Road to Self-Reliant Semiconductor Ecosystem

This editorial is based on "More wafer work" which was published in The Financial Express on 03/09/2025. The article brings into picture India's semiconductor push, with CG Semi set to launch the first Made-in-India chip this year, while stressing that with only one fab under construction compared to China's 44 and the US's 15, India must cut red tape and expand rapidly to claim a share of the trillion-dollar chip market.

For Prelims: India's Semiconductor Mission, Production Linked Incentives (PLIs), Design Linked Incentives (DLIs), 'Vikram' 32-bit microprocessor, Chip to Startup (C2S) program, "Chip 4" alliance.

For Mains: Recent Advancements in India's Semiconductor Sector, Key Issues Associated with India's Semiconductor Sector.

India's semiconductor journey gained momentum with CG Semi company announcing the first **Made-in-India chip by year-end**, following the Cabinet's approval of four new semiconductor projects.India aims to capture **8-10% of the trillion-dollar global chip market by 2030.** However, the country faces significant challenges in scaling up fabrication capabilities, with **only one mega fab under construction compared to China's 44 and the US's 15.** As the Indian Prime Minister emphasized, **India now needs "less paper work and more wafer work"** to transform from a late entrant into a competitive semiconductor powerhouse.

What are the Recent Advancements in India's Semiconductor Sector?

- **Made-in-India Chip Production: India is making significant strides in semiconductor manufacturing with CG Semi's announcement of producing its first "Made-in-India" chip by the end of 2025.**
  - This development marks a pivotal moment as India transitions from being a consumer to a creator in the global semiconductor space.
  - The Indian Prime Minister asserted that "Oil was black gold. But chips are digital diamonds".
    - With major investments like CG Power's ₹7,600 crore Outsourced Semiconductor Assembly and Test (OSAT) facility and multiple semiconductor fabs under construction, this chip signifies a long-awaited leap.
- **Government Incentives and Strategic Policies:** The Indian government's proactive role through the India Semiconductor Mission (ISM) has accelerated the country's semiconductor ambitions.
  - By offering ₹76,000 crore in Production Linked Incentives (PLIs) and Design Linked Incentives (DLIs), India is rapidly becoming a hub for global chipmakers.

    - The government's approach is evident through the ₹7.1 billion commitment for semiconductor-related infrastructure like the Mohali lab upgrade and skill development initiatives.
- **Workforce Development and Talent Pool Expansion:** As India aims to meet the projected demand for 500,000 semiconductor professionals by 2030, workforce development is a central pillar of its semiconductor strategy.
    - As per the 'SemiconIndia Future Skills Talent Committee report', about 1.25 Lakh semiconductor design engineers were working in India in the year 2022.
    - Collaboration between the government, academia, and industry has led to the establishment of specialized training centers in key semiconductor hubs like Bengaluru and Noida.
        - This talent pipeline is crucial for sustaining India's growth in chip design and manufacturing.
- **Strategic Global Partnerships and Collaborations:** India's semiconductor ambitions are increasingly bolstered by strategic collaborations with global players.
    - Key partnerships include the joint ventures of Tata with Powerchip Semiconductor of Taiwan and the collaboration between Micron and the Gujarat government for a $2.75 billion OSAT facility.
    - These partnerships not only bring in crucial technology transfer but also align India with global semiconductor giants, positioning it as a key player in the global supply chain.
- **Transition to Advanced Semiconductor Technologies:** India is swiftly adopting advanced semiconductor technologies such as Silicon Carbide (SiC) and 3D Glass packaging, which are critical for sectors like defense, automotive, and AI.
    - These innovations are positioning India at the forefront of next-gen semiconductor capabilities, especially in power electronics and electric vehicles.
    - The government's focus on these technologies is clear from the establishment of the first commercial SiC fab in Odisha, set to produce high-performance chips for diverse applications.
- **Infrastructure Development and State-Level Initiatives:** India's semiconductor ecosystem is being supported by significant infrastructure development, including dedicated semiconductor parks and enhanced connectivity to global supply chains.
    - The introduction of plug-and-play facilities in Gujarat and Uttar Pradesh demonstrates India's effort to build an enabling environment for semiconductor fabs.
    - These state-led initiatives are integral to attracting more foreign investment and ensuring that the entire supply chain—from design to manufacturing—is localized.
- **Growing Domestic Market Demand:** The growing demand for semiconductor devices in India, particularly in smartphones, electric vehicles, and telecom, makes local chip production a national imperative.
    - As India is expected to reach 1 billion smartphones by 2026, from 770 million currently, the semiconductor market is set to expand significantly.
        - The Indian government's efforts to reduce dependence on imports and manufacture chips domestically are increasingly aligned with the nation's digital and defense strategies.
    - The country's first fully **indigenous 32-bit microprocessor, 'Vikram,'** designed & developed by the **Vikram Sarabhai Space Centre of ISRO in collaboration with SCL, Chandigarh**

