vGaN Vertical GaN

onsemi Powers Next Leap Forward in AI & Electrification

onsemi's vertical gallium nitride (vGaN) transistors are the next-generation class of power devices designed to handle extremely high voltages at high frequency with superior efficiency compared to traditional silicon chips. This industry-first technology is pioneered by onsemi's R&D team based in Syracuse, NY. The company's state-of-the-art 66,000 square-foot facility includes a cleanroom with highly specialized tools, all dedicated to vGaN development.

Today's commercial GaN devices are typically built in a lateral structure, meaning that GaN is grown on top of a silicon or sapphire substrate. In the case of vertical GaN, GaN is grown on top of a GaN substrate. This vertical design allows current to flow straight through the chip rather than just across its surface, allowing higher current densities and operation at much higher voltages than lateral GaN devices and enabling switching frequencies much higher than silicon or silicon carbide (SiC). As a result, vertical GaN enables smaller, lighter and more efficient electronics – from electric vehicle (EV) chargers to AI data centers and renewable energy systems, and more.

Researchers have pursued vertical GaN for over 15 years, but only now is onsemi the first company in the world to bring it to market at scale. Vertical GaN manufacturing is inherently complex because it requires growing thick, defect-free GaN layers on bulk GaN substrates—a process far more intricate than standard silicon fabrication. Achieving this demands precise epitaxial growth and innovative techniques tailored to its vertical architecture. onsemi's 130-plus patents cover all aspects of the fundamental device architecture and processing. It is a materials science and manufacturing challenge akin to building a skyscraper on a foundation the width of a sidewalk.

Interesting Facts

- **Precise Accuracy:** Growing crystals efficiently in highly-controlled furnaces where atoms are deposited layer by layer, one billionth of a meter at a time, enabling perfect uniformity. These furnaces operate at temperatures above 1,000°C or nearly the same temperature as volcanic lava.
- **Crystal Power:** Vertical GaN is built on a hexagonal wurtzite structure, meaning a hexagonal lattice where gallium and nitrogen atoms stack in alternating layers, which gives it unique electronic & optical properties compared to cubic silicon.
- **Skyscraper Tech:** The vertical architecture is like building electrical "skyscrapers" instead of "ranch houses," allowing power to move straight through the chip instead of only its surface.
- **Miniaturization Marvel:** Compared to commercially available lateral GaN, vGaN devices are approximately three times smaller and can reduce size and losses of high end power systems by almost 50%. That's like shrinking a shoebox-sized power converter into something closer to a paperback book – cutting both size and weight.
- **Voltage Champ:** Vertical GaN devices can handle over 1,200
- **Strategic Material:** GaN is considered so strategically important that it's on the U.S. Department of Defense's list of critical materials.

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Applications for vGaN

onsemi's vGaN technology is designed to handle high voltages in a monolithic die – 1,200 volts and beyond – switching high currents at high frequency with superior efficiency. High end power systems built with this technology can reduce losses by almost 50% and by operating at higher frequencies can also reduce the size, including passives like capacitors and inductors by a similar amount. Additionally, compared to commercially available lateral GaN, vGaN devices are approximately three times smaller. This makes onsemi's vGaN ideal for critical high-power applications where power density, thermal performance and reliability are paramount, including:

- **AI Data Centers:** Reduced component counts, increased power density for 800V DC-DC converters for AI compute systems to greatly improve cost per rack
- **Electric Vehicles:** Smaller, lighter and more efficient inverters, for increased EV range
- **Charging Infrastructure:** Faster, smaller, more rugged chargers
- **Renewable Energy:** Higher voltage handling, reduced energy losses for solar and wind inverters
- **Energy Storage Systems (ESS):** Fast, efficient, high-density bidirectional power for battery converters and microgrids
- **Industrial Automation:** Smaller, cooler, higher efficiency motor drives and robotics
- **Aerospace, Defense and Security:** Higher performance, enhanced ruggedness and more compact designs

As the world races toward a future defined by electrification and AI, onsemi's breakthrough in vertical GaN technology marks a pivotal moment. By overcoming long-standing materials and manufacturing challenges, onsemi has unlocked a new class of ultra-efficient, high-voltage power devices that will help shape the next generation of energy systems. From shrinking the footprint of EV chargers to powering AI data centers more sustainably, vertical GaN is not just a technological milestone—it's a strategic leap forward in building a smarter, cleaner, and more electrified world.