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INDIA FRONT

Volume 1, Issue 2 I DECEMBER 2025
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Issue Theme: The Silicon Ambition

BIG AMBITION. BIGGER ACTION.

GLOBAL IMPACT: GUARANTEED.



PANKAJ MOHINDROO, Chairman, ICEA
India's Silicon Resolve is massive. The $500 billion gambit is just the starting point.
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A strategic macroeconomic blueprint designed for leadership
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You make it.
This content isn't for the passive observer. It is for the architect of the new economy. The pages you just turned hold the insights of those in the arena—the decision-makers, the risk-takers, and the builders. If you are looking for the edge that separates the leader from the follower, you have found your home.
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The story of India is a narrative of exponential ambition, playing out on the demanding stage of Semiconductors. The microchip is the physical architecture of national sovereignty, digital infrastructure, and industrial capacity. The world is betting trillions on this technology, and India has made a decisive wager on its own capability.

We launch the second edition of India Front, focused on The Silicon Mission, at this pivotal juncture. The national commitment is clear, but success now demands a ruthless focus on execution. We must unpack the single most critical challenge: establishing the high-volume, domestic technological backbone necessary for self-reliance.

To map the definitive blueprint for this mission, we have convened an elite cohort of eleven leaders, led by our cover story featuring Pankaj Mohindroo of ICEA. He outlines the strategic vision required to pivot India from simply consuming electronics to becoming a global manufacturing powerhouse, securing the end-to-end supply chain. Critical strategic and macro-economic analysis is provided by Dr Arvind Virmani of NITI Aayog. We gain essential insights into the product paradigm from Raja Manickam of iVP Semi, and a deep dive into skill transformation from Jayant Krishna of NSDC. Raghu Panicker of Kaynes Semicon provides the crucial solutions necessary to achieve the zero-defect standard. Dr Danish Faruqui of Fab Economics cuts through the hype with his thesis, Vande Silicon Turns Capital into Capability.

Shari Liss of the SEMI Foundation outlines the path to redefining the workforce architecture for global standards. Kumar Priyadarshi of TechoVedas champions domestic equipment mastery as the final step to true sovereignty. The implementation journey is captured by Mona Khandhar (GoI), detailing the execution masterclass of Fab-ulous Gujarat, while Anil Bhardwaj of FISME maps the path for our Small Giants—the MSME sector—to anchor the supply chain. Enjoy this edition, and best wishes for the new year.

Rishi Vora
Editor and Publisher

SOLUTIONS SNAPSHOT



PANKAJ MOHINDROO, Chairman, ICEA
We would benefit from having two or three display fabs to complement the semiconductor units.



Shari Liss, VP, Global Workforce Development & Initiatives, SEMI & SEMI Foundation
We must certify "Fab-Ready" instructors to expand training capacity exponentially. This ensures students learn the reality of the shop floor, not just the theory of the textbook.



Jayant Krishna, former CEO & COO, NSDC
India's rising stature is insufficient to command attention in the fiercely competitive global chip-making landscape. Soft power won't work here; only execution excellence will.



Raghu Panicker, CEO, Kaynes Semicon
It is imperative that all subsidised OSAT units are mandated to use a specified proportion of locally approved materials. Guaranteed Consumption Agreements reduce the risk for domestic suppliers, allowing them to achieve global standards.



Mona Khandhar, Former Principal Secretary (Science & Technology), Gujarat Government
Gujarat has prepared a 20 MLD Common Effluent Treatment Plant (CETP) and plans to advance sewage treatment to tertiary levels, thereby completing the sustainability cycle.



Dr. Sunil R Parekh, Chairman CERC, Founding Curator AGS - World Economic Forum; and Advisor to Zydus & Jubilant
Gujarat is not just giving subsidies on paper. It is actively laying down the physical infrastructure, which is upgrading rapidly. Undoubtedly, speed is the Key in Gujarat's success.



Dr Arvind Virmani, NITI Aayog Member

The ultimate test is the percentage of your economy that a hostile supplier can choke off. We must ensure no external denial can paralyse the state. This secures a nation that is sovereign by definition and unbreakable in spirit.



Dr Danish Faruqui,
Chief Executive Officer of Fab Economics

India has the potential to produce over 300,000 semiconductor manufacturing and packaging workers over the next ten years—four times the domestic requirement.



Anil Bhardwaj, Secretary General, FISME

The final 10-20% of the government's PLI payout should be tied to verifiable local sourcing. This Local Linkage Doctrine compels global giants to uplift local vendors, transforming transactions into structural partnerships.



Raja Manickam, Founder & CEO, iVP Semi

Service nations earn wages; product nations build wealth. India must escape the Capex Trap—where subsidies merely fund foreign equipment imports—and pivot toward genuine IP ownership. By mandating technology transfer and enforcing a zero-defect mandate measured in parts-per-billion, we transition from a design-service hub to a high-margin global powerhouse.



Kumar Priyadarshi, Founder, Bharat Semitech & TechoVedas

Advanced blueprints are useless without the skilled hands to execute them. We must pivot to polytechnic graduates—the true captains of this revolution. They possess the muscle memory and technical discipline required to translate digital design into steel and silicon.

INDIA FRONT

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The Great Indian Silicon Ambition: An Introduction

The 10 Commandments of Success

Rishi Vora

The signal was unmistakable. At Semicon India 2025, Prime Minister Narendra Modi was presented with the Vikram 3201 processor—a fully indigenous chip forged by ISRO's SCL. It was a symbolic victory. But symbols do not run economies. The real revolution cannot take place in a conference hall in New Delhi; it is taking shape on the industrial plains of Gujarat and Assam.

The silence of those plains has been shattered. The roar of piling rigs now drowns out the decade-long hum of policy debates. This is the sound of committed capital hitting the ground. Tata Electronics is pouring ₹91,000 crores ($11 billion) into Dholera. Micron has committed $2.75 billion to its assembly hub. CG Power is deploying ₹7,600 crores. We have moved from a theoretical "if" to a logistical "how." This edition of India Front Magazine documents this historical pivot.

India currently faces a projected import bill of $123 billion in 2025. We are technologically dependent. In our cover story, ICEA Chairman Pankaj Mohindroo sketches the counter-strategy: a $500 billion manufacturing blueprint. NITI Aayog's Dr Arvind Virmani adds the strategic steel, defining the "Chokepoint Doctrine." We are building a resilience shield against global supply chain shocks. The goal is absolute industrial sovereignty.

Yet, capital is the easy part. The true challenge is execution. We are starting with 28 nm legacy nodes while global

leaders race toward 2nm. We are a decade behind. This is why speed is the only variable that matters.

Mona Khandhar reveals the administrative master-class behind "Fab-ulous Gujarat," showing how the state is compressing a ten-year learning curve into a 24-month sprint. But building the shell is useless without mastering the atom. Raghu Panicker of Kaynes Semicon demands a "zero defect" culture. In a market where we compete with established global fabs, "good enough" is a failure.

Raja Manickam challenges us to stop being a "service nation." We must become a "product nation" that owns the IP. Kumar Priyadarshi takes the mission deeper, arguing for "Equipment Sovereignty"—because if we import the tools, we remain dependent. Meanwhile, Anil Bhardwaj maps the path for our MSMEs to anchor this supply chain with a new digital discipline.

Finally, the story turns to the ultimate bottleneck: the human mind. Reports indicate we face a shortage of 300,000 professionals by 2027. Shari Liss of the SEMI Foundation steps in with the solution: a "pedagogical pivot" to tear down the walls between the classroom and the clean-room. Jayant Krishna reinforces this hard truth: we cannot download a mindset. We must purge the "Chalta Hai" attitude and forge a workforce of absolute industrial precision.

From these blueprints, a new industrial code emerges. Distilled from the insights of these architects, here are the immutable laws for our ascent.

1. Build for the World

The era of import substitution is dead. As Pankaj Mohindroo asserts, a domestic market of $110 billion cannot sustain a $500 billion ambition. The mandate is clear: India cannot afford to manufacture a chip that isn't competitive in Taiwan or California.

2. Sovereignty Means Owning the Machine

True independence is not owning the chip; it is owning the tool that builds it. Kumar Priyadarshi warns that if we import the critical subsystems, we remain a vassal state. The commandment is "Equipment Sovereignty".

3. Zero Defects is the Only Religion

In the silicon world, perfection is not a goal; it is a baseline. Raghu Panicker defines the new standard: when a single speck of dust can destroy a wafer, the margin for error is zero. This requires replacing approximation with precision.

4. Build an Ecosystem, Not Just a Factory

Capital is fleeting; infrastructure is forever. Dr Sunil Parekh distinguishes between buying a factory and building a legacy. A fab cannot stand alone; it needs a "village" of reliable drainage, redundant power, and ultra-pure water.

5. Speed is the Currency

Opportunity does not wait for bureaucracy. Mona Khandhar's "Gujarat Model" proves that the only competitive advantage against China is velocity. In a sector where technology cycles last 18 months, a six-month delay is catastrophic.

6. Kill the Chalta Hai Mindset

We cannot download a workforce. Jayant Krishna warns that our greatest enemy is cultural, not technical. The Chalta Hai (it's okay) attitude is incompatible with nanometre precision. We must forge a workforce of military-grade compliance where protocol is sacred.

7. Solve the Pareto Risk

The machines are useless without the minds to run them. Dr Danish Faruqui identifies the talent shortage as a Pareto risk—the single most significant threat to fab utilisation. Shari Liss provides the solution: the "Earn-and-Learn" model.

8. Move from Service to Product

India must stop being the world's back office. Raja Manickam argues that the "Service Nation" model earns wages, but the "Product Nation" approach earns wealth. We must own the IP and dictate the roadmap.

9. Digitise the DNA

For the 63 million MSMEs, access to the market requires data. Anil Bhardwaj prescribes the "Digital Caliper Revolution". Small enterprises must pivot from visual approximation to digital logging. If you cannot trace it, you cannot sell it. Digitisation is a passport to the global supply chain.

10. Secure the Chokepoints

National security is defined by the percentage of the economy that a hostile supplier can switch off. Dr Arvind Virmani's "Chokepoint Doctrine" dictates that we must identify and immunise the specific technologies that can paralyse our economy. We must reduce that vulnerability to zero.



PANKAJ MOHINDROO
Chairman, ICEA

THE $500 BILLION BLUEPRINT

From Service Giant to Product Sovereign. ICEA Chairman Pankaj Mohindroo decodes the definitive strategy to pivot India from a digital back-office to a hardware architect.

Rishi Vora

The silhouette of construction cranes rising over the arid plains of Dholera signifies more than infrastructure. It signals the definitive arrival of India's industrial resolve. For fourteen years, the nation's semiconductor ambitions matured through high-level policy debates. Today, as the first fabrication unit emerges, those theoretical frameworks have crystallised into physical reality. But Dholera is not the destination. It is merely the launchpad. The government's vision extends far beyond erecting a factory; it is to build a legacy in the global value chain. The target is a staggering $500 billion in electronics production by 2031. **Pankaj Mohindroo**, Chairman of ICEA and the veteran architect of this ecosystem, argues that India is undergoing a definitive evolution. We are shifting focus from satisfying domestic demand to commanding global markets. To navigate this high-stakes marathon, India Front's **Rishi Vora** sat down with him to decode the operational reality of this transition.

The physical emergence of the Fab in Dholera is a powerful visual. Does this moment feel like vindication for the ecosystem after fourteen years of policy oscillation, or is it just the beginning of the real marathon?

It is undoubtedly vindication. I have been deeply involved in this gruelling, long-gestational battle for nearly fifteen years. Bringing the stakeholders to a consensus was an intricate exercise in industrial diplomacy. Seeing the infrastructure rise at Dholera is the tangible proof that the India Semiconductor Mission (ISM) has graduated from

PowerPoint to concrete. However, you are right to acknowledge that it is just the beginning. The execution phase is brutal. We are two years away from the first chip, and that is when the real race for yield, efficiency, and market share begins.

There is a concern that our domestic consumption—projected around $110 billion—cannot entirely absorb the output of the Dholera fab. Are we risking a supply glut without formal purchase guarantees?

We must promptly address the arithmetic. The $110 billion figure is a consumption metric, which is irrelevant to our strategic goals. Our vision is production, not just consumption. The target is $500 billion in total output by 2031. Let me break down that number: $350 billion will come from final products, $75 billion from sub-assemblies, and a critical $75 billion from components—including $15 billion in pure semiconductors. The domestic market provides a robust $80 billion foundation. However, to reach the $500 billion target, we must leverage this volume to achieve the global competitiveness required for exports. The market is not the Indian consumer buying a phone; the market is the global OEM embedding an Indian-designed, Indian-fabricated chip into their supply chain. If we rely solely on domestic absorption, the math fails. We are building for the world.



A major counterargument from sceptics is the Chinese price. Can Indian chips, even with PLI, compete with Chinese legacy nodes?

The narrative of cheap Chinese dumping is a dangerous fallacy we tell ourselves to feel superior. We must shed this complacency. China is not winning because of low prices; they are winning due to their competence. They are producing high-node chips with terrifying aggression, scale, and quality. It is a myth that their products are inferior. To compete, India cannot rely on tariffs alone. We are entering a hyper-competitive arena where Chinese incumbents are aggressive on price because they have mastered yield and volume. We have to match that industrial athleticism. The China Plus One sentiment opens the door, but only competitive excellence will keep us in the room.

> **“Seeing the infrastructure rise at Dholera is tangible proof that the India Semiconductor Mission (ISM) has graduated from Power-Point to concrete. However, you are right to acknowledge that it is just the beginning. The execution phase is brutal. We are two years away from the first chip, and that is when the real race for yield, efficiency, and market share begins.**



You cannot build a capital-intensive ecosystem like semiconductors when your money costs twice as much as your rival's. We have petitioned the government: if you want a $500 billion reality, you must level the financial playing field through aggressive interest subvention.

