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India Becomes 7th Nation to Master Gallium Nitride (GaN) Chip Technology

27 May 2026 · SCIENCE & TECH · SECURITY & DEFENCE · GS3

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27 May 2026 · 4 min read · 2 tags

WHY IN NEWS:

DRDO's Solid State Physics Laboratory (SSPL), Delhi — with support from facilities in **Hyderabad** — has indigenously developed **Gallium Nitride Monolithic Microwave Integrated Circuits (GaN MMICs)**, making India the **7th nation globally** to master GaN chip technology. The other six are the **USA, France, Russia, Germany, South Korea and China**. The breakthrough is strategically significant because it followed **France's refusal** to transfer GaN technology under the Rafale offset clause.

WHAT IS GALLIUM NITRIDE (GAN)?

PARAMETER	DETAIL
Material class	**Wide bandgap semiconductor**
Bandgap	**3.4 eV** (vs Silicon's 1.1 eV; Gallium Arsenide 1.4 eV)
Key properties	High thermal stability (operates beyond 300°C, components rated up to ~1000°C in pulsed conditions); high electron mobility; high power density
Switching speed	10x faster than Silicon
Power efficiency	~3x higher than Silicon for RF/microwave applications

GaN is grouped with **Silicon Carbide (SiC)** as the two leading **wide-bandgap semiconductors** — the post-Silicon era of power and RF electronics.

WHAT ARE MMICS?

Monolithic Microwave Integrated Circuits are integrated circuits operating at microwave frequencies (~300 MHz – 300 GHz). All active and passive components — transistors, capacitors, transmission lines — are fabricated on a **single semiconductor substrate**, giving:

- **Compactness** — palm-sized modules replacing rack-sized RF assemblies.

- **Reliability** — fewer interconnections → fewer failure points.
- **Reproducibility** — wafer-scale manufacturing.

GaN MMICs are the **active elements in AESA radars, electronic warfare suites, satellite payloads, and 5G/6G base stations**.

STRATEGIC AND DEFENCE APPLICATIONS

APPLICATION	ROLE OF GAN
AESA radars (e.g., Tejas Mk1A, Sukhoi-30 MKI upgrades, future MWF)	T/R modules in active phased arrays
Electronic Warfare suites	High-power jammers, ESM/ECM systems
Secure satellite communications	Power amplifiers for X/Ku/Ka-band uplinks
Naval radars (e.g., MF-STAR derivative, indigenous LRSAM)	Long-range air & surface search
5G/6G base stations	Power amplifiers (commercial spillover)
EV chargers, data centres, aerospace power supplies	Wide commercial application

WHY IT MATTERS — THE RAFALE BACKSTORY

When India signed the **Rafale deal (36 jets) in 2016**, the offset clause envisioned transfer of advanced RF technologies. **France's Thales** declined to transfer GaN MMIC technology, citing national-security restrictions. DRDO's SSPL was tasked with indigenous development — and has now delivered, ~10 years later.

This positions India in a select club:

COUNTRY	GAN MMIC CAPABILITY
USA	Raytheon, Northrop Grumman, Wolfspeed
France	Thales, UMS
Russia	NIIET, NIIPP
Germany	UMS, Fraunhofer IAF
South Korea	RFHIC, Samsung
China	CETC, HiSilicon (subject to US export controls)
India	**DRDO-SSPL**

SSPL — THE LAB

PARAMETER	DETAIL
Full name	Solid State Physics Laboratory
Parent	DRDO
Established	1962 (as Electronics & Radar Development Establishment unit); renamed SSPL 1986
Location	Lucknow Road, Timarpur, Delhi
Mandate	Microelectronics, photonics, sensors for defence applications
Recent achievements	Indigenous T/R modules for Uttam AESA radar (Tejas Mk1A); MEMS gyros; QKD demonstrator

ECOSYSTEM LINKAGES

- **India Semiconductor Mission (ISM) — ₹76,000 crore (Dec 2021); 10+ projects with ~₹1.6 lakh crore investment** approved as of late 2025/early 2026 (PIB Year-End Review 2025), including Tata-PSMC Dholera, CG Power-Renesas, Tata Sanand, Kaynes Sanand, Micron Sanand and subsequent OSAT/compound-semi approvals.
- **Compound Semiconductor Mission** — separately mooted for GaN/SiC, given that ISM's first 5 are mostly Silicon-based.
- **Quantum Mission (₹6,003 crore, April 2023)** — overlaps with SSPL's QKD and single-photon detector work.

WIDER SIGNIFICANCE

- **Defence self-reliance** — Atmanirbhar Bharat in the highest-end RF technology.
- **Export potential** — GaN MMICs are dual-use; commercial 5G/6G demand alone is multi-billion-dollar.
- **De-risking from China/Taiwan supply chains** — current global GaN supply is geographically concentrated.
- **Talent stack** — the IIT/IISc + DRDO + private-sector pipeline now has a flagship indigenous IC technology to anchor.

CHALLENGES

- **Scale-up from lab to foundry** — SSPL's pilot line must transition to a high-volume **compound semiconductor fab** (none operational in India yet).
- **Substrate dependence** — SiC and sapphire substrates still largely imported.
- **IP and standardisation** — global GaN IP is heavily patented; freedom-to-operate audits needed.
- **Cost competitiveness** — global GaN MMIC prices have fallen sharply; Indian production must hit scale to compete.

WAY FORWARD

- **Dedicated Compound Semiconductor Fab** under ISM-2.0 — GaN + SiC + GaAs at scale.
- **Strategic stockpile** of substrates (SiC, sapphire, GaN-on-Si wafers).
- **Public-private partnership** — DRDO-SSPL + Tata Electronics / Bharat Electronics / private players for commercialisation.
- **Export controls calibration** — India must adopt a **deemed-export** regime balancing security and commerce.
- **Skill mission** — compound semiconductor technicians and process engineers.

UPSC RELEVANCE

GS Paper 3 — Science & Technology / Security:

- Achievements of Indians in science & technology; indigenization of technology and developing new technology.
- Awareness in the fields of IT, space, computers, robotics, nano-technology, bio-technology.
- Defence — indigenisation, defence-industrial complex.

Analytical hooks for Mains:

- Self-reliance in critical technologies — lessons from the Rafale offset experience.
- Compound semiconductors as the next frontier of the semiconductor mission.
- Dual-use technology governance — export controls and strategic autonomy.

FACTS CORNER

Announcement: May 26–27, 2026 (DRDO).

Developing agency: DRDO — Solid State Physics Laboratory (SSPL), Delhi.

Product: GaN Monolithic Microwave Integrated Circuits (MMICs).

India is the 7th nation with GaN MMIC mastery, after USA, France, Russia, Germany, South Korea, China.

GaN bandgap: 3.4 eV (Silicon: 1.1 eV).

GaN applications: AESA radars, EW, satellite comms, naval radars, 5G/6G base stations.

Backstory: France declined GaN transfer under the Rafale 2016 offset clause.

India Semiconductor Mission (ISM): ₹76,000 crore, December 2021.

National Quantum Mission: ₹6,003 crore, April 2023.

Other wide-bandgap semiconductor: Silicon Carbide (SiC).

Sources: PIB, The Hindu, Sify

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