What are the Key Issues Associated with India's Semiconductor Sector?

- **Lack of Advanced Fabrication Facilities: One of the major challenges facing India's semiconductor ambitions is the absence of advanced fabrication plants (fabs) that can produce high-end chips.**
    - Despite large investments and incentives from the government, India still lacks the infrastructure for cutting-edge semiconductor production, especially in nodes smaller than 28nm.
    - The global semiconductor market, increasingly reliant on advanced 5nm and 3nm chips, demands significant investment in high-tech fabs, something India has yet to fully

develop.
    - **As of 2025, India has only one mega fab under construction**, while countries like China have 44 fabs, and the US has 15.
        - Despite the ₹76,000 crore allocated under ISM, **India's current fabs target only mature nodes rather than advanced-node chips**, limiting its competitiveness in advanced semiconductor markets.
- **Talent Shortage and Skill Gap: India's semiconductor sector is facing a severe skill gap. Although the government aims to train 85,000 professionals through the** Chip to Startup (C2S) program**, a recent study estimated a shortage of 250,000-300,000 semiconductor professionals by 2027.**
    - The need for highly specialized talent in areas like advanced chip design, 3D packaging, and AI-enabled semiconductors remains unmet, hindering sector growth.
- **Dependence on Imported Equipment and Materials:** India's semiconductor sector remains heavily reliant on imported equipment and raw materials, such as specialized gases and chemicals.
    - This dependency puts India at risk of supply chain disruptions, as seen during the Covid-19 pandemic.
    - Despite efforts to localize parts of the supply chain, India still imports a large percentage of the materials required for semiconductor production, limiting the competitiveness of local fabs and increasing costs.
        - In FY 2023–24, its semiconductor imports surged by **18.5%.** At present, India imports roughly **90–95% of its semiconductor** and electronics components, with major suppliers including **China, Malaysia, Taiwan, Thailand, and Singapore.**
- **Geopolitical Risks and Global Competition: India's semiconductor sector faces increasing geopolitical challenges, particularly in a global environment where chip supply chains are being weaponized.**
    - The ongoing tensions between the US, China, and Taiwan, along with trade restrictions on chip technology, make India vulnerable to global political shifts.
    - The US-led "Chip 4" alliance aims to build a China-free supply chain, offering India an opportunity as an alternative hub but also exposing it to risks of tech denial if it falters.
- **Slow Pace of Project Implementation:** Despite the government's large financial commitments, the pace at which semiconductor projects are being implemented in India remains slow.
    - Delays in approvals, infrastructure development, and project timelines are preventing India from becoming a semiconductor powerhouse as quickly as it needs to.
    - These delays are critical as India seeks to capitalize on the rising global demand for chips, particularly in areas like electric vehicles, smartphones, and AI.
    - As of 2025, India has **only cleared 10 semiconductor projects** under ISM, with several still in the planning stages.
        - The **$19.5 billion Vedanta-Foxconn chip project collapsed in 2023** after Foxconn withdrew over tech partner and other challenges, dealing a setback to India's semiconductor ambitions.
- **Limited Focus on Front-End Manufacturing: India's semiconductor industry is currently skewed towards back-end operations like assembly, testing, marking, and packaging (ATMP), with limited progress in front-end fabrication.**
    - While OSAT projects are multiplying, the lack of front-end fabs for producing the actual chips limits India's role in the global semiconductor value chain.
        - This gap makes India a player in low-value-added activities and keeps it dependent on foreign players for core chip production.
    - While the country has a robust pool of over **20% of the world's chip design engineers**, its presence in the more **capital-intensive and value-added fabrication stage remains small.**
- **Inadequate Focus on Research and Development (R&D): While India has made strides in semiconductor manufacturing, it lags behind in semiconductor R&D.**
    - The lack of indigenous innovation in chip design and advanced semiconductor technologies like quantum computing and AI chips is a significant bottleneck.
        - Without a stronger focus on R&D, India risks being left behind as the global market shifts toward more specialized and complex semiconductor technologies.
- **Infrastructure and Connectivity Challenges:** While the government is developing semiconductor parks and other infrastructure, India still faces significant challenges in creating the

