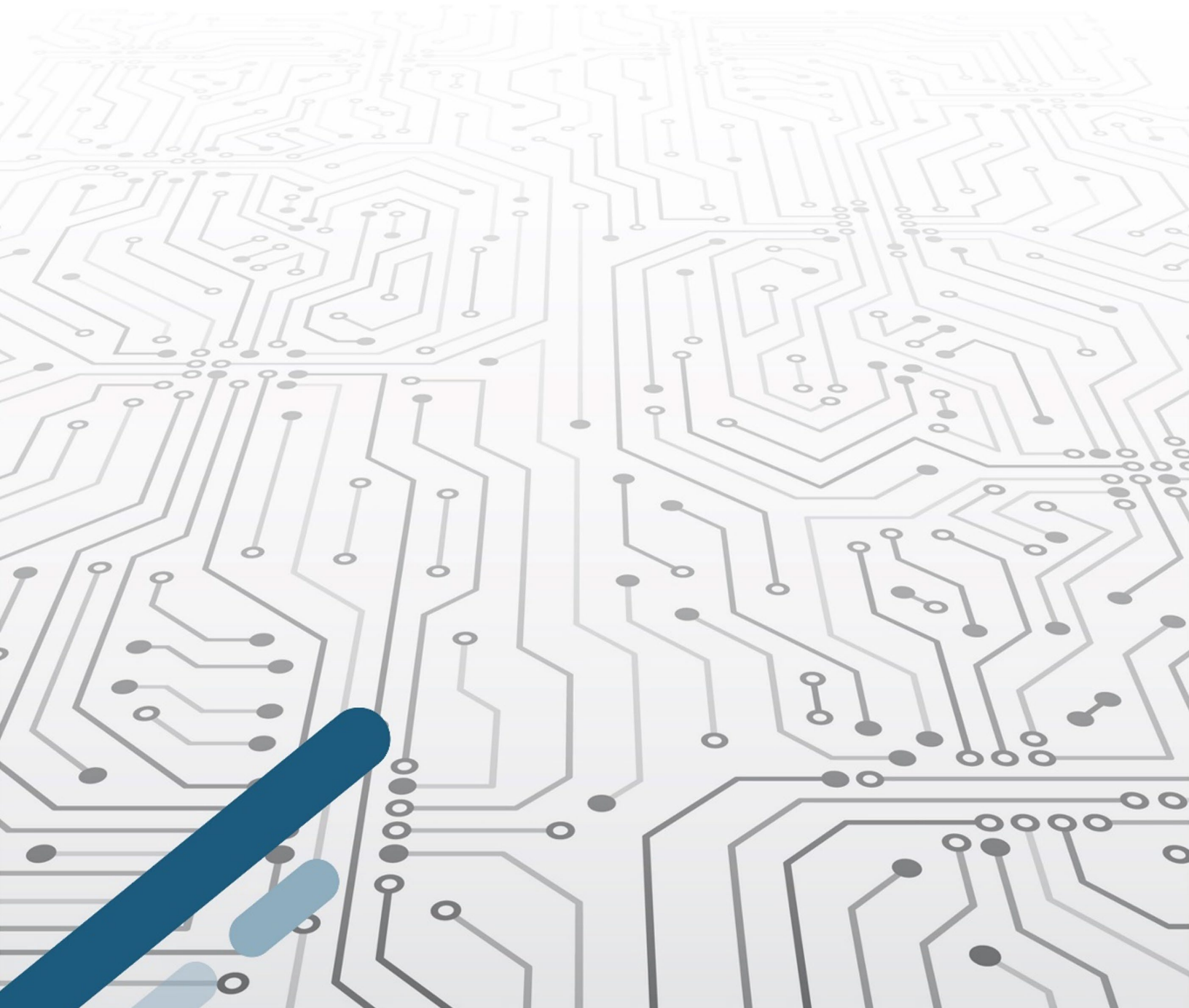
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India Semiconductor Readiness Assessment Report: Initial Findings

