

5. Global Hub for semiconductor design and R&D – Economy

India is increasingly emerging as a global hub for semiconductor design and R&D, leveraging its strong human capital and expanding digital ecosystem. However, transitioning from a design-led ecosystem to a full-fledged semiconductor manufacturing powerhouse remains a strategic and economic challenge.

1. Semiconductors- Concept and Nature

1. Definition and composition

1. Semiconductors are materials with electrical conductivity between conductors and insulators, commonly made of silicon.
2. They are fabricated into integrated circuits containing millions or billions of transistors, diodes, capacitors, and resistors.

2. Functional role

1. They process, store, and transmit electrical signals in electronic systems.
2. Act as the core building blocks of all modern digital devices.

2. Importance of Semiconductors

1. Backbone of digital economy

1. Power devices such as smartphones, computers, data centres, and telecom infrastructure.
2. Enable digital governance, fintech, e-commerce, and cloud computing ecosystems.

2. Strategic and national security dimension

1. Essential for defence electronics, missile systems, and surveillance technologies.
2. Secure supply chains reduce vulnerability to geopolitical disruptions.

3. Enabler of emerging technologies

1. Critical for Artificial Intelligence, 5G networks, Internet of Things, electric vehicles, and quantum computing.
2. High-performance chips drive innovation in automation and Industry 4.0.

4. Economic growth and industrialisation

1. The global semiconductor market is projected to reach USD 1 trillion by 2030.
2. Acts as a multiplier industry, stimulating electronics manufacturing and exports.

3. India's Emerging Strength- Design and R&D Hub

1. Strong human capital base

1. India accounts for nearly 20 percent of the global semiconductor design workforce.
2. Large pool of engineers skilled in chip design and embedded systems.

2. Global Capability Centres (GCCs)

1. India hosts around 7 percent of global semiconductor GCCs.
2. Multinational firms undertake advanced chip design, including cutting-edge nodes such as 2 nm.

3. Design-led ecosystem advantage

1. India has established leadership in fabless design and intellectual property development.
2. Strong presence in VLSI design, chip verification, and system architecture.

4. Challenges in Semiconductor Manufacturing

1. High capital intensity

1. Semiconductor fabs require investments of billions of dollars.

2. Long gestation periods and uncertain returns deter private investment.

2. Technological barriers

1. Advanced chip manufacturing technologies are concentrated in a few countries.
2. Limited access to cutting-edge lithography and fabrication equipment.

3. Complex production ecosystem

1. Chip manufacturing involves 500–1500 highly specialised steps.
2. Requires ultra-clean environments, uninterrupted power supply, and large quantities of pure water.

4. Skill gap in fabrication

1. India has strength in design but lacks trained workforce for fab operations.
2. Need for technicians, process engineers, and equipment specialists.

5. Policy and regulatory challenges

1. Concerns over policy stability, bureaucratic delays, and tariff structures.
2. Fragmented institutional coordination across ministries.

6. Weak research ecosystem

1. Limited original research and innovation in semiconductor materials and processes.
2. Dependence on imported technology and intellectual property.

5. Government Initiatives and Policy Framework

1. Semion India Programme

1. Aims to build a comprehensive semiconductor and display manufacturing ecosystem.
2. Provides financial incentives for fabs, packaging, and design.

2. India Semiconductor Mission 2.0

1. Focuses on equipment manufacturing, materials, and full-stack design capabilities.
2. Seeks to strengthen supply chain resilience and domestic IP development.

3. Design Linked Incentive (DLI) Scheme

1. Encourages design and development of integrated circuits, chipsets, and system-on-chip solutions.
2. Promotes innovation and startup participation in semiconductor design.

4. Research and innovation initiatives

1. Anusandhan National Research Foundation supports academic-industry collaboration in deep tech domains.
2. Research, Development and Innovation Fund promote commercialization of critical technologies.

5. Capacity building programs

1. Indian Nanoelectronics Users' Programme supports R&D through advanced nano-centres at premier institutions.
2. Focus on strengthening academic infrastructure and research capabilities.

6. Strategic Partnerships and Global Integration

1. International collaborations

1. Initiatives like India-US iCET promote cooperation in critical and emerging technologies.
2. Partnerships with global semiconductor firms for technology transfer.

2. Supply chain diversification

1. India aims to position itself as an alternative manufacturing hub amid global geopolitical shifts.
2. Integration into trusted semiconductor supply chains is a key objective.

7. Way Forward

1. Develop fabrication ecosystem

1. Establish semiconductor fabs with sustained fiscal and policy support.
2. Promote ancillary industries such as chemicals, gases, and equipment manufacturing.

2. Strengthen research and innovation

1. Invest in indigenous R&D in semiconductor materials and advanced nodes.
2. Encourage academia-industry collaboration and patent generation.

3. Skill development and workforce planning

1. Create specialised training programs for fab technicians and engineers.
2. Align skilling initiatives with industry requirements.

4. Policy coherence and governance reform

1. Ensure stable, predictable and investor-friendly policy environment.
2. Improve inter-ministerial coordination and ease of doing business.

Conclusion

India's rise as a semiconductor design hub provides a strong foundation, but achieving manufacturing self-reliance requires overcoming structural, technological, and institutional challenges. With sustained policy support, strategic partnerships, and investment in innovation, India can emerge as a significant player in the global semiconductor value chain.

Source- <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2239608®=3&lang=1#~~~text=As%20per%20Industry%20estimates%2C%20India,global%20semiconductor%20chip%20design%20workforce>