Let's address the node distinction. While the public imagination often defaults to smartphone chips, the Dholera facility's focus is to power industrial electronics.

That is an accurate reading of the roadmap. We must decouple the public fascination with ultra-advanced smartphone chips from the industrial reality. The $50,000 wafers rolling out of Dholera are not intended for flagship handsets—that is not the immediate target. The real volume lies in the foundational layers: industrial electronics, automotive systems, and consumer durables like air conditioning. These sectors rely heavily on higher nodes. By securing this layer, we aren't just filling a gap; we are powering the operational backbone of the global economy.

Solutions Spotlight

1. **The Financial Equaliser:** The state must neutralise the 5% interest rate disadvantage against China and Vietnam to make capital-intensive fabs viable through aggressive interest subvention.

2. **The Missing Link:** Launch a dedicated incentive scheme to establish 2-3 Display Fabs, closing the critical gap in the electronics supply chain.

3. **The Volume Play:** Prioritise legacy nodes (28nm+) for industrial and automotive electronics, where volume and longevity outstrip the volatility of smartphone chips.

We are engaging in a volume-based strategy, focussing on areas with the highest demand.

How do we transition from an ecosystem of service providers to one of product owners who architect and hold the intellectual property?

I want to address the criticism often levelled at this phase of our evolution—what some cynically call being "Tech Coolies". I strongly reject that label. The service economy was a blessing, contributing to the establishment of our current capital reserves and talent pipeline. A coolie carries the load that makes the journey possible; that value is immense. However, the pivot is now non-negotiable. We have mastered "design" for MNCs. The next step is architectural sovereignty—designing the product, owning the mask set, fabricating it locally, and finding the customer. That is the difference between a contractor and an industrial power. We are seeing major conglomerates like L&T entering the design space. Startups are entering the design space, but big capital is making a significant impact to bridge the gap from design to product.

Beyond the PLI and government investments, Indian manufacturing still contends with structural disabilities.

We have solved the labour arbitrage; our demo-



The government must move from being a regulator to a partner. Build the pipelines of trust, and then be merciless on those who evade it. But do not choke the ecosystem with suspicion before it even learns to breathe.

graphic dividend is real. We have solved the power cost issue; we are now competitive with China. The remaining anchor is the cost of capital. An Indian manufacturer fights with one hand tied behind their back, paying 7.5% to 8.5% interest. A competitor in China or Vietnam pays 3% to 4%. This interest rate gap of nearly 5% is a lethal structural tax. You cannot build a capital-intensive ecosystem like semiconductors when your money costs twice as much as your rival's. We have petitioned the government: if you want a $500 billion reality, you must level the financial playing field through aggressive interest subvention.

Looking at the ecosystem gaps, where is the next immediate fire that needs fighting?

The glare is on the Fab, but the void is in the Display sector. We do not have a single display fab. For a nation aiming to be a global electronics hub, this is a gaping hole. We would benefit from having two or three display fabs to complement the semiconductor units. That is the unfinished agenda of ISM 2.0.

Finally, if you had to distil the industry's request to the Government of India into a single mandate for the next decade, what would it be?

Trust us. When Arun Jaitley was finance minister, he asked me the same question. My answer remains unchanged. We are transforming a nation's historical view of the private sector with suspicion. The government must move from being a regulator to a partner. Build the pipelines of trust, and then be merciless on those who evade it. But do not choke the ecosystem with suspicion before it even learns to breathe.

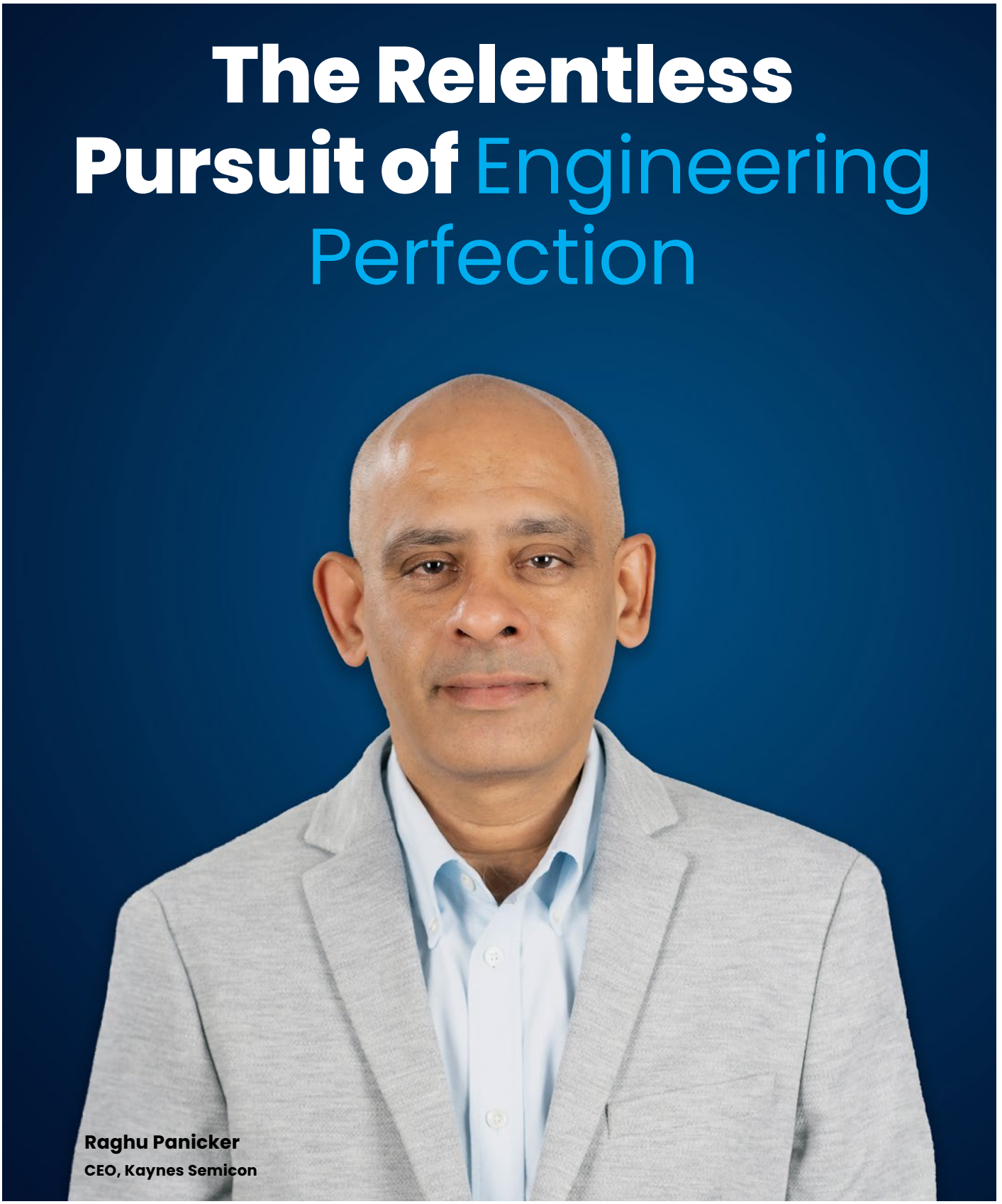
Key Takeaways

Harmonise domestic consumption with global scale. The strategy is no longer "Import Substitution" versus "Export Growth"—it is both. By securing the $100 billion domestic market as a baseline and targeting the global value chain for scale, India activates two engines of growth simultaneously. This creates a manufacturing ecosystem that is resilient by design.

Strategy Note

1. The Math of Export: Domestic demand is insufficient to sustain the mega-fabs; export is not a choice; it is an arithmetic necessity.
2. Competence over Cost: China wins on yield and quality, not just subsidy. We must match their engineering rigour.
3. The Capital Tax: Without aggressive interest subvention, the 5% cost-of-capital gap makes Indian manufacturing structurally uncompetitive.

The Relentless Pursuit of Engineering Perfection



Raghu Panicker
CEO, Kaynes Semicon

Supremacy is not purchased; it is engineered. Raghu Panicker, CEO of Kaynes Semicon, argues that the true test of our ambition lies in mastering the unforgiving physics of zero defects

Rishi Vora

The thrilling race for India's semiconductor sovereignty requires operational excellence. Economic stakes are high: the domestic market, worth over $41 billion, is expected to grow 19% to $109 billion by 2030. National investment in ten packaging and fabrication projects has accelerated this historic opportunity. But turning this momentum into technological autonomy requires capital and high-quality standards. The zero-defect mandate depends solely on outsourced semiconductor assembly and test (OSAT). Perfect, world-class execution across materials, infrastructure, and human capital is now the main challenge, not investment.

In this high-stakes environment, the perspective of key industry figures is vital. **Raghu Panicker** identifies the "Zero Defect" mandate as the industry's great filter. His vision extends beyond simply building factories; it encompasses the development of a self-sufficient ecosystem capable of surviving the unforgiving physics of advanced packaging, propelling India to the forefront of next-generation packaging technologies.

Built to Endure

The pursuit of global yield rates is the ultimate test of an OSAT ecosystem. As India embraces advanced packaging methods essential for the next generation of 7nm and 5nm process nodes, the technical complexity increases exponentially. Miniaturised computing packages, which tightly integrate multiple specialised chips for logic, memory, and functions into a single unit, quietly undermine long-term reliability.

Such a challenge stems from the inherent friction created when dissimilar materials, such as rigid silicon and

flexible protective polymers (the soft side of the chip), are tightly bonded together. When exposed to the intense, repeated heat and cooling cycles of real-world operation—as in a car engine or a high-powered AI data centre—these materials expand at different rates. This is the nightmare scenario: a chip that passes the factory test but fails in the field. To fix this, Panicker advocates for urgent funding in material science. India's quality manufacturing must be founded on proprietary polymer science rather than on borrowed process optimisation. "We must own the chemistry of the adhesives and underfills that hold the package together rather than on borrowed process optimisation." He argues that Indian research and development should focus on creating and standardising high-reliability and low-stress polymeric materials. Furthermore, he notes that the evolving supply chain requires new national measurement standards and enhanced testing methods to ensure the consistency and stability of underfills and adhesives.



"We must own the chemistry of the adhesives and underfills that hold the package together rather than on borrowed process optimisation

Intelligence over Inspection

Data drives efficiency in an industry where nanometre precision and tight margins are paramount. Traditional controls have proven too slow for the demands of modern scaling. The global market for digital twin technology is experiencing significant growth, projected to expand at a compound annual growth rate (CAGR) of approximately 48%. This transformation represents a shift from reactive control to proactive, intelligent governance.

In an industry where margins are measured in nanometres, traditional quality control is too slow. Panicker highlights the "highest immediate return" investment: AI-driven predictive manufacturing. He asserts that this optimal return stems from the strategic integration of Predictive Yield Optimisation (PYO) and Virtual Metrology (VM). This approach leverages machine learning to swiftly analyse vast amounts of real-time sensor data on the factory floor, enabling the prediction of potential defects and the recommendation of optimal process adjustments before the chip undergoes final testing.

"By merging PYO with predictive maintenance—which has the potential to reduce unexpected downtime by 20%—we address the dual need for consistent quality and stable production," Panicker elaborates. "Moreover, our attention must be directed towards advanced digital twin models that utilise sophisticated computational techniques. This method encompasses the application of computational fluid dynamics (CFD), which simulates heat transfer within the packaged chip, and finite element analysis (FEA), which assesses mechanical stress and structural integrity. This capability allows us to swiftly predict heat distribution and residual stresses in complex packaged devices, effectively transitioning quality control from a reliance on historical measurements to the anticipation of potential issues ahead of time."

Securing Global Trust

India's commitment to the semiconductor ecosystem is substantial. Yet accessing the global market, particularly high-reliability sectors, demands immediate, ironclad trust. Securing certification from a major internation-

al Tier-1 customer involves a gruelling process of deep quality audits, detailed documentation (like PFMEA), and the rigorous production part approval process (PPAP). To overcome the perception of being a nascent ecosystem, India needs a single mechanism to validate its quality baseline. "The policy mechanism most needed to rapidly build global trust and facilitate certification for all Indian OSAT players is the establishment of a National Consortium Quality Board (NCQB)," Panicker argues. This industry-led board will harmonise all quality documentation and enforce compliance with global standards by issuing a formal, globally recognised process maturity endorsement. This centralised vetting process would dramatically accelerate the trust-building timeline required for international qualifications.

Collective investment in capital-intensive resources is required to move to advanced chip stacking, which is vital for AI and high-performance applications. High-end metrology tools—the specialised machines necessary for the non-destructive inspection of ultra-fine-pitch microbumps and verification of precision assemblies—are expensive for the new entrants. "To enable the ecosystem to successfully implement advanced packaging, the critical shared resource needing immediate collective investment is the establishment of a National Advanced Packaging Metrology Center (NAPMC)," Panicker advises. The high initial costs can be effectively reduced by pooling these advanced metrology tools, allowing all Indian OSAT companies to quickly check their complex processes and speed up their technological development.

Mastering the Execution

The strategic localisation of the semiconductor industry's supply chain is crucial for self-sufficiency. Although securing silicon wafers remains a long-term goal, there is presently a promising opportunity within the field of speciality materials. Panicker observes that semiconductor-grade encapsulation materials (moulding compounds) are among the most vital input materials that could be fully localised in India over the next two to three years. India's well-established chemical industry makes achieving the required purity levels a feasible technical objective.

While the ISM provides 50% financial assistance for capital expenditures, the real need lies in policy support that goes beyond monetary aid. Panicker advocates for the implementation of guaranteed consumption agreements (GCAs). He states, "It is imperative that all subsidised OSAT units, such as those supported by Micron, Tata, and CG Power, are mandated to use a specified proportion of locally approved encapsulation materials." This policy reduces the risk linked to the material supplier's initial investment by establishing a stable internal market. This enables companies to accelerate their development and achieve global standards.

