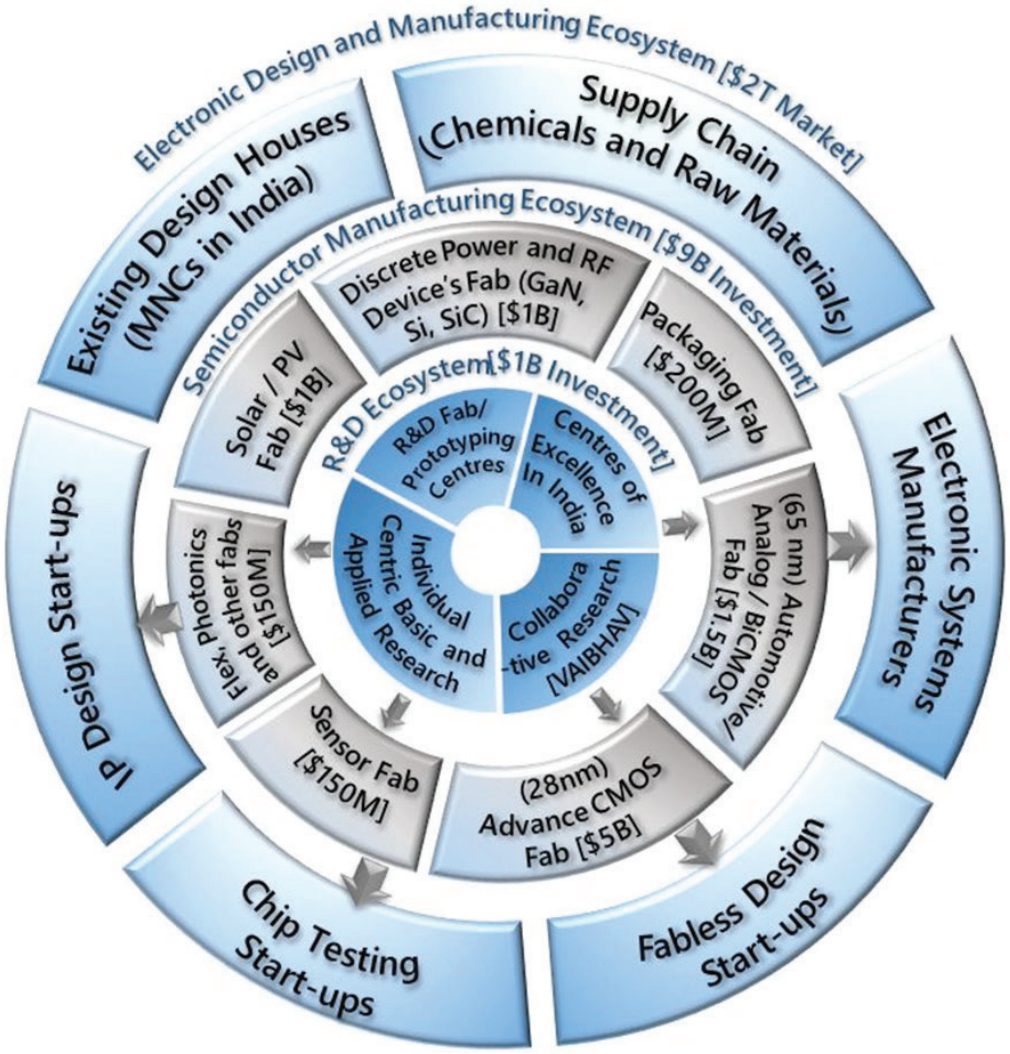


Figure 1. The infographic outlines the holistic approach required to support a USD 2 trillion electronic design and manufacturing ecosystem, highlighting the necessity of a USD 9 billion investment in semiconductor manufacturing and USD 1 billion in collaborative industry-academia R&D (Picture credit: Prof. Mayank Shrivastava, IISc)

Conclusions

India's journey to becoming a developed nation by 2047 hinges on its ability to harness the potential of nanoelectronics and other emerging technologies. By fostering stronger academia-industry collaborations, building a robust ecosystem for startups, and strategically investing in semiconductor manufacturing, India can position itself as a global leader in technology. The vision of Viksit Bharat is within reach, but a concerted effort from all stakeholders is required to turn this potential into reality.

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