STEPHEN EZELL I JUNE 2022



ABOUT THIS REPORT

On January 31, 2023, India and the United States announced the joint initiative on Critical and Emerging Technology (iCET), which committed the two countries to expand strategic technology partnerships and defense industrial cooperation between their nations' businesses, academic institutions, and government agencies. As part of the iCET, the Semiconductor Industry Association in the U.S. and India's India Electronics Semiconductor Association (IESA), agreed to undertake a "readiness assessment" to identify near-term industry opportunities and facilitate the longer-term strategic development of their complementary semiconductor ecosystems. The Information Technology and Innovation Foundation (ITIF), a Washington, DC-based science and technology policy think tank, was commissioned to undertake authorship of this assessment, and in May 2023 an ITIF representative undertook a fact-finding trip to India for this purpose.

INITIAL FINDINGS

India plans to expand its global market share across each key phase of the semiconductor production process: 1) design; 2) fabrication; and 3) assembly, test, and packaging (ATP). It has announced ambitious incentives, established a new national semiconductor mission, and has made significant progress already in attracting investor interest.

While India brings significant strengths to the semiconductor manufacturing ecosystem; it can become a strong global player by further addressing investment barriers such as the business environment, customs/tariffs, taxation, and infrastructure.

The Indian federal government—alongside the governments of leading states in the semiconductor, information and communications technology (ICT), and electronics sectors, notably Gujarat, Karnataka, Tamil Nadu, and Telangana—is working extremely hard to understand and address the needs, challenges, and concerns of semiconductor enterprises across a wide range of issue areas, particularly: regulation, taxation, infrastructure/logistics, talent, incentives, and customs. The Indian government and state officials were keen to express the view that India's approach to industry has evolved from "red tape" to "red carpet" in the fiercely contested global competition to attract high-value-added, globally mobile semiconductor industry (and broader high-tech) investment.

There is evidence that Indian policy is moving the needle in the right direction, as in recent years the nation has demonstrated consistent improvement in global competitiveness indices such as the World Intellectual Property Organization (WIPO) Global Innovation Index (GII), the Logistics Performance Index (LPI), and the World Bank Ease of Doing Business report. Collectively, this reflects a recognition that while it is vitally important that nations craft semiconductor competitiveness strategies and extend effective incentives to attract semiconductor-sector activity, the most important determinant of a nation's (and/or state's) ability to attract high-tech investment (whether from domestic or foreign sources) is the quality, stability, and predictability of the business environment it offers.

Many nations have recently introduced strategies and incentive packages to attract semiconductor manufacturing activity—these include the CHIPS and Science Act in the United States, the EU Chips Act in Europe, and the K-Belt Strategy in Korea—yet India offers some of

the most attractive incentives globally. In total, India is offering $30 billion in support for semiconductors and related industries, including $10 billion for the semiconductor/display sector; $7 billion for electronics manufacturing; and $13 billion for related sectors—such as solar photovoltaic cells, electric and other automotive vehicles, and white goods—which matters because these will be key, growing sectors of the Indian economy (alongside ICTs and electronics) demanding consumption for the anticipated increases in Indian semiconductor output.

Indian policymakers recognize that the stable, secure, and dependable supply of electricity is a foundational starting point toward attracting semiconductor manufacturing investment. To this end, the Indian federal government—alongside Indian states—has made considerable investments in increasing electricity production and developing reliable and redundant electricity grids. India's installed capacity of 410 gigawatts (GW) is now the world's third largest, with an ever-greater supply, at least 172 GW, being renewable power. Indicative of the increasing quality of India's electric grid, India's Semiconductor Laboratory has not sustained a power outage since 1983. Several regions—such as Dholera, in Gujarat, which is seeking to establish a semiconductor cluster as well as Mysuru, in Karnataka—also highlighted significant recent improvements to their respective water/sewer, port, airport, road, and high-speed rail infrastructure.