Additionally, the concluding phase of testing often emerges as a considerable bottleneck. Currently, the Indian ecosystem does not possess adequate specialised testing equipment (referred to as Automatic Test Equipment, or ATE), which is necessary for high-frequency, advanced devices crucial for 5G, electric vehicles, and AI applications. Although the Design Linked Incentive (DLI) scheme promotes indigenous chip designs, this limitation hampers their validation procedures. Panicker underscores that the development of national advanced testing centres (NATCs) must be a central priority of the nation's investment policies. Consolidating specialised ATEs in shared facilities reduces the financial burden on individual companies. "We must

Solutions Spotlight

1. **The Trust Engine:** Establish a National Consortium Quality Board (NCQB) to issue global-standard "Process Maturity Endorsements," accelerating vendor qualification.
2. **The Shared Eye:** Create a National Advanced Packaging Metrology Center (NAPMC) to provide startups access to ultra-expensive inspection tools without the CapEx burden.
3. **The Chemistry First Policy:** Fund proprietary polymer science R&D. We cannot rely on imported glues; we must own the materials that hold the chip together.

promptly establish and execute standardised testing protocols to ensure that this process complies with international standards," he maintains.

Finally, the entire endeavour rests on human capital. India needs 85,000 skilled engineers by 2027 to meet the surging demand in the electronics sector. The most challenging specialised skill to instill in entry-level staff is not technical knowledge but operational discipline—static-safe precision handling (ESD-compliant micro-handling). This skill demands continuous, non-negotiable adherence to protocol. "To standardise this critical procedure and overcome cultural inertia, we must implement mandatory continuous training using virtual reality (VR) and augmented reality (AR) in cleanroom simulation environments," Panicker recommends. These technologies allow trainees to practise rigorous protocol compliance in high-fidelity, measured environments before ever touching sensitive silicon.

To maintain this highly specialised workforce and ensure permanent expertise, two structural solutions are proposed: to prevent the operational wisdom brought by expat experts from departing, Panicker calls for the India Semiconductor Technology Transfer Fellowship (ISTTF). "This program should require that expats clearly document important operational steps and the key principles of a zero-defect culture in official, localised training manuals." He explains that this process transfers tacit expertise into a permanent organisational capability. Panicker calls for the National Semiconductor Engineering Accreditation Framework (NSEAF) to support the highly trained technicians whose mastery of cleanroom procedures is vital. This step-by-step accreditation system, which relies on proven skills, needs to establish official partnerships with state technical universities to award academic credits for specialised cleanroom experiences. This national recognition elevates the technician's professional status and provides a clear long-term growth pathway within the ecosystem.

Redefining Global OSAT Standards

The investment acquisition phase is complete. India has successfully developed its semiconductor ambitions into a portfolio of ten approved projects, supported by a commitment of ₹1.6 trillion. Implementation precision is now the priority. To succeed at this crucial juncture, systemic policy must align with a culture of zero defects. In addition to hiring 85,000 skilled engineers by 2027 and acquiring advanced ATE, the challenge lies in building a robust, independent system that can adapt to global changes and meet the highest reliability standards.

India is moving beyond mere borrowing by implementing a specialised framework that integrates national R&D efforts for proprietary polymeric materials, institutionalises quality through the NCQB, and retains talent through the NSEAF. The nation is well-positioned to engage in the global semiconductor industry and shape the next era of world-class OSAT excellence.

Key takeaways

1. **The Thermal Timebomb:** The biggest risk isn't electrical; it's mechanical. Thermal mismatch between chip and package is the silent killer we must solve with material science.
2. **Predict, Don't Inspect:** Traditional QC is dead. The future is Virtual Metrology and Digital Twins that predict failures before they occur.
3. **Tacit Knowledge:** We must capture the muscle memory of expat experts. The India Semiconductor Technology Transfer Fellowship should mandate that expats document their unwritten operational wisdom into permanent manuals.

Strategy Note

Panicker's masterstroke is the GCA (Guaranteed Consumption Agreement). By legally forcing PLI beneficiaries to source a percentage of materials (like moulding compounds) locally, he creates an instant, guaranteed market for Indian chemical companies, removing the risk of entry.

THE SIGNAL IN THE NOISE

The world is loud, and business is chaotic. While others are busy chasing the headlines of what happened yesterday, we are focused on the blueprints for tomorrow.

India Front is not a ledger of events; it is a playbook for execution. We cut through the clutter to bring you the raw strategies from the minds shaping the nation. We believe that true leadership isn't about consuming information; it is about finding clarity.

No fluff. No speculation. Just the unvarnished strategy of ascent. This is not news; this is intelligence.

INDIA FRONT

INFORM. INSPIRE. INVOLVE.

The Manual for Indiav's Industrial Ascendancy.



Shari Liss, VP, SEMI Foundation

A Global Perspective:

Converting Demographics into Dominion

Shari Liss, VP, Global Workforce Development and Initiatives, SEMI & SEMI Foundation, outlines the roadmap for India to meet the global standard.

Amishi Mehta

India is poised to embark on a historic industrial revolution. As the semiconductor market enters a trajectory of rapid ascent—projected to breach $100 billion by 2030—the challenge shifts from capital to capability. The establishment of new fabs demands an estimated 70,000 highly skilled engineers and technicians in the next five years. This talent deficit is India's most critical challenge; it is also its greatest opportunity. The nation possesses the demographic dynamism the world envies, but volume is not skill. The solution requires a radical redefinition of workforce architecture. Shari Liss, VP, SEMI Foundation, advocates for aggressive "earn-and-learn" models and global partnerships to ensure India commands the future of silicon.

Guardians of Yield

The modern fabrication plant demands operational mastery. Liss identifies the "Technician Gap" as the primary bottleneck. She highlights two pivotal roles: the Semiconductor Equipment Maintenance Technician—the guardian of machine uptime—and the Facilities/EHS Engineer, who manages the critical life-support systems of the fab, from



The earn-and-learn model succeeds because it is governed by employers and sculpted to meet industry competencies. It is a strategic alliance where employers share responsibility for the entire process, from curriculum design to on-the-job training. The outcome is profound: graduates are "job-ready technicians," capable of navigating the rigours of a fab from day one, rather than requiring months of retraining.

ultra-pure water to toxic gas remediation. These are not assembly-line jobs; they are high-precision roles that form the bedrock of rapid production ramps. Without this cadre of highly trained professionals, high yields remain a mathematical impossibility.

Co-Governing the Classroom

India's academic institutions are citadels of rigour, but they often lack industrial intimacy. Liss champions a "Pedagogical Pivot"—dissolving the barriers between the lecture hall and the cleanroom. She advocates for the "Earn-and-Learn" model, whether through full-length apprenticeships or targeted rapid-skilling programmes. "The earn-and-learn model succeeds because it is governed by employers and sculpted to meet industry competencies," Liss elucidates. It is a strategic alliance where employers share responsibility for the entire process, from curriculum design to on-the-job training. The outcome is profound: graduates are "job-ready technicians," capable of navigating the rigours of a fab from day one, rather than requiring months of retraining.

The Train-the-Trainer Model

To teach the future, one must tangibly experience it. A significant disconnect exists where university faculty are teaching manufacturing processes they have never witnessed. Liss proposes a transformative solution: "Faculty Immersion Fellowships" She envisions an 8-week, industry-embedded program where professors and vocational instructors immerse themselves inside operational cleanrooms alongside veteran mentors. "This model acts as a force multiplier," Liss notes. By certifying the educators, India creates a new cadre of "Fab-Ready" instructors who can expand training capacity exponentially, ensuring that students are taught the reality of the floor, not the theory of the textbook. The result? A new cadre of certified fab instructors is poised to guide the next generation. "This model acts as a force multiplier, creating industry-aligned educators who can expand training capacity exponentially," Liss adds with palpable optimism.

Redefining the Factory

The archaic image of manufacturing—dirty, dangerous, and dull—requires radical rehabilitation. Semiconductor fabrication is precision science; it is pristine, futuristic, and indispensable. Liss insists that raising visibility demands "intentional outreach" that begins as early as primary school. The goal is to rebrand the fab not as a factory, but as a laboratory of the future. By connecting the digital

Solutions Spotlight

To rapidly operationalise Shari Liss's strategic roadmap, three immediate tactical vectors pave the way for ascendancy:

1. The "Fab-Ready" Fellowship (an 8-week immersive program for instructors to gain cleanroom certification)
2. Localised Curriculum Integration (fusing SEMI University modules into the AICTE curriculum for global standardisation)
3. The Apprentice Corps (institutionalising a National Semiconductor Apprenticeship framework that links academic credit with work experience).

reality of India's youth to the chips that power it, and by highlighting the cardinal role of sustainability in cleanroom careers, the industry can tap into the soaring aspirations of a conscientious generation.

Prioritising Liveability

India cultivates world-class talent, but retaining it requires more than patriotism. Liss extends the vision beyond the factory gates to the concept of "Ecosystems of Livability." To prevent brain drain, India must construct comprehensive regional ecosystems where individuals can flourish. This mandates the development of high-quality semiconductor hubs replete with "Soft Infrastructure"—affordable housing, quality healthcare, green mobility, and vibrant community spaces. "The goal is to render staying in India as rewarding—professionally and personally—as any global alternative," she affirms. Retention is a function of lifestyle, not just salary.

> **By certifying the educators, India creates a new cadre of "Fab-Ready" instructors who can expand training capacity exponentially, ensuring that students are taught the reality of the floor, not the theory of the textbook**

Speed through Partnership

Finally, India's paramount advantage is acceleration. By utilising established global frameworks, it need not reinvent the wheel. Liss points to SEMI University (SEMI U) as a robust platform ripe for immediate adaptation. She proposes a "Coalition of the Willing"—a partnership between SEMI India, MeitY, the NSDC, and top industry OEMs like ASML, Lam Research, and Applied Materials. By integrating SEMI U's technical training directly into Indian curricula, this coalition can launch "Train the Trainer" academies to certify thousands of instructors within the first year. The result would be immediate, scalable, and aligned with global best practices.

India's Stellar Silicon Future

The path to semiconductor sovereignty is luminous. Liss concludes, "Constructing this pipeline is not merely a workforce objective—it is the very foundation of India's semiconductor destiny." India stands at the cusp of a historic transformation. Capital is committed. Geopolitical forces are propelling India forward. The nation is ready to transmute its massive potential into a precise, disciplined, and highly skilled force. The talent is present. The roadmap is lucid. The future awaits its builders.

Strategy Note

Elevating Technicians: Focus on equipment maintenance and EHS roles as the core technical gateways to success.

Integrated Pedagogy: Use the "earn-and-learn" model as the golden key to align training with industry needs for day-one readiness.

Holistic Hubs: Curate liveable ecosystems (housing, healthcare, culture) to ensure retention and domestic growth.

Strategic Leaps: Leverage platforms like SEMI University and multi-stakeholder coalitions for rapid, globally aligned workforce scaling within the first year.



Jayant Krishna
Former CEO and COO, NSDC

The ZERO-ERROR Workforce

You can buy machines, but you cannot download a mindset. Jayant Krishna, former CEO and COO of the National Skill Development Corporation (NSDC), argues that India's chip ambition hinges on transforming a 'Chalta Hai' workforce into a precision army.

Team India Front

The global semiconductor map is being redrawn, and India is no longer just a spectator. India is increasingly assuming a central role in a rapidly evolving economic landscape. The industry is hurtling toward a $1 trillion valuation, driven by the voracious appetite of artificial intelligence, IoT, and autonomous mobility.

But the industry isn't just about growth numbers; it is about survival. The world needs a diversified, resilient supply chain, and that need has handed India a rare industrial opening. With domestic consumption set to hit $100 billion in five years, India is pivoting. The nation is moving from being a passive buyer of chips to a sovereign builder of them. This is the roadmap for the next decade. India is positioning itself as a primary node in the global silicon network. But strategy is easy; execution is brutal. The entire transition rests on one variable: human capital. You can buy lithography machines and allocate land, but you cannot download a semiconductor ecosystem. It requires a workforce with deep intellectual rigour and specialised skills—something that cannot be built overnight. Jayant Krishna, a seasoned veteran of the skilling ecosystem and the former CEO and COO of NSDC, candidly acknowledges the significant stakes involved. He notes that the explosion of AI is "propelling an unprecedented growth," potentially driving the industry to "$1 trillion per annum in 10 years or perhaps earlier." As the race for dominance spills out of Taiwan, China, and the US, Krishna observes that "India too is trying to board the bandwagon"—a move that is no longer optional given our consumption patterns.

Deconstructing the Competence Void

The problem isn't a lack of engineers. We have millions. The problem is a lack of "specific competence". Semi-



The explosion of AI is propelling an unprecedented growth, potentially driving the industry to $1 trillion per annum in 10 years or perhaps earlier.

conductor manufacturing is unforgiving. It happens at an atomic scale where the margin for error is zero. A standard electronics degree is insufficient. We need a specialised cadre that understands the chip value chain's tripartite structure: design, fabrication, and testing. Krishna warns against treating this talent pool as a monolith. He insists that "besides a proficiency in electronics, our engineers must possess the niche skills required across the semiconductor value chain from design, manufacturing, testing, and supply chain."

He breaks this group of professionals down with clinical precision: Design requires mastery of microelectronics; Fabrication demands the messy, complex world of cleanroom protocols; and Testing acts as the critical firewall ensuring quality assurance of semiconductor devices to ensure their performance and reliability. If the talent isn't as sophisticated as the chips, the fabs will fail."