necessary connectivity between manufacturing hubs, research centers, and global markets.
    - Inadequate logistics and transport infrastructure in certain regions, especially in the development of state-level parks, could delay the scaling of semiconductor manufacturing and impede India's growth as a manufacturing hub.
    - Although states like **Uttar Pradesh** are developing dedicated semiconductor parks, these areas **lack sufficient infrastructure for efficient movement of materials and goods.**
        - In contrast, **semiconductor hubs in Taiwan and South Korea are already well-connected** with seamless logistics and supply chain systems.
- **Environmental Concerns and Sustainability: The semiconductor industry is resource-intensive, requiring significant energy and water consumption, as well as posing potential environmental risks.**
    - A large semiconductor plant producing 40,000 wafers per month consumes 4.8 million gallons of water daily
    - Also, India's semiconductor plans have yet to fully address the environmental challenges posed by the production processes, such as waste management and the carbon footprint of semiconductor fabs.

What Measures can India Adopt to Enhance the Semiconductor Sector?

- **Strengthening R&D and Innovation Ecosystem: To compete globally, India must significantly ramp up its investments in semiconductor research and development.**
    - By establishing dedicated R&D hubs for advanced chip technologies like quantum computing, AI, and 3D packaging, India can lead innovation in emerging sectors.
    - Strengthening partnerships between academia, industry, and government-backed research institutions can create a robust innovation pipeline, helping to bridge the technology gap with global leaders.
        - **Targeted grants for startups focused** on semiconductor R&D can further encourage homegrown innovations.
- **Accelerating Talent Development and Upskilling:** India must address the critical skill gap in the semiconductor industry through robust education and training programs.
    - A nationwide skill development initiative should focus on high-tech domains such as chip design, nano-manufacturing, and semiconductor materials science.
    - Collaboration between tech companies, universities, and vocational institutions can create specialized curriculums and hands-on training centers.
        - Additionally, incentivizing professionals to pursue advanced semiconductor-related courses through subsidies or scholarships will help in building a sustainable talent pool.
- **Fostering Private Sector Investment in Fabrication Plants:** India must incentivize private companies to establish advanced semiconductor fabrication plants (fabs) through targeted financial incentives and streamlined regulatory processes.
    - By offering substantial tax breaks and reducing the timeline for regulatory approvals, India can create a more attractive environment for foreign and domestic investors to build and scale fabrication units.
    - Ensuring long-term policy stability and transparent incentive structures will reduce investor risk and increase global confidence in India's semiconductor manufacturing capabilities.
- **Creating a Semiconductor Supply Chain Cluster:** India needs to focus on developing a comprehensive semiconductor supply chain ecosystem that includes raw material suppliers, component manufacturers, and testing facilities.
    - A semiconductor "super cluster" can be established, with strategic locations offering all the necessary infrastructure, including transportation, power, and skilled labor.
    - This holistic approach will not only support the semiconductor fabs but also foster collaborations between various players across the value chain, making India a competitive hub for semiconductor production and export.
- **Strengthening Environmental Regulations and Sustainability Practices:** Given the high resource intensity of semiconductor manufacturing, India must adopt stringent environmental regulations for the semiconductor industry.