Indian policymakers recognize that regulatory, tax, and customs environments are important considerations in attracting globally mobile high-tech investment. To this end, Indian policymakers have made strides in setting up single-window clearance for businesses (i.e., India's National Single Window System (NSWS) digital platform), but more progress is needed. Elsewhere, India has worked with semiconductor design firms and electronics manufacturers to design advanced pricing agreements (APAs), agreements between taxpayers and national tax authorities determining the transfer pricing methodology for pricing taxpayers' international transactions for future years. In July 2017, India significantly simplified and streamlined its tax system with the introduction of the goods and services tax (GST), essentially a destination/consumption-based tax that replaced one of the world's most complicated origin-based indirect tax systems. Stability, certainty, and efficiency are important attributes of nations' and states' tax environments that enterprises assess when making globally mobile investment decisions.

While India brings a number of strengths to the table and is already highly competitive in semiconductor research and design, India's capabilities in large-scale manufacturing are currently limited, but poised to grow significantly. Manufacturing semiconductors is one of the most complex manufacturing endeavors humanity has ever undertaken, and the reality is India's experience in this field is limited. This is why the Government of India's efforts to jump-start semiconductor manufacturing are so essential and the establishment of the India Semiconductor Mission (ISM) and the related Production-Linked Incentives (PLI) Scheme is so timely.

Further, moving bits within the semiconductor supply chain is as important as moving atoms across global supply chains, meaning data and information should be no more dutied than key inputs, components, or final goods in this sector. This is equally important for the semiconductor manufacturing process, as digital designs need to cross borders between the design and manufacturing side of the business. Further efforts to facilitate multilateral trade and promote IP

protection more aligned with global practices in entities like the WTO would help catalyze more investment.

Lastly, while India's intellectual property environment has shown signs of improvement in recent years, challenges remain regarding patent and copyright eligibility requirements that are outside of international standards, long patent pendency periods, expensive and time-consuming pre- and post-grant oppositions, and excessive reporting requirements. India ranked 42nd out of 55 countries assessed in the 2023 Global Intellectual Property Center International IP Index. Making improvements in IP protection will increase the confidence of semiconductor firms to make big bets with their IP in India.

US-INDIA PARTNERSHIP IN SEMICONDUCTORS

India and the United States enjoy a tremendous opportunity to learn from one another as they seek to strengthen the competitiveness of their semiconductor sectors and deepen their partnerships in global semiconductor supply chains. To this end, the U.S. CHIPS Program Office at the Department of Commerce should invite their Indian counterparts from the India Semiconductor Mission for a capacity-building trip to Washington, DC, and explore avenues to jointly collaborate on strengthening their respective sectors:

- The U.S. CHIPS and Science Act included $500 million for a CHIPS for America International Technology Security and Innovation Fund. A not-insignificant share of these funds should be allocated to partnerships with Indian stakeholders (and possibly simultaneously other Quad-nation partners). For instance, to support both design and foundry interests, a joint prototyping testbed foundry could be set up as a way to validate innovative chip designs. Collaboration need not be restricted to silicon activities but can also support early research toward product development.
- Part of that funding could be used for India and the United States to work together to stand up a world-class R&D Center and Test and Characterization facility for the development of embedded systems and semiconductor products. Electronic Manufacturing Centers (EMCs) could be set up as domain-specific Centers of Excellent in manufacturing. As many as 25 EMCs could be established with as little as $3 million in funding.
- The two countries should collaborate to develop a heat map (i.e., a comprehensive cross-country semiconductor supply value chain map) to support a robust and resilient semiconductor ecosystem.
- Similarly, India can be a key supplier of talent and know-how to produce the scientists, engineers, and technicians that will be needed as workforces are expanded and trained to accommodate the desired growing semiconductor activity in both nations. Recently, in May 2023, the Union Minister of Electronics and IT, Ashwini Vaishnaw on behalf of the Indian Semiconductor Mission, signed an MoU with Purdue University for capacity building, research and development, and industry participation.[1]
- India and the United States should collaborate on talent development: certainly, the $200 million CHIPS for America Workforce Education fund will create opportunities for joint curriculum development, student exchanges at the Masters and Ph.D. levels in relevant engineering fields, and possibly new pathways for the circulation of students—

and even workers—between the two nations in this critical sector. Further, workforce development initiatives should also look into the skilled trades (such as construction) as such workers will be key to building and operating semiconductor fabs.