The Investment-Talent Nexus

The government has taken the lead in formulating policies. The $10 billion India Semiconductor Mission (ISM) and the PLI scheme have created a runway for global capital. It signals that India is open for high-tech business. We are already seeing the results: Micron and Kaynes Semicon in Sanand, the Tata-PSMC partnership in Dholera, and the Tata assembly plant in Morigaon. The wave is spreading to Uttar Pradesh with the HCL-Foxconn JV and back to Gujarat with the CG Power-Renesas alliance. The effort is a nationwide mobilisation.

States are also joining the industrial fray. Karnataka recently signed a strategic MoU with the Taiwan-based Allegiance Group to build an India–Taiwan Industrial Technology Innovation Park. This ₹1,000 crore project is designed to be a crucible for chip design and manufacturing. But Krishna sounds a note of caution. Early wins are not final victories. He argues that the govern-

Solutions Spotlight

1. **Mandatory Apprenticeship Ratio:** Don't just encourage it; mandate it. Every PLI beneficiary should engage 2.5% to 10% of their workforce as apprentices. This compels the industry to establish its own talent pipeline, rather than relying on external recruitment.

2. **The Cleanroom Compliance Standard:** We need a national certification for cleanroom protocol and safety, strictly aligned with Taiwanese and South Korean standards. An Indian technician should be able to seamlessly integrate into any fabrication facility, anywhere in the world.

3. **Differential Funding Norms:** Treat semiconductor skilling as a strategic sector. Standard government compensation norms simply would not work for this capital-intensive training. The government needs to offer higher grants to fund the expensive infrastructure required for real training.

> **Besides a proficiency in electronics, our engineers must possess the niche skills required across the semiconductor value chain from design, manufacturing, testing, and supply chain**

ment "needs to show far greater hunger to attract Foreign Direct Investment (FDI)." He is direct: "India's growing global power is surely not good enough to attract global attention in the chipmaking global landscape. Soft power won't work here; only execution excellence will."

Skilling for the Zero-Error Standard

The biggest hurdle might not be technical—it's cultural. A Fab is the most complex factory humans have ever built. It demands "cleanroom" discipline, where a speck of dust or a sloppy procedure destroys millions in inventory. Krishna describes this behavioural shift as non-negotiable. "Beyond technical skills, fabs require strict adherence to protocols, safety, and teamwork," he says. He points out that the Indian workforce must "instil discipline and a compliance culture essential for a zero-error cleanroom environment," a trait he frankly admits is "usually absent in most industrial workers." The fix? Benchmarking. He suggests training programs must "match Taiwanese or South Korean standards," and we must aggressively push apprenticeships, mandating units to have "2.5% to 10% of their employee strength" trained on the shop floor.

Rewriting the Fiscal Book

Finally, we need to talk about money. Skilling for software costs a laptop and WiFi. Skilling for semiconductors costs cleanrooms, EDA tools, and hazardous chemicals. Krishna points out that "semiconductor skill courses are capital intensive and that government compensation norms simply would not work. Private players can't afford the CapEx without passing crushing costs to students. Krishna urges the government to pump in more money, bypassing standard norms to treat this as a strategic sector. And for the teachers we don't have? We import the expertise. He recommends a "Train the Trainer" model, sending Indian trainers to hubs like Taiwan or South Korea for rigorous immersion, creating a multiplier effect back home.

Is India Ready?

India is standing on the edge of an industrial revolution. The ambition is there. The diplomacy is working. Now, we just need the hands and minds ready to build when the world comes calling.

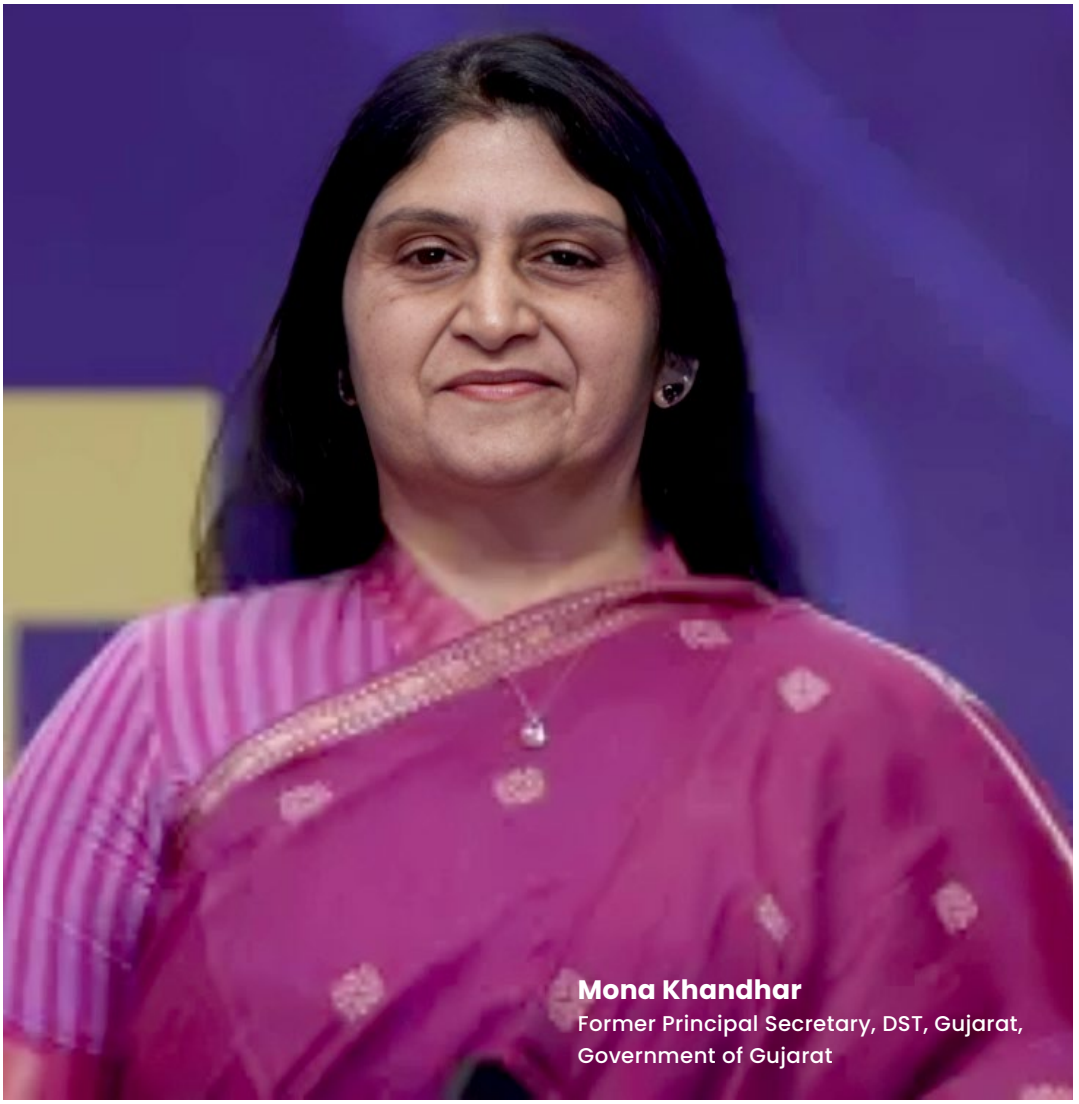
Key Takeaways

1. **The Talent Trinity:** It's not just one skill. Success needs three: design, manufacturing, and testing.
2. **Cultural Evolution:** Technical skills are secondary to the behavioural shift. We need a zero-error, high-compliance culture on the shop floor.
3. **FDI Aggression:** Diplomatic influence is insufficient to attract semiconductor giants. The industry demands execution excellence, not just a strong national brand. The state must show greater hunger for foreign capital to move from assembly to genuine fabrication.

Strategy Note

The Train the Trainer Bridge: The bottleneck isn't students; it's teachers. India lacks professors with practical experience in 28nm or 5nm fabrication. The solution: export our potential trainers. Send them to hubs like Taiwan (ITRI) and South Korea for rigorous, 6-month immersion programmes. These master trainers return to seed domestic institutes, creating a multiplier effect that localises global expertise.

Fab-ulous Gujarat:
Steering India to Semiconductor Pole Position



Mona Khandhar
Former Principal Secretary, DST, Gujarat,
Government of Gujarat

The architect of the Semiconductor Policy and former Principal Secretary (Science & Technology), Gujarat, GoI, Mona Khandhar, decodes the execution blueprint behind Gujarat's rapid silicon ascent

Amishi Mehta

History favours the quick. The debate is over. Gujarat has sprinted. In just under two years, the state has locked in over ₹1.25 lakh crore in semiconductor investments, turning a policy document into a construction boom. The proposal is no longer a plan. It is a physical reality. Imagine a canvas bigger than Singapore—920 square kilometres of industrial potential in Dholera. While the world searches for the next manufacturing haven, Gujarat has already built it. The state has compressed a decade of evolution into a 24-month execution masterclass. The result? The outcome is a smooth transition to the world's most intricate technology.

Gujarat has answered the global call with absolute precision. By becoming the first Indian state to launch a dedicated Semiconductor Policy for the years 2022 to 2027, Gujarat has moved beyond theoretical discussions. We engaged Mona Khandhar, former Principal Secretary, Department of Science & Technology, Government of India, and the architect behind this transformation, to understand the mechanics of this success. The narrative that emerges is one of synchronised aggression—state machinery that has pre-empted every hurdle to creating a home for the titans of technology.

The Zero-Friction Promise

The centrepiece of this vision is the Dholera Special Investment Region (SIR). In the world of high-tech manufacturing, "plug and play" is often a buzzword. This idea is now a geological reality in Gujarat. Khandhar outlines a meticulous level of preparation. The state understood early that global fabs cannot wait for land acquisition battles. "In Dholera, we didn't just mark territory; we prepared it", Khandhar asserts. "The land parcels are government-owned, pre-cleared, and litigation-free. They are encumbrance-free." This is the zero-friction promise. But land is just the canvas. The painting requires utilities of industrial-grade reliability.

Building the Infrastructure

Khandhar reveals a three-pronged utility masterplan that rivals any global hub. Water is the lifeblood. Understanding the semiconductor industry's thirst for ultra-pure water, Gujarat has commissioned a dedicated pipeline from the Narmada canal, supported by a 150 MLD water treatment plant. However, the vision extends beyond this. Gujarat has prepared a 20 MLD Common Effluent Treatment Plant (CETP) and plans to advance sewage treatment to tertiary levels, thereby completing the sustainability cycle.

Power plays a crucial role. A factory cannot stop operating. Khandhar describes a "100% redundancy model." Dholera is fed by a dual-grid architecture, tapping into both the state and national grids. "The connectivity is commissioned and energised," she notes. "Redundancy is available right at the doorstep cable." Furthermore, the state has synchronised 300 MW of solar power with the grid and has a roadmap to scale the project to a massive 5 GW of renewable energy. This is not just power; it is green, resilient, and infinite energy.

Anchoring with Titans

The efficacy of this infrastructure is best measured by the ambition of its tenants. Tata Electronics, in partnership with Taiwan's PSMC, is not just building a factory; they are constructing India's first AI-enabled commercial fab. This ₹91,000 crore behemoth will produce 28,000 wafers per month, targeting the high-volume legacy nodes—specifically 28nm, 40nm, 55nm, 90nm, and 110nm.

Why are they targeting these specific nodes? These are the workhorses of the modern world, powering everything from electric vehicles to power management ICs. By concentrating on these specific nodes, Tata and Gujarat are strategically seizing the majority of global demand, instead of pursuing the unstable frontier.

The Sanand Cluster

While Dholera captures headlines, the Sanand region is quietly evolving into a formidable OSAT cluster. It's not just about Micron. The third pillar of this

Understanding the semiconductor industry's thirst for ultra-pure water, Gujarat has commissioned a dedicated pipeline from the Narmada canal, supported by a 150 MLD water treatment plant. However, the vision extends beyond this. Gujarat has prepared a 20 MLD Common Effluent Treatment Plant (CETP) and plans to advance sewage treatment to tertiary levels, thereby completing the sustainability cycle.

Strategy Note

The government's top priority should be requiring and rewarding Indian conglomerates to hire or train the right people, processes, and systems to operate technological transfers. India must also promptly implement a talent development plan to produce 300,000 skilled workers in ten years.

ecosystem is CG Power, which has partnered with Japan's Renesas and Thailand's Stars Microelectronics to set up a massive ₹7,600 crore facility. This plant is a game-changer for capacity. The CG Power facility, unlike smaller pilot lines, boasts a projected capacity to produce 15 million chips daily. This transforms Sanand from a single-company site into a multi-anchor cluster, creating a gravitational pull for suppliers that a standalone factory could never achieve.

Designing for Life

Perhaps the most understated operational challenge in building a greenfield semiconductor city is the human element. High-tech expats and elite engineers need more than just a job; they need a life. Recognising that Dholera is a new city, the Gujarat government has activated the "Liveability Protocol" to bridge the gap between construction and habitation.

To solve the immediate housing crunch for the influx of global experts, the state is facilitating the construction of 1,500 serviced apartments within the SIR. Simultaneously, Tata Electronics is developing its own residential township with 530 units. But the masterstroke is the creation of a global "Tent City"—a rapid-deployment, high-quality hospitality zone designed to host visiting engineers and technical consultants immediately, ensuring that the lack of hotels never slows down the commissioning process. This ability to solve "soft" problems with "hard" infrastructure is what sets the Gujarat model apart.



Building the Supplier Village

A fab cannot stand alone. It needs a village of suppliers. Gujarat is actively building this "Tier 2" ecosystem through a cluster development model. Khandhar highlights the natural advantage Gujarat already holds as India's petrochemical capital. "We have a strong presence of gas, chemicals, and engineering industries," she notes. "The potential to localise the supply chain is immense."