    - Ensuring that fabs adhere to green building standards, implement water and energy conservation measures, and use sustainable raw materials will enhance the sector's global reputation.
    - Introducing eco-certifications for semiconductor projects and incentivizing companies to adopt circular economy practices can reduce environmental impact while also attracting green investments.
- **Building Strategic Alliances with Global Semiconductor Leaders:** India should deepen collaborations with global semiconductor powerhouses to secure technology transfer, supply chain integration, and strategic market access.
    - Forming joint ventures with leading semiconductor companies from Taiwan, the US, and Japan can facilitate knowledge exchange, particularly in advanced manufacturing technologies.
    - These partnerships can also help India secure access to critical technologies in the design and fabrication process, positioning the country as a key player in the global semiconductor ecosystem.
- **Revamping Policy Framework for Faster Approvals:** To speed up semiconductor sector growth, India must streamline its policy and regulatory frameworks, eliminating bureaucratic hurdles that delay project initiation.
    - A dedicated one-stop-shop for semiconductor investments can help expedite the approval process for new fabs and related infrastructure projects.
    - Reducing the paperwork, providing faster land clearances, and offering more flexible zoning laws will foster a quicker and more dynamic semiconductor development environment.
- **Promoting Fabless Semiconductor Startups:** India should actively support the growth of fabless semiconductor companies, which focus on designing chips but outsource manufacturing to established fabs.
    - By providing design-linked incentives (DLI) and easier access to venture capital, India can stimulate a thriving ecosystem of semiconductor startups.
    - Encouraging these companies to create innovative chips for industries like automotive, telecom, and consumer electronics will diversify India's semiconductor offerings and reduce dependence on foreign chip designs.
- **Integrating Semiconductor Manufacturing with Digital India Initiatives:** India should leverage its growing digital infrastructure, such as the National Digital Highway and 5G rollout, as a platform for boosting semiconductor demand.
    - By aligning semiconductor production with Digital India initiatives, the country can ensure a strong domestic market for chips.
    - Government-backed programs for IoT, smart cities, and AI-enabled technologies should be tied to local chip manufacturing, creating a steady and guaranteed demand for semiconductors in both public and private sectors.

Conclusion:

India's semiconductor journey stands at a defining moment—backed by strong policies, global collaborations, and rising domestic capabilities. While challenges in advanced fabrication, talent, and supply chains remain, the trajectory is clear. As the **Indian Prime Minister emphasized at Semicon India 2025, India is poised to be Designed in India, Made in India, and Trusted by the world** . With the world ready to build the semiconductor future with India, the nation has a unique opportunity to emerge as a resilient and competitive chip powerhouse.

Drishti Mains Question:

"India's semiconductor sector stands at the crossroads of opportunity and vulnerability — with rising investments, strategic global alignments, and persistent structural challenges." Discuss in the context of India's ambition to emerge as a global chip manufacturing hub by 2030.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims:

Q. Which one of the following laser types is used in a laser printer? (2008)

(a) Dye laser
(b) Gas laser
(c) Semiconductor laser
(d) Excimer laser

Ans: (c)

Mains

Q. India aims to become a semiconductor manufacturing hub. What are the challenges faced by the semiconductor industry in India? Mention the salient features of the India Semiconductor Mission. (2025)