- Finally, in May 2023, the U.S. National Science Foundation (NSF) and the Department of Science and Technology (DST) of the Indian government signed an Implementation Arrangement on research cooperation that will allow investigators from both countries to collaborate to write a single proposal that will undergo a single review process at NSF. This should create a new pathway for expanding microelectronics research activity between U.S. and Indian collaborators.

IN CONCLUSION

I. India represents a capable, dynamic, rapidly evolving economy ready to expand upon its strengths in the semiconductor design space into the more manufacturing-oriented facets of semiconductor production: fabs and ATP.

II. Indian policymakers—at the federal and state levels—are eager to attract such investment and are willing to actively engage the industry to understand its needs, challenges, and obstacles and to respond with innovative incentives, policies, and infrastructure investments, as needed, to address them.

III. While India's highly generous investment incentives are geared, appropriately, to attract initial investors as proof points for the country's capabilities in semiconductor fabrication and ATP, it's important to remember the longer-term goal is the transformation of the business environment to enable India's sustainable, long-term competitiveness in this sector.

IV. Indian policymakers should not seek just one fab or one ATP site, but to make India a globally competitive player in all facets of semiconductor production, aspiring over the course of the coming decade to achieve double-digital global market shares in all major facets of the semiconductor industry (not just design) and becoming a key, market-based partner in global semiconductor production and supply chains. Achieving that will require successfully addressing the impediments identified here.

ITIF's final report will explore all these topics in greater detail and will be delivered in Fall 2023.

BACKGROUND

Semiconductors represent the heartbeat of the modern digital economy, a $575 billion industry in 2022 that stimulated $7 trillion in global economic activity, including serving as the foundation for the global electronics and ICT industries and making a range of downstream applications such as artificial intelligence (AI) possible. India already constitutes a very important player in this industry—accounting for roughly 20 percent of global semiconductor chip design activity—but India rightly aspires to achieve a much-greater global footprint in semiconductor production and value chain activity, particularly by building on its strengths in chip design by expanding its semiconductor fabrication and outsourced semiconductor and test (OSAT) footprint (also referred to as assembly, test, and packaging, or "ATP.") As Indian Prime Minster Shri Narendra Modi recently commented, "It is our collective aim to establish India as one of the key partners in global semiconductor value chains." India's semiconductor market, valued at $15 billion in 2020, is expected to grow to over $64 billion by 2026, doubling again to reach $110 billion by 2030, at which point analysts anticipate India will command at least a 10 percent share of the global semiconductor market.[2]

In April 2023, India jumped up six places, to 39th, in the 7th Edition of the 139-nation LPI, which measures the quality of countries' logistics infrastructure and efficiency. Similarly, India increased its rank in the 2022 GII to 40th place, a significant improvement over its 81st-place ranking in 2015. The World Bank's Ease of Doing Business series of reports has unfortunately been discontinued, but in the final (2020) report, India ranked 71st, a doubling of improvement from its 142nd rank in 2014.

Recently, India has been successfully demonstrating its capability to assume a much larger role in global electronics and ICT manufacturing supply chains. India's electronics production, valued at just $76 billion in 2021, is expected to grow four-fold by 2026, to $300 billion, including a tripling of mobile phone production, and an increase in production of other ICT hardware to $40 billion.[3] India's exports of electronics have tripled since 2018, to $23 billion in the year through March, while India doubled its share of global smartphone production (to 19 percent) over the past five years. Analysts estimate that Apple may produce one-quarter of its smartphones in India by 2025, demonstrating a substantial acceleration of India's capacity to attract manufacturers like Foxconn and produce complex, high-value-added ICT goods.