The strategy is deliberate co-location. This is already bearing fruit. Inox Air Products has committed ₹500 crore to build an ultra-high purity gas facility in Dholera, specifically to feed the Tata Electronics fab. Similarly, local giants like Gujarat Fluorochemicals are leveraging their expertise in fluoropolymers to supply critical materials. Furthermore, reports indicate that over 30 Japanese suppliers are currently evaluating or setting up units in the state. This initiative reduces import dependency and fortifies thesupply chain against global shocks.

> **We have a strong presence of gas, chemicals, and engineering industries. The potential to localise the supply chain is immense**



Speed as Strategy

If Dholera is the hardware, the Gujarat State Electronics Mission (GSEM) is the operating system. Bureaucracy often kills speed, but Khandhar describes GSEM as a "Nodal Accelerator" designed to bypass red tape entirely. "We have synergised completely with the Government of India," Khandhar explains. "All process duplication has been avoided. GSEM acts as the single point of contact."

The system is a profound administrative innovation. Instead of running between ministries, investors interface with one empowered entity. Automated escalation mechanisms and weekly coordination meetings guarantee the elimination of delays. This concept is "ease of doing business" reengineered as "speed of doing business."

Talent as Infrastructure

Human capital is the final component that completes the puzzle. Gujarat cranks out more than 100,000 STEM graduates each year, but the focus has shifted to hyperspecialisation. Khandhar outlines a "hub and spoke" skilling architecture that creates a direct pipeline from the classroom to the cleanroom. She cites the groundbreaking ATMP Training Centre at Pandit Deendayal Energy University (PDEU)—a first-of-its-kind collaboration with Micron and NSDC to train 1,000 professionals specifically in packaging technologies. Similarly, IIT Gandhinagar has launched a special B.Tech. in Integrated Circuit Design. Such an initiative is the ultimate confidence builder for investors: a "talent inventory" that is just as robust as the land inventory. The Gujarat model is an operational masterclass. The state has shifted the paradigm from signing MoUs to breaking ground. By pre-empting the complex needs of the future, Gujarat has rewritten the contract between government and industry. The silence of the Dholera plain has been replaced by the hum of industry. As the first chips prepare to roll out, they carry a message to the world: Gujarat is no longer just ready. It has arrived.

Key takeaways

1. **Redundancy is Reliability: In chips, a power cut is a disaster. Gujarat's dual-grid architecture and water recycling loops offer the 100% uptime guarantee that global majors demand.**
2. **Talent Inventory:** Infrastructure is not just concrete; it is people. By launching specialised semiconductor courses at PDEU and IIT Gandhinagar, the state is building a "human inventory" to match its industrial one.
3. **Soft Infrastructure Matters:** You cannot build a high-tech city without high-tech lifestyles. The focus on "Liveability"—housing, schools, and recreation—is critical to retaining the elite workforce that will run the fab.

The Gujarat Playbook



Dr Sunil Parekh
Chairman CERC, Founding Curator
AGS - World Economic Forum,
Advisor Zydus & Jubilant

Capital can buy a factory. Only an ecosystem can build a legacy. Dr Sunil R Parekh talks to **Amishi Mehta** on how the state became the global model for success.

You know it. It's Gujarat. It's the classic success model. But one thing is clear: this state doesn't just host industries; it builds them. We are watching a new chapter unfold. One that has transformed India's economic landscape. Repeatedly. Now, the state is using that proven template for the most complex sector in history: semiconductors. Dr Sunil R Parekh, a distinguished industry veteran, contextualises this. It's not a gamble, It's an evolution. It's Gujarat's industrial DNA in action. He argues the history is clear. The state establishes pioneering industries. How? Anchor investments. Substantial incentives. Quality infrastructure. This approach works. It catalyses the entire value chain. Every one wins.

The Architecture of Legacy

The blueprint is proven. Parekh points to the milestones. The Alang shipbreaking industry. The auto sector started with the Tata Nano project. The massive petroleum refineries established a chemical foundation, paralleling the auto sector's rise to global prominence. These giants contributed to the development of downstream sectors. Fertilisers. Pesticides. Pharma. Paints. Even the textile looms were powered by local cotton. The cooperative prowess of Amul was

Strategy Note

1. Legacy as Leverage: Use the proven "Anchor Investment" model. It built Auto. It built Pharma. Now it builds Silicon.
2. Proactive Governance: Fix risks early. Secure grants ahead of demand.
3. Ecosystem Readiness: It's parallel processing. Build the factory. Build the water supply. Build the advisory board. All at once.

evident. Parekh observes: these "form the backbone of industrial power." Now, that backbone is silicon. The numbers are staggering. Ten major investments. $19 billion. Two fab lines. Eight assembly units. The market is exploding. Domestic consumption will hit $110 billion by 2030. The mission is total self-reliance. It's not just chips. It's the whole chain: "Suppliers of 500-odd chemicals and 50 gases, all of ultra-purity.

Engineering Abundance

Semiconductors are unforgiving. They demand precision. Parekh compares the industry to the chemical sector, requiring "large quantities of both extremely reliable power and water of ultra-high purity." Gujarat values its resources. The government is paying "special attention to details." Success is the only option. Look at the Dholera Special Investment Region (SIR). The infrastructure is live. Water treatment. Sewage treatment. Common Effluent Treatment Plants (CETP) are operational. The facility includes a 300 MW solar park, already completed and ready. The progress in Sanand GIDC matches this momentum. Infrastructure is upgrading fast. Parekh cites a prime example: a September 2024 tender to "redesign storm water drainage". Why? He is emphatic. Gujarat is "not just giving subsidies on paper." It is "actively laying down physical infrastructure." Speed is key.

The Strategy of Confidence

Confidence is high. Investors feel it. Parekh reveals a massive strategic move: the state requested a grant of over ₹40,000 crore from the Union government. This is not a piecemeal request; it is a proactive move to "fund development of industrial infrastructure —utilities, logistics, security — specifically to meet global-scale semiconductor manufacturing demands." Then there is the Gujarat Semiconductor Policy 2022 27. High-quality water at ₹12 per cubic metre for five years. Aggressive land incentives. It is a fiscal environment built for speed.

The 28nm Victory

Concrete helps. But strategy matters more. The world races for single-digit nanometres, but India is smart. We are starting with 28 nm chips. Why? As Minister Vaishnaw confirms, "This type accounts for over 60 per cent of India's needs."

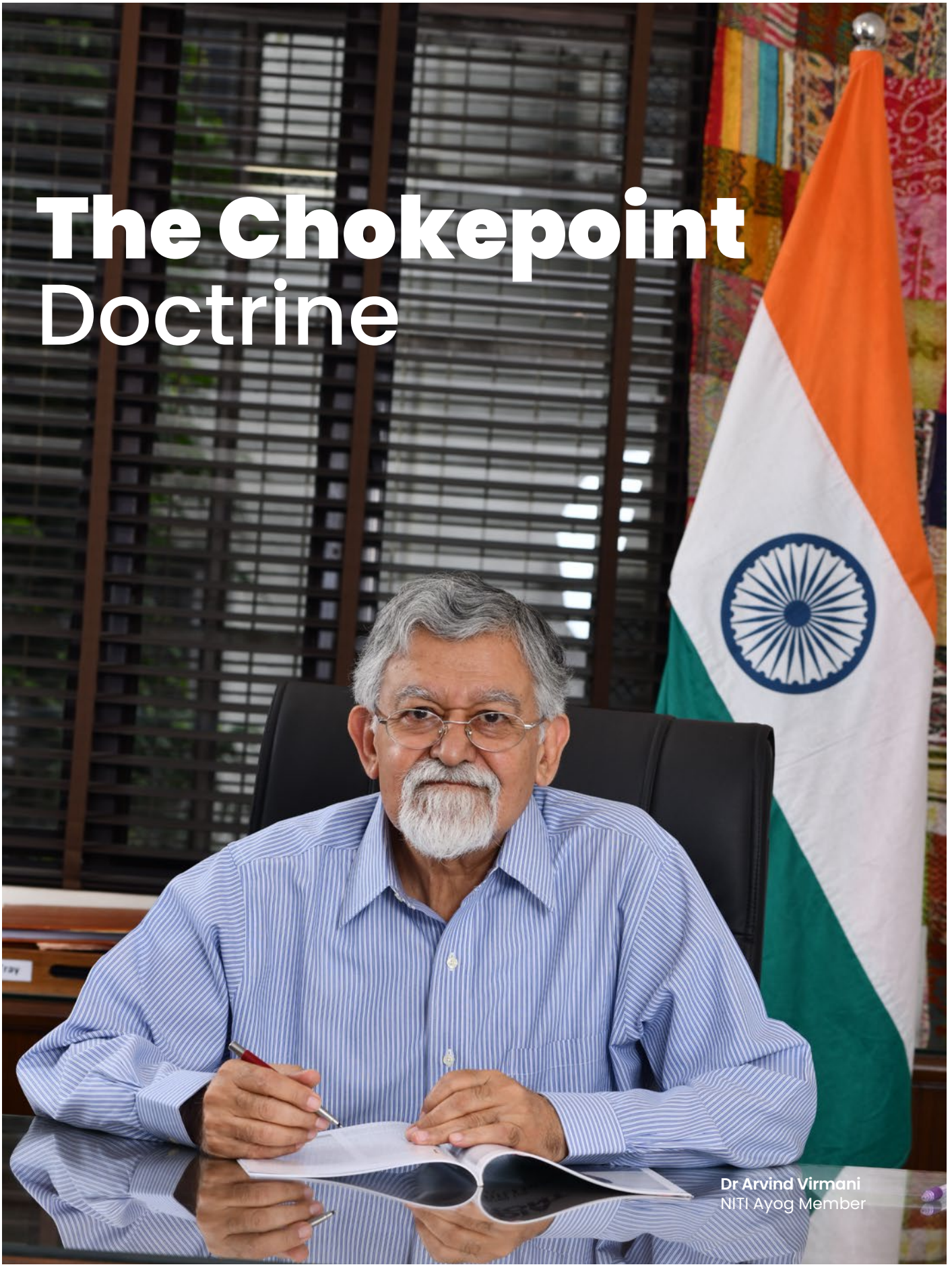
It is the volume game. It is a strategic win, capturing 60% of the market volume rather than chasing the bleeding edge. It is "a good way to usher in the industry." The anchor is dropped. The ecosystem is rising. Gujarat is ready to lead.

The Engineered Miracle

This is how you build a self-reliant future. Gujarat has changed the way things are done by combining strong financial support—like subsidies for land, power, and water—with protection for infrastructure. By fixing drainage systems and securing power grids before the first machine is installed, the state has removed the risk from the equation. It has replaced uncertainty with a plug-and-play ecosystem. The strategy is clear: de-risk the investment, secure the operations, and capture the market with a pragmatic 28 nm entry. Gujarat has proven that industrial miracles aren't magic. They are engineered.


INDIA'S
DECADE.
YOUR OPPORTUNITY.
We are standing at the edge of a historic transformation. The old rules are being rewritten, and new empires are being forged right now. From policy to practice, from concept to concrete, the story of India's rise is the most exciting narrative in the global economy. But opportunity favors the prepared.
India Front exists to ensure you understand the forces at play before the rest of the world catches up. Don't watch the revolution from the sidelines. Master the trends. Own the future.
INDIA FRONT
Where the Future Gets Built.

The Chokepoint Doctrine



Dr Arvind Virmani
NITI Ayog Member

Investment is not just economics; it is immunisation. NITI Aayog Member and renowned economist Dr Arvind Virmani delineates the definitive blueprint for India's silicon supremacy

Rishi Vora

The moment has arrived. The global semiconductor landscape is undergoing a historic realignment, and India stands ready to anchor this new era. We are witnessing the birth of a manufacturing renaissance. With the global semiconductor industry projected to breach the $1 trillion mark by 2030, and India's own domestic market racing toward $110 billion, the sector is the new gold rush—and India is the most promising frontier. The government's $10 billion incentive package is a declaration of intent. It is an invitation to the world to witness India's pivot from a digital powerhouse to a hardware sovereign. The energy is palpable. The ambition is limitless. The journey to India's chipmaking success is an inevitability.

The Momentum of Now

Dr Arvind Virmani, a member of NITI Aayog decodes the essence of this historic realignment. He views the current landscape with a palpable sense of urgency coupled with marked optimism, noting that the paradigm has shifted. "The conversation has moved from possibility to velocity," he states. The delays of the past have only served to build a reservoir of potential, which is now being unleashed at an extraordinary rate. Dr Virmani is unequivocal in his assessment: "There is zero doubt about our preparedness." The global community has fully recognised India's capabilities, and the administration is proceeding with absolute clarity regarding the necessary tactical actions. This reflects the voice of a nation in motion. The debate on the 'how' is largely settled; the focus has now locked entirely onto high-velocity execution.

The Sovereign Guarantee

This mission rests on a bedrock of fiscal certainty. While semiconductor fabrication is capital-intensive, India's fiscal architecture is engineered to sustain long-term gestation periods. Dr Virmani portrays the mission as a precise, ring-fenced commitment.

"The chip mission has outlined specific incentives based on meeting certain criteria," he notes. Crucially, regarding the funding, Dr Virmani affirms:



Once a commitment is made, the resources are found by the Finance Ministry. When our government commits to a policy, it is delivered. The budgetary support promised is guaranteed.

"Once a commitment is made, the resources are found by the Finance Ministry." There is no ambiguity. When the Government of India commits to a policy, the budgetary support is delivered with precision against specific plans. This sends a resonant signal to the global ecosystem: India offers not just incentives, but systemic continuity.

Frictionless Borders

India is actively dismantling barriers to create a seamless highway for global technology. The philosophy now embraces "strategic trade synergy." Through high-velocity FTAs, India is integrating into global supply chains.

Dr Virmani notes pacts with Australia and the UK are set, while EU talks target a December completion."The U.S. President himself indicated an agreement could materialise shortly," he reveals, predicting a "big effect on FDI." Dr Virmani highlights a critical advantage: eliminating procedural friction. "In complex supply chains, components move back and forth," he explains.

"Zero duty is not just about cost; it is about virtual, frictionless movement. Eliminating the procedure is the key." This creates a definitive "red carpet" for high-tech manufacturing.

Solutions Spotlight

1. **The E-Chanakya Protocol:** Deploy "Expert AI Systems" to rewrite economic laws. Use AI to eliminate bureaucratic friction.
2. **Corporate-Led Skilling:** Shift to industry-defined competence. The strategy leverages global anchor investors to define curriculum and channels CSR funds directly into technical training.
3. **The Frictionless Corridor Leverage:** FTAs for zero-duty, zero-delay movement. Eliminate procedural drag to replicate the efficiency of a single global factory

The Quality Ladder

Every mature economy ascends a "Quality Ladder," beginning with assembly and testing before migrating to backward integration. Dr Virmani views this evolution as inevitable. However, semiconductors are unique; they function as critical "choke points" in the global ecosystem.

Consequently, production strategy must look beyond conventional cost metrics. "We must adopt a long-term strategic perspective," Dr Virmani asserts.

While our demographic dividend provides the comparative advantage, the ultimate objective is not just industrial competence, but sovereign security against geopolitical leverage.

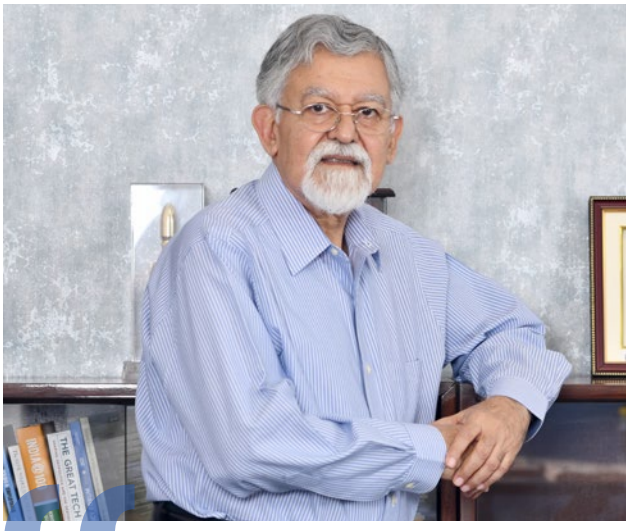
The Empirical Shift

Beyond technical skills, Dr Virmani identifies a profound cultural pivot: the migration toward a true "research mindset." He illustrates this with a stark pedagogical contrast. "Historically, if a text stated 'Corn is yellow,' the student accepted it passively. The research mentality is radically different," he asserts. "The instinct must be verification: 'Let's go to the field. Let's experiment. Let's confirm it.' That is the shift we are instilling."

This spirit of empirical inquiry is the bedrock of deep-tech innovation. We are transitioning from a culture of rote compliance to one of experimental verification. By embedding this scientific rigor at the grassroots, India is evolving from the world's back office into its primary laboratory. We are cultivating a generation that does not merely consume knowledge, but interrogates, validates, and invents it.

The Skilling Revolution

To bridge the capability gap, the strategy pivots to a new collaborative model: utilising Foreign Direct Investment (FDI) as a vector for knowledge transfer. Global anchor



"The ultimate test is the percentage of your economy that a hostile supplier can choke off. We must ensure no external denial can paralyse the state. This constructs a strategic immunity shield to secure a nation that is unbreakable in spirit.



By embedding scientific rigor at the grassroots, India is evolving from the world's back office into its primary laboratory. We are cultivating a generation that does not merely consume knowledge, but interrogates, validates, and invents it.

Key Takeaways

1. Funding is ring-fenced. Once policy is committed, capital is guaranteed, offering investors absolute continuity.
2. A cultural pivot from "Rote Learning" to "Research Mindset." The next generation is being trained to verify facts experimentally.
3. Dr Virmani's strategy leverages FDI to transfer global playbooks, aligning domestic talent with precise industrial standards.

investors bring the operational playbook; India provides the scale. "FDI plays a critical catalytic role," Dr Virmani observes. "Global investors know the precise skill requirements. They partner with local entities, and the capability upgrade happens organically." Simultaneously, the vision empowers the corporate sector to lead. While companies are not educators, they possess the clearest view of the skills deficit. Dr Virmani proposes a transformative mechanism: channelling Corporate Social Responsibility (CSR) funds specifically toward technical skilling. By financing this specialised education, the industry effectively crafts its own future workforce. This is a solution-oriented approach that converts a demographic challenge into a sustainable competitive advantage.

The E-Chanakya Moonshot

Perhaps the most audacious proposition concerns the architecture of governance itself. To ensure the state matches the velocity of industry, Dr Virmani proposes a paradigm shift: "Expert System". He envisions specialised AI models—conceptually dubbed "E-Chanakya"—trained on the vast corpus of India's economic statutes.

"We could be the first nation to deploy AI specifically for economic administration," he posits. Such a system could audit the regulatory labyrinth in six months—a task requiring human committees decades—and condense 20 redundant forms into two. Crucially, Dr Virmani invites the private sector to collaborate on "demonstration projects" to validate this future, transforming bureaucratic friction into a competitive advantage.

The Immunity Shield

This mission converges on a singular mandate: Strategic Autonomy. Dr Virmani defines the "Choke Point Doctrine": "The ultimate test is the percentage of your economy that a hostile supplier can choke off." We must ensure no external denail can paralyse the state. This constructs a "Strategic Immunity Sheild"—mastering the atom to secure a nation that is sovereign by definition and unbreakable in spirit.

Strategy Note

National security is now defined by "Chokability"—the percentage of the economy that halts if a foreign power cuts supply. The mission's goal is to reduce this vulnerability to zero.



Dr. Danish Faruqui ,
CEO, Fabeconomics

Vande Silicon Turns Capital into Capability

Money buys the hardware, but people drive the yield. Dr Danish Faruqui, Chief Executive Officer of Fab Economics argues that the real bottleneck isn't capital—it's how fast India can learn the art of chipmaking.

Rishi Vora

India's forthcoming two years in the global race for silicon supremacy will serve as a critical litmus test. The nation's ambitious quest to secure its semiconductor future— a sector anticipated to undergo a trillion dollar capacity expansion this decade— now depends on addressing one pressing challenge: technology and talent transfer. With an estimated $60 billion in investment at stake, Dr Danish Faruqui, CEO of Fab Economics, offers a blueprint for assertive success. He warns that repeated delays in the semiconductor sector can erode the credibility of even the most established players, resulting in permanent market share losses. For a new entrant like India, the consequences of a stall would be dire. "The world is watching," Dr Faruqui asserts. We must adhere to established timelines for greenfield fabs and OSAT readiness with military precision.

Winning on Two Fronts

Capital is available, but risks remain. Dr Faruqui identifies Talent and Technology Transfer as the two most significant non-financial risks facing India's mission. "Globally, the semiconductor talent shortage poses

the greatest Pareto threat to achieving full utilisation of newly announced fabs," he explains.

He characterises this deficit as the perpetual supply crunch of the decade. The severity is such that global Boards now place talent availability above incentives when selecting new sites. In India, the workforce shortage in manufacturing and packaging is currently at a staggering 100%. Dr Faruqui warns that the lack of action in cultivating domestic talent has already incurred a cumulative opportunity cost of billions over the past decade. Unlike the US, which has a 7–10-year horizon to fix this, India needs a workforce ready for the shop floor in 2–3 years.

The Art of Replication

For Indian corporate giants venturing into silicon for the first time, the hurdle is "Site-Level Technology Transfer." Dr Faruqui describes Manufacturing Grade Technology (MGT) as the holy grail. This is not merely intellectual property; it is the operational mastery of processes, materials, and equipment. Semiconductor manufacturing necessitates a strict "Copy-Exact" transfer process—far more rigorous than the product-level technology transfer of other industries. Effective transfer demands expertise across personnel, processes, and systems. "No established player will delay their roadmap to teach a partner who isn't ready," Dr Faruqui notes. Despite government subsidies covering 50% of technology transfer fees, global technology partners (MTPs) remain hesitant to collaborate with Indian players due to deficiencies in "Absorptive Capacity." To succeed, Indian conglomerates must prioritise the development of these internal receiving teams immediately.

India has the potential to produce over 300,000 semiconductor manufacturing and packaging workers over the next ten years—four times the domestic requirement. This surplus capability allows India to alleviate the worldwide talent crisis.

Solutions Spotlight

The government's top priority should be requiring and rewarding Indian conglomerates to hire or train the right people, processes, and systems to operate technological transfers. India must also promptly implement a talent development plan to produce 300,000 skilled workers in ten years.

Failure to cultivate this absorptive intelligence creates a perilous dependency. Without an indigenous cadre of process engineers capable of decoding transferred protocols, India risks becoming a mere assembly hub rather than a sovereign technological power, perpetually tethered to foreign IP holders for every incremental yield improvement.

Exporting Brain Power

Dr Faruqui flips the narrative: the crisis is actually an export opportunity. "The entire growth of the semiconductor industry depends on talent," he asserts. He projects that India has the potential to produce over 300,000 semiconductor manufacturing and packaging workers over the next ten years—four times the domestic requirement. This surplus capability allows India to alleviate the worldwide talent crisis. Fab Economics has developed a specialised programme capable of training workers in semi-manufacturing and packaging in just 2 – 3 years, a method Dr Faruqui claims is "more effective and agile" than traditional models. By positioning itself as the "Talent Granary" of the semiconductor world, India can make itself an indispensable node in the global supply chain, regardless of chip volume.

Beyond the Subsidy

Long-term viability is not built on subsidies; it is built on Total Cost of Ownership (TCO). Dr Faruqui identifies two structural levers that will make India competitive against Asian peers: Local materials and energy costs. He asserts that a domestic supply chain of semiconductor-grade speciality chemicals and gases would provide an unmatched competitive edge, reducing logistics costs and lead times. Furthermore, energy pricing is critical. Dr Faruqui proposes that energy costs for semiconductor projects in India should be targeted at globally competitive industrial rates (approximately 3-4 cents/kWh) to ensure the fab remains profitable after the subsidy period ends.

A Different Game

Finally, Dr Faruqui advocates for a unique, customised policy framework to attract Display Fabs (LCD/OLED). "The current mission is insufficient because display fab manufacturing has distinct success factors," he argues. The geopolitical dynamics and capital requirements differ significantly from silicon logic fabs.

He highlights a significant financial obstacle: the minimum capital expenditure (CAPEX) requirement for a display fab is often over $1.2 billion (INR 10,000 Crore). This entry barrier precludes the majority of Indian business houses. Furthermore, display fabs have massive, specific requirements for industrial gases and cleanliness standards that require a bespoke ecosystem. Dr Faruqui urges the government to create a dedicated "Display Ecosystem Plan" rather than lumping it in with general logic fabs.

Strategic Approach

Dual-Approach Accelerated Path. Indian semiconductor fabrication and ATMP companies should build or outsource technology transfer skills. The government must quickly develop an Indian version of the rapid (2–3-year) semi-manufacturing talent development programme to close the talent gap. This plan will solve a global problem.

"Energy costs for semiconductor projects in India should be targeted at globally competitive industrial rates (approximately 3-4 cents/kWh) to ensure the fab remains profitable after the subsidy period ends.

Defining the Decade

Dr Faruqui's vision lays out the reality: India can turn its $60 billion risk into a trillion-dollar asset, but only if it shifts focus from "signing MOUs" to "building capability." If India can swiftly train a workforce of 300,000 and master the art of Manufacturing Grade Technology transfer, it will not just participate in the market—it will define it.

Key takeaways

1. **Talent is the Pareto Risk:** The lack of skilled staff is the single biggest threat to fab utilisation (80% of the risk comes from 20% of the causes).
2. **Energy is Destiny:** To compete with Taiwan and Vietnam on TCO, India must offer industrial power at roughly 3-4 cents/kWh.
3. **Speed is Reputation:** In semiconductors, a delay is not just a cost overrun; it is a reputation killer. India must execute on time to earn global trust.


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Raja Manickam,
Founder & CEO, iVP Semi

The **Product Mastery** Manifesto

Scale is fragile. Sovereignty is built on IP, not just assembly. iVP Semi Founder & CEO Raja Manickam delineates the six pillars of ruthless execution to pivot India from a service hub to a product powerhouse.

Rishi Vora

The chip epoch has begun. The Indian digital economy is reaching a significant level of growth. The nation is demanding propulsive force in semiconductor self-reliance. This mandates an industrial pivot towards advanced fabrication and packaging. The initial, critical springboard is Assembly, Test, Mark, and Pack (ATMP)/OSAT—the foundation of all final chip products. The national strategy focuses on accelerated capacity scaling via global subsidies. Monetary allocation is merely the opening gambit. The decisive factor transcends subsidy economics; it relies on the flawless execution of a localised, product-centric strategy. Veteran semiconductor leader and CEO of iVP Semi, Raja Manickam, provides the definitive blueprint. His perspective is incisive and solution-driven. He argues that the current scale-and-subsidy model risks capital flight and fosters brittle mega-factories. The path forward requires a paradigm shift: from merely securing job work to cultivating a product powerhouse. He remarks, "Would we be building manufacturing factories using government funding to subsidise global chip companies? Alternatively, we could have Indian

Solutions Spotlight

1. Mandate technology transfer to establish indigenous equipment manufacturing.
2. Foster regional ecosystems instead of massive, centralised plants.
3. Instil a zero-defect, PPB mindset through heavy investment in automation and discipline.
4. Shift national focus to product creation for maximum margin and autonomy.
5. Fund entire strategic systems (e.g., 6G NTN) by supporting multiple domestic chip startups.
6. Adopt an apprenticeship model using real equipment for on-the-job competence.

semiconductor companies that are growing and driving demand." This is the critical juncture.