In December 2021, India stood up the India Semiconductor Mission (ISM), a government organization, to guide the promulgation of federal government policy and incentive packages to attract semiconductor-sector investment across each key phase of semiconductor production: design, fabrication, and ATP (with additional incentives to attract display fabs). India's incentives to attract a semiconductor fab are especially generous. For an approved application across any semiconductor technology node, including legacy (i.e., chips made using 28-nanometer process nodes or larger) for a fab worth at least $2.5 billion making 40,000 wafer starts per month (WSPM), the Indian government would reimburse 50 percent of the fab cost on a pari passu basis (i.e., extending funds upfront), with a state partner expected to kick in an additional 20 percent. As India's Commerce and Industry Minister Piyush Goyal recently explained, "Very often you have anchor companies who set the trend," and clearly these incentives are designed to attract such a landmark fab.

To attract semiconductor OSAT/ATP investment, the Indian federal government is offering an incentive covering 50 percent of the capital expenditure (CapEx) cost, with a state partner expected to kick in an additional 20 percent.[4] The incentive applies to an investment of at least $6.5 million in an OSAT facility, or $13 million for a compound semiconductor, silicon photonics, or sensor fab. To attract expanded investment in semiconductor chip design, India's design-linked incentive (DLI) program offers to cover 50 percent of CapEx, with this amplified by deployment-linked incentives that offer additional incentives of 4-6 percent based on incremental year-over-year net sales increases. Other infrastructure support for this sector includes access to a national electronic design automation (EDA) grid, a core intellectual property (IP) repository, prototyping assistance, and post-silicon validation. Separately, India's Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS) provides a 25 percent CapEx incentive for downstream investments in the semiconductor supply chain such as semiconductor-grade chemicals and gases, engineering and R&D support, and other intermediate goods. India has many globally competitive players in the industrial chemicals and gases sector, although it's been noted some of these companies will need to refine the purity of their products to support semiconductor-grade needs.

India's semiconductor ecosystem, especially chip research, and design, is supported by a rich variety of supporting assets that well position the nation for an expanded global role in semiconductor production. For instance, the Semiconductor Fabless Accelerator Lab (SFAL) represents a globally competitive Center of Excellence supporting India's fabless ecosystem. India's Semiconductor Laboratory (SCL) is a research institute under the Ministry of Electronics and Information Technology (MeitY) coordinating R&D in the field of semiconductor technology, micro-electro-mechanical systems (MEMS), and producing chips for mission-oriented purposes such as India's space program. At the Indian Institute of Science in Bangalore, the Centre for Nano Science and Engineering (CeNSE) operates the National Nanofabrication Centre, a state-of-the-art CMOS/MEMS-capable research facility. MeitY's Centre for Development of Advanced Computing (C-DAC) supports additional R&D efforts. And of course, a variety of world-leading semiconductor and semiconductor manufacturing equipment firms, including Texas Instruments, Micron, Intel, AMD, Applied Materials, and Lam Research, conduct semiconductor design activity in India, collectively designing over 2,000 chips annually and employing 120,000 semiconductor industry design and research engineers.

India has committed to the development of a skilled workforce in part through the Chips to Startup (C2S) program, which seeks to train 85,000 high-quality and qualified engineers in Very Large-Scale Integration (VLSI) and Embedded System Design specialties. Engineers will be trained at 120 Indian academic institutions across the Masters and Ph.D. levels over the next five years, developing a talent pool supporting India's aspirations in semiconductor design and fabrication, with the goal of making India a "Semiconductor Talent Nation." India's over 1,000 universities and 23 Indian Institutes of Technology (IITs) are also important contributors to India's semiconductor talent ecosystem.

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ENDNOTES

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