Bailing Out of the Import Trap

India faces immediate operational challenges that are fundamentally structural, particularly concerning the use of public funds. Currently, the ATMP units primarily belong to the legacy packaging category, and they source essential equipment from global suppliers. Manickam identifies a critical issue, noting, "My concern is that India does not manufacture any equipment used in ATMP. All equipment is imported." Consequently, government subsidies intended for ATMP developers ultimately serve to procure equipment from foreign firms. He argues that this arrangement is far from optimal, stating, "It could be done better if there was a push to manufacture some of the equipment in India and facilitate technology transfer." Moreover, he calls for immediate action regarding the future of the sector: "Advanced packaging, or heterogeneous packaging, involves processes akin to fab operations. Currently, no one in India is involved in this field. Achieving commercial viability will require three to five years, so proactive measures are essential. The ultimate aim is to establish indigenous capabilities rather than merely engaging in assembly."

Decentralising Scale

The prevailing industrial ethos of centralisation and scaling has become an unnecessary vulnerability. Manickam advocates a decentralised manufacturing model, highlighting the risks associated with colossal factories. He notes, "In the past 30 years, there has been a push for centralising and scaling megafactories, but they have become so large that their cash breakeven point is exceedingly high." This model is inherently fragile; if utilisation drops by even 10%, manufacturing companies can become cash flow negative. He argues that, in light of current geopolitical fragmentation, pursuing large-scale operations with megafactories is illogical. The superior strategy, he suggests, is for state governments to cultivate ecosystems that enable companies to create value within these frameworks.

Raising Quality to Zero Defects

Products must always be reliable and never compromise in order to build trust around the world. This is the most important quality standard for big international buyers. Manickam talks about how strict the industry is: "Yields in the semiconductor industry are 99.9%, and the standard for quality is zero defects, or defects are measured in parts per billion." Getting to this level of quality takes time and requires strict discipline in the

> **"Indian factories must abandon the "adjustment" mindset and commit to heavy investment in automation and rigorous inspection. This culture of quality is not merely an operational cost; it is a strategic investment that builds immediate global trust.**



Indian chip companies should receive lower wafer pricing and reduced packaging costs for a minimum of five years—a strategic shield to maintain competitiveness until volume scales are achieved.

factory. He stresses the need for a change in mindset: Indian factories need to stop taking shortcuts and start thinking about investing in automation and inspections. This culture of quality is an investment that builds trust right away.

The ultimate transition for India must be from a design services hub to a high-value product creation engine, where the highest margins and maximum autonomy reside. "The profits are highest for product companies," states Manickam. He emphasises that product companies leverage the existing ecosystem and "do not own any assets." As the ATMP/OSAT ecosystem develops, these product innovators will naturally emerge. He asserts that Indian companies will gravitate towards profitable opportunities. To accelerate this pivot, he mandates two key interventions: first, conglomerate partnerships, whereby large Indian private sector players must take a proactive role. In addition to financial investment—which he notes they "have not done so far"—these conglomerates should adopt startups, providing them with practical access to end products, testing slots, and marketing channels, thus aiding their evolution into product companies. The second intervention involves enhancing price competitiveness; since subsidies use taxpayer money, this capital should directly benefit local firms. Specifically, Indian chip companies should receive lower wafer pricing and reduced packaging costs for a minimum of five years. We need this strategic subsidy to maintain competitiveness until we achieve volume scales.

The Product Pivot

ATMP serves as a model for job work; it cannot operate as a product business. For it to achieve genuine success independently, the government must comprehensively define and fund local product development. Manickam proposes a strategic procurement policy that focuses on identifying sectors where India aims to reduce its dependence on foreign goods and services, such as telecommunications. He discusses the potential of 6G technology utilising NTN (Non-Terrestrial Networks) and states, "We need to define the whole NTN system and manufacture all the chips that go into it." To establish a fully homegrown system within three to five years, this approach requires investment from various chip startups engaged in developing processors, RF components, power chips, and AFE chips. We must apply this systematic approach to cameras, energy systems, data centres, and other relevant fields.

Engineering Sovereign Demand

The most dangerous phase for a nascent semiconductor industry is the "Valley of Death"—the gap between building a factory and finding a customer who

Strategy Note

Service Nations earn wages, but Product Nations earn wealth. India must move from Design Services (low margin, low IP) to Product Ownership (high margin, high IP). The goal is to create companies that own the chip, not just the companies that package it.

trusts your output. Manickam argues that relying solely on global exports to bridge this gap is a strategic error. A new ecosystem cannot beat 30-year incumbents on day one. Instead, India must engineer its own survival through "Captive Consumption." The logic is stark: India is digitising faster than any other nation, yet it builds this digital empire almost entirely on imported silicon. This dependency is a leak in the national hull.

The solution lies in leveraging the state's massive buying power as an industrial lever. Manickam advocates for an "Aggregation Strategy." Consider the millions of smart energy meters, the explosive growth of two-wheeler EVs, and the nationwide rollout of 5G infrastructure. These are not just utility projects; they are volume guarantees. If the government mandates that a fraction of this critical infrastructure runs on domestically packaged chips, it creates an instant, unshakeable market. This "baseload volume" is the oxygen that new Indian product companies need to survive their infancy.

This approach does more than just fill order books; it fundamentally alters the design philosophy. It forces Indian companies to stop cloning generic global chips and start building "Solution Silicon"—chips specifically engineered for the rugged, high-temperature, cost-sensitive realities of the Indian environment. A chip designed for a dusty, variable-voltage grid in rural India has no global competitor because no global major is designing for that constraint. By owning this niche, Indian firms create a protective moat, allowing them to perfect their yields and margins at home before stepping into the brutal global ring. This is how you transition from a "subsidy recipient" to a "sovereign powerhouse."

Talent Foundry

The ATMP industry demands a unique set of skills, particularly from highly skilled, hands-on technicians and process engineers. This role is markedly different from programming; acquiring the necessary skills requires substantial practical experience. Manickam highlights a new approach to training, stating, "Just as auto mechanics need engines to learn how to disassemble and reassemble them, we require the appropriate tools, methods, and materials for hands-on, practical training." However, structured training should be viewed as just a starting point. Trainees are required to complete internships, similar to the expectations for medical students. After their training, they must gain real-world work experience to effectively refine their skills. Without opportunities that extend beyond formal training, their abilities may deteriorate rapidly. To retain skills effectively, individuals must have the opportunity to apply their knowledge of processes and tools immediately.

Attaining Hands-on Mastery

Manickam's experienced view gives India a clear plan for becoming a leader in silicon production and moving from relying on subsidies to making its own products. The main solutions are getting rid of the import trap by mandating technology transfer to setting up local equipment manufacturing for ATMP and OSAT; reducing risk by decentralising and focusing on regional ecosystems instead of megafactories; enforcing quality standards by instilling a zero-defect PPB mindset; driving product creation by changing national goals and stipulating lower prices for domestic chip companies; funding entire systems by defining strategic market segments and funding multiple chip startups to deliver complete indigenous systems; and implementing hands-on training by using an apprenticeship model with real equipment and materials. The successful implementation of these strategies is now within reach.

Key Takeaways

Achieving India's semiconductor sovereignty requires a decisive pivot from the brittle subsidy model to flawless execution and product mastery. This transformation is driven by six mandates: enforcing technology transfer and zero-defect quality, prioritising regional ecosystems over megafactories, using strategic funding and lower pricing to drive domestic product demand, and establishing an apprenticeship model for talent mastery.

Small Giants Engineering the Silicon Revolution



Anil Bhardwaj
Secretary General, FISME

Gigafactories dominate the headlines, but the ecosystem is built on the shop floor. FISME Secretary General Anil Bhardwaj argues that India's semiconductor destiny relies not on a few giants, but on the precision engineering of 63 million small enterprises.

Team India Front

The narrative of India's chip mission often zooms in on the solitary giants—the gigafactories standing as modern industrial cathedrals. But shift the lens, and the true scale of the opportunity reveals itself: a sprawling, vibrant grid of 63 million enterprises. The immense size of the Indian MSME sector necessitates placing it at the forefront of the semiconductor mission. Commanding nearly 30% of the national GDP and mobilising a workforce of over 110 million, this sector is an undeniable centre of gravity for the Indian economy—the decentralised manufacturing fortress of the nation. While the global semiconductor supply chain undergoes a radical geopolitical reconfiguration, a massive domestic reality is taking shape. The Indian MSME sector is not just the supplier base for this mission; it is the ultimate consumer of the digital economy these chips will power—from smart payment boxes in kirana stores to CNC machines in industrial clusters.

The maths of this ecosystem is compelling. For every dollar invested in a fab, roughly 30–40 cents cascades down into the ancillary network of precision components, speciality chemicals, and assembly services. This multiplier effect generates an untapped $40 billion opportunity. The challenge is no longer about intent; it is about readiness.

Speaking exclusively to Team India Front, Anil Bhardwaj, Secretary General of the Federation of Indian Micro and Small & Medium Enterprises (FISME), maps the operational ascent from local vendor to global partner. His insight is sharp: the transition isn't about buying expensive machinery; it is about adopting a mindset of uncompromising precision.

From Approximation to Precision

The global semiconductor supply chain operates on a singular mandate: zero variation. To meet such an exacting standard, the margin for error is non-existent. For Indian MSMEs often reliant on "visual approximations", entering this elite supply chain requires a cultural pivot to absolute precision. Bhardwaj identi-

fies the entry point not as expensive automation but as data discipline. "I have seen astounding results with the use of even basic tools," Bhardwaj observes. "The pivot is simple. It is about consistency in measuring and recording."

We call this the "Digital Caliper Revolution." It serves as the foundational bridge between analogue workshops and a digital fab. Before a factory can deploy robots, it must first master data logging. By moving from manual gauges to digital calipers and micrometres and diligently logging that data onto cloud platforms or simple Excel sheets, a small unit digitises its DNA. This discipline transforms the shop floor into a data centre, enabling early error detection and traceability. Digitisation is the first signal to a global buyer that an MSME respects the language of precision.

The Whiteboard Effect: Visual Management as Culture

Once measurements are digitised, the next hurdle is real-time accountability. High-tech efficiency does not always require million-dollar software. Bhardwaj highlights the immense power of "Visual Management"—simple, analogue tools that create a culture of ownership. "Displaying just three data points on a whiteboard—parts made, components rejected, and time lost—creates an instructive effect," he notes. "It orients the entire shop floor to the goal."

Context is critical here. In a high-speed semiconductor supply chain, hidden inefficiencies are fatal. A simple whiteboard acts as a "real-time feedback loop." When every worker sees the "time lost" metric, the culture shifts from production to productivity. This visibility unites the workforce around a fundamental principle: you cannot improve what you cannot see.

A Global Trust Passport

How does a manufacturer in a Tier-2 cluster prove they are world-class without spending a fortune on foreign audits? Bhardwaj advocates against duplicating efforts. The vehicle for trust already exists; it just needs a new destination. He points to the MSME sustainable ZED (Zero Defect, Zero Effect) certification. "We don't need a new scheme," he asserts. "We can transform the existing ZED standards—Bronze, Silver, and Gold levels—into the recognised India Semiconductor Ready mark."

Infrastructure for such certification is already in place. The Ministry of MSME provides substantial subsidies to cover the cost of these certifications. By aligning this existing framework with the specific rigours of the chip industry, India can instantly verify thousands of suppliers. Such a move turns a government certificate into a global "Trust Passport," solving the verification bottleneck that currently slows down vendor onboarding.

Shared Laboratories

The cost of high-precision testing equipment—like vibration testers or mass spectrometers—can be prohibitive for a single unit. The solution lies in "Common Facility Centres." Bhardwaj advocates for a cluster-based approach where shared high-

Solutions Spotlight

1. **The visual management quick win:** Adopt simple shop-floor dashboards immediately. This creates a 'real-time feedback loop' that aligns the workforce instantly toward quality without expensive software.
2. **The ZED-plus Standard:** Quickly update the current ZED Gold certification to add specific rules for semiconductors, giving global buyers an immediate, government-approved "rust badge.
3. **The shared lab model:** aggressively use government cluster schemes to build common facility centres, transforming R&D from a crushing capital expense into a manageable operating expense for small players.

tech labs become the norm. "This is the model that works best," he explains. "Government schemes exist to help cluster associations create these common platforms." The shared economy model fundamentally alters the economics of business operations. It transforms a Capital Expenditure (Capex) problem into an Operating Expenditure (Opex) solution. A small vendor doesn't need to own a $100,000 lab; they just need access to one in their cluster. Such resource pooling allows Indian MSMEs to maintain a low-cost base while delivering the high-fidelity quality required by global anchors.

Mastering the Micron

Transitioning to semiconductor ancillaries requires a specific skill upgrade. Bhardwaj identifies two mission-critical competencies valued by global experts: micro-precision measurement and contamination control. "This goes far beyond basic workshop skills," he notes. "It is the ability to read and calibrate tools down to the micron level."

Equally critical is the environment. "Contamination control is of critical importance," he adds. Strict protocols for controlling fingerprints and particles are the difference between acceptance and rejection. The path forward involves leveraging the vast ITI (Industrial Training Institutes) network to fast-track training for a thousand technicians in these specific, niche skills. Success requires creating a workforce that understands that cleanliness is not just hygiene—it is revenue.

Partnership by Design

Finally, Bhardwaj proposes a powerful policy nudge to cement a localised supply chain. The relationship between the "Big Fab" and the "Small Supplier" must be structural, not accidental. He suggests a tier-based incentive structure for the large chipmakers. "The final 10-20% of the government's PLI payout could be directly tied to verifiable local sourcing from certified MSMEs," he proposes. We define this as

Strategy Note

> The connection between big fabs and small suppliers cannot be left to chance. It must be mandated. By tying the final tranche of PLI incentives to local sourcing, the government can force a structural partnership that uplifts the entire MSME ecosystem.

the "Local Linkage Doctrine." It compels the giants to launch structured supplier development programs, where they actively audit, train, and uplift local vendors. Such a policy transforms a transaction from purchasing to partnership, ensuring that the supply chain is deeply rooted in Indian soil.

The Evolution Beyond Chips

The relationship between the gigafactory and the MSME is not merely transactional; it is foundational. While the fab serves as the anchor, the MSME ecosystem provides the bedrock. By upgrading to the absolute fidelity required by the semiconductor sector—mastering data consistency, adopting global quality standards like ZED, and acquiring precision skills—India's small manufacturers are not just qualifying for a new supply chain; they are graduating to a new industrial league. This "nano-precision" capability will ripple outward, raising standards across aerospace, defence, and medical devices. The semiconductor mission, therefore, is more than a bid for chips—it is the definitive engine of India's holistic industrial evolution.

Key Takeaways

> The revolution begins on the shop floor. For India's MSMEs, the entry ticket to the semiconductor economy is not massive capital but massive discipline. By digitising measurement, visualising efficiency, and adopting the Zero Defect mindset, India's small manufacturers can transform from local vendors into global anchors. The opportunity is worth $40 billion, and it is theirs for the taking.



Kumar Priyadarshi
Founder, Bharat Semitech and TechoVedas

Build the Builder

We speak of “Make in India” chips. But if we import the tools needed to forge them, can we truly claim sover-eignty? Kumar Priyadarshi, Founder, Bharat Semitech and TechoVedas, engineers the answer.

Team India Front

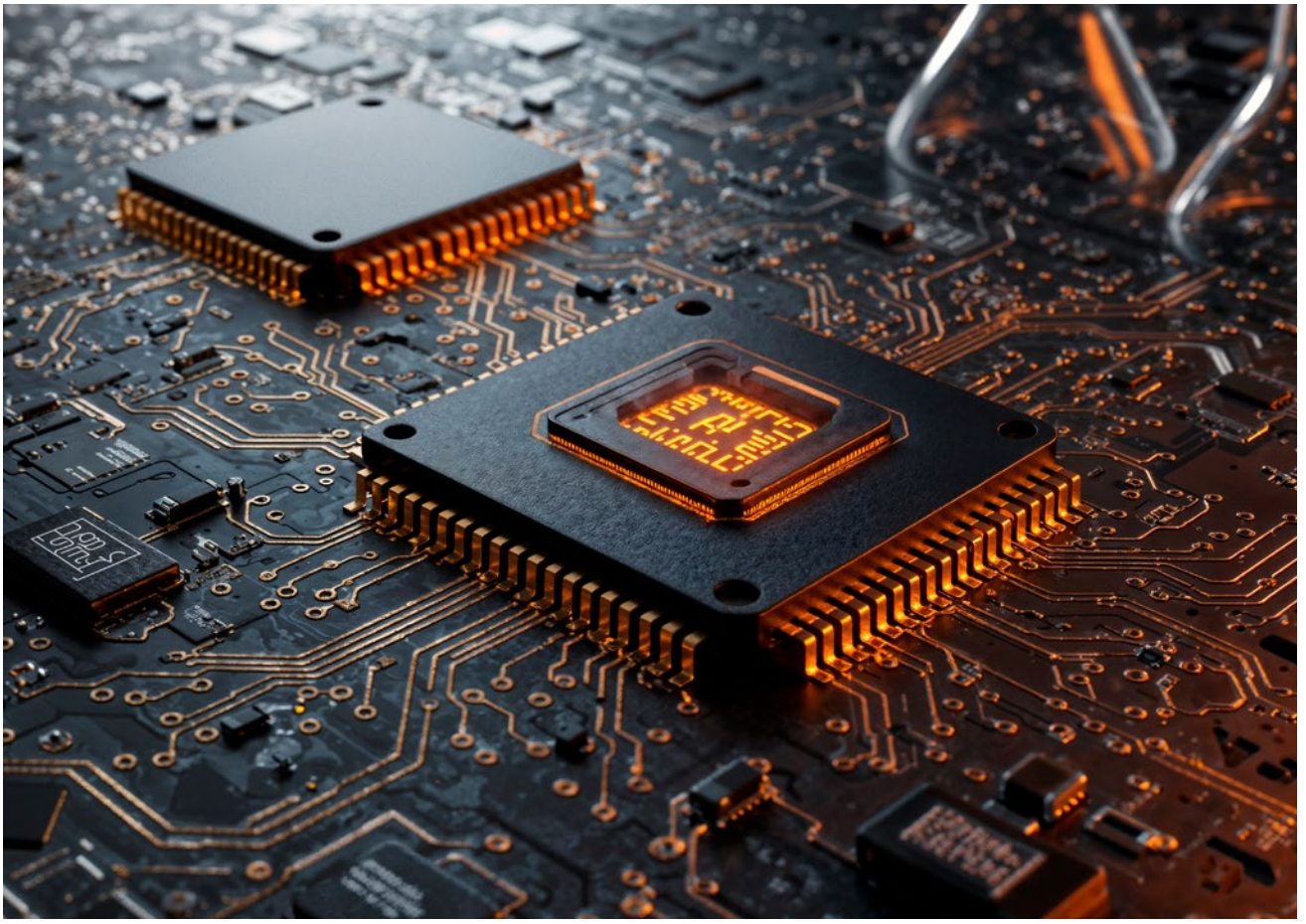
The ambition is absolute. India is not merely erecting factories; it is constructing an industrial fortress. As the nation's first fabrication unit rises in Dholera and massive assembly hubs emerge in Morigaon, national ambition has quietly shifted to the next, more critical frontier: "Equipment Sovereignty." True power in the semiconductor age isn't just owning the chip. It is mastering the machine that creates it. **Kumar Priyadarshi, Founder, Bharat Semitech and TechoVedas**, represents this next phase of India's evolution. Priyadarshi argues that India is ready to graduate. We must move from being a buyer of technology to a builder of it. The goal is to close the loop—ensuring that the chemical delivery systems, the automation modules, and the critical infrastructure driving our fabs are designed, engineered, and built on Indian soil. Securing this capability completes the self-reliance puzzle.

Cracking the Oligopoly

To understand the magnitude of Priyadarshi's mission, look at the global landscape. The semiconductor equipment sector is one of the world's most exclusive clubs. A handful of giants—Applied Materials, ASML, and Tokyo Electron—command the market. India's entry is a move of calculated precision. We aren't trying to compete head-on with the giants on day one. We are targeting the "Critical Subsystems"—a multi-billion dollar sector that powers them. Priyadarshi's roadmap is pragmatic and aggressive. Bharat Semitech has successfully localised the Chemical Delivery Module (CDM) and the Equipment Frontend Module (EFM). These are the arteries of the fab—pumping high-purity chemicals and managing wafer automation with zero-error precision. By manufacturing these domestically, India is not just saving costs; it is securing the operational resilience of its future industry.

The Smarter Alternative

How do we scale indigenous manufacturing capability? Priyadarshi outlines a clear path to dominance. The market for "auxiliary systems" is massive. Every fab needs thermal chillers, vacuum



valves, and mass flow controllers. Bharat Semitech is proving that Indian engineering can match global specifications for these critical tools. By securing this layer, we build a foundation immune to global supply chain shocks.

It is not just about copying; it is about improving. Priyadarshi reveals his team is integrating predictive maintenance directly into their hardware. "In a fab, you don't wait for a machine to break," he notes. "You predict the failure." Such a value-addition positions Indian tools as smarter, data-driven alternatives to legacy imports.

The New Elite

Advanced blueprints are useless without the skilled hands to execute them. While the industry often chases high-profile engineering degrees, Priyadar-

Solutions Spotlight

1. The Subsystem Entry: Don't fight ASML; supply them. India should target critical subsystems (chillers, pumps, CDMs)—a high-value niche that bypasses decades of R&D.

2. **Predictive Hardware:** Embed IoT and predictive maintenance into legacy tools (like pumps and valves), offering the global fab a "smarter" version of the standard equipment.

3. The Polytechnic Pivot: Shift the hiring focus from general engineers to polytechnic technicians. They possess the "muscle memory" and hands-on discipline required for precision equipment manufacturing.

Key Takeaways

1. **Sovereignty is Hardware:** You cannot call yourself a chip nation if you import every screw. Localising the tool supply chain is the final step in true independence.
2. **The Hub-and-Spoke CoE:** Training on simulators isn't enough. We need ₹100 Cr "Hubs" with real machines so students encounter real-world friction before they enter the workforce.
3. **Predict Failure:** In a fab, downtime costs millions. The future of equipment isn't just reliability; it's the ability to predict its own maintenance.

shi identifies Polytechnic Graduates as the true captains of this revolution. Unlike the "white-collar" drift often seen in traditional engineering streams, these graduates possess the hands-on technical discipline required for high-precision manufacturing.

They are the ones who translate a digital design into steel and silicon. Priyadarshi emphasises that respecting and upskilling this specific demographic is the key to matching German or Japanese manufacturing quality.

The 100-Crore Classroom

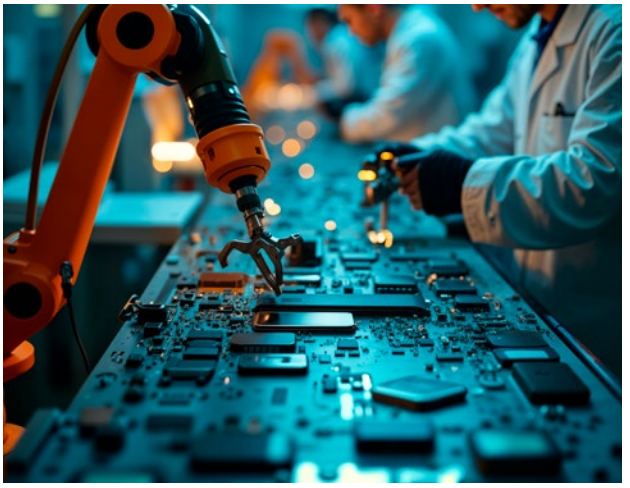
But you cannot master a billion-dollar machine using a textbook. To accelerate this momentum, the ecosystem requires infrastructure that matches its ambition. Priyadarshi proposes a centralised Centre of Excellence (CoE) model—high-impact hubs equipped with industrial-grade machinery worth ₹100 crore. In this architecture, the "hub" acts as a state-of-the-art facility mirroring a real semiconductor plant, while the "spokes" form a network of universities channelling talent into this hub for rigorous, practical training. This ensures the workforce entering India's fabs is not just theoretically sound but operationally battle-ready.

Trust as Currency

For entrepreneurs joining this mission, the rules are clear: quality is the currency. In a sector where feedback spans years, trust is the sole valuable asset. Through TechoVedas, Priyadarshi is instilling this discipline across the startup ecosystem, ensuring capital flows only into technologically robust, viable ventures.

The End of Figuring It Out

The time for experimentation has passed. This is the reality of the new industrial order. Priyadarshi's message is a clarion call for maturity. The era of "figuring it out" is over. Success now demands the precision to target critical subsystems, the discipline to train on industrial-grade hardware, and the foresight to localise the machinery of production. India has proven it can design the chip. Now, India must build the fortress that forges it.



Strategy Note

The Arteries of the Fab: While the Lithography machine gets the glory, the Chemical Delivery Module (CDM) keeps the fab alive. Localising these "Arteries" is the fastest route to equipment sovereignty.

Harnessing the Collective Intellect



Amishi Mehta, Co-founder and COO, India Front

Securing the semiconductor ecosystem is the ultimate masterstroke for India's industrial autonomy. Throughout these pages, it is clear that we are no longer just planning for the future; we are actively setting the pace for global manufacturing. By investing in our own expertise and turning capital into genuine capability, India is claiming a definitive seat at the table of global technology. This effort has moved beyond projection and into the grit of real-world execution.

As we wrap up this work on silicon, the next logical challenge is already coming into view. Every high-volume fab and AI-driven data centre we've discussed relies on a massive, constant supply of power. You cannot scale a digital economy on an analog energy foundation. The success of our technological ambitions depends on how we generate and distribute energy at a scale never seen before.

That is why we are shifting our focus to the energy revolution for our next chapter. Titled "The India Edge: Leading the Global Green Wave", our third edition will dive deep into the Renewables landscape. We will look at the execution behind the 500 GW roadmap, moving from the massive projects in the Rann of Kutch to the new Green Hydrogen corridors.

The goal remains the same: to stop talking about intent and start mastering the "how". We will bring together the primary movers of this transition to tackle the real-world gaps in our green journey.

Thank you for being part of this roadmap. Make sure you're with us for the next one—the story of India's industrial rise is only just getting started.

THE SIGNAL IN THE NOISE

The world is loud, and business is chaotic. While others are busy chasing the headlines of what happened yesterday, we are focused on the blueprints for tomorrow.

India Front is not a ledger of events; it is a playbook for execution. We cut through the clutter to bring you the raw strategies from the minds shaping the nation. We believe that true leadership isn't about consuming information; it is about finding clarity.

No fluff. No speculation. Just the unvarnished strategy of ascent. This is not news; this is intelligence.

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The Manual for India's Industrial Ascendancy.


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We are standing at the edge of a historic transformation. The old rules are being rewritten, and new empires are being forged right now. From policy to practice, from concept to concrete, the story of India's rise is the most exciting narrative in the global economy. But opportunity favors the prepared.
India Front exists to ensure you understand the forces at play before the rest of the world catches up. Don't watch the revolution from the sidelines. Master the trends. Own the future.
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