

Power electronics market to grow at 10% CAGR from \$25.5bn to \$65.2bn by 2036

Silicon carbide will become the dominant power semiconductor material by 2036, reckons IDTechEx.

Since the development of power diodes and thyristors in the 1950s, silicon has been the dominant material for power electronics across applications ranging from electric vehicles to wind turbines. However, the emergence of wide-bandgap semiconductors such as silicon carbide (SiC) and gallium nitride (GaN) has enabled industry to push to higher voltages and smaller form factors while increasing efficiency and maintaining reliability. At the same time, early-stage research into the next generation of semiconductor materials, ultrawide-bandgap (UWBG) semiconductors, threatens to disrupt this space further.

In its report: 'Power Electronics Market 2026–2036: Data Centers, Electric Vehicles, and Renewables', market research firm IDTechEx therefore expects the power electronics market to grow at a compound annual growth rate (CAGR) of 10% from US\$25.5bn in 2026 to US\$65.2bn by 2036.

A material difference: key properties differentiating Si, SiC, GaN, and UWBGs

The most obvious difference between silicon, SiC, GaN, and UWBGs at a material level is their bandgap. This directly influences critical properties of the materials such as their critical breakdown fields, dictating the maximum voltage at which power semiconductors can safely operate. A higher critical breakdown field enables higher-voltage operation or, alternatively, enables the same voltage operation with a smaller drift layer, minimizing form factor and on-resistance. However, other metrics are also important in evaluating semiconductor materials. Electron mobility and drift velocity affect a device's switching performance, in turn affecting the switching frequencies that can be achieved by a power transistor. However, it is worth noting that device architecture also plays a key role here; for example, GaN high-electron-mobility transistors (HEMTs) enable rapid switching frequencies, on the order of MHz.

With thermal management playing a crucial role in system design, the thermal properties of semiconductor materials are also an essential consideration. With material and device considerations taken into account,

SiC is well positioned to complement silicon in applications requiring high-voltage, while GaN complements especially well in lower-power, fast-switching applications. Material properties of some UWBGs are very interesting. Especially diamond, due to its large bandgap, high switching performance, and exceptional thermal conductivity, has the potential to function as the 'ultimate' power semiconductor, at least in theory.

Data centers drive wide-bandgap innovations, while renewables support silicon's staying power

One of the power electronics applications experiencing the most hype recently is data centers, especially for AI training, where the next generation of servers requires an overhaul of power architecture, switching from AC-to-DC conversion at the rack level to a 'sidecar' architecture, delivering 800VDC to the rack. This will eventually be superseded by a 'native' 800VDC architecture, where grid voltage will be stepped down to 800VDC by solid-state transformers, to then be distributed around the data center. While this is expected to bring significant efficiency improvements, the primary reason is one of necessity; incumbent power architecture simply will not be able to provide the power necessary for Nvidia's Vera Rubin Ultra servers and beyond. Detailed insights on the 800VDC transition are included in the report 'Power Electronics Market 2026–2036: Data Centers, Electric Vehicles, and Renewables'.

In electric vehicles, the shift to an 800V powertrain was a key driver for wide-bandgap innovation, where the benefits of SiC over incumbent silicon technology were evident, and worth the cost premium in many performance models.

In data centers, similar drivers are pushing innovation in wide-bandgap technology, especially for GaN. On the low-voltage side (stepping 800VDC down to 50V, or 12V, or 6V), efficiency and miniaturization are key. The ultra-fast switching of GaN reduces the size of passive components (inductors, capacitors etc) and thus the overall footprint of the device. With a drive to keep as much space as possible for compute, device

size is a metric of critical importance driving GaN commercialization. On the high-voltage side, solid-state transformers are likely to rely on SiC technology,

where single MOSFETs are now able to operate at 10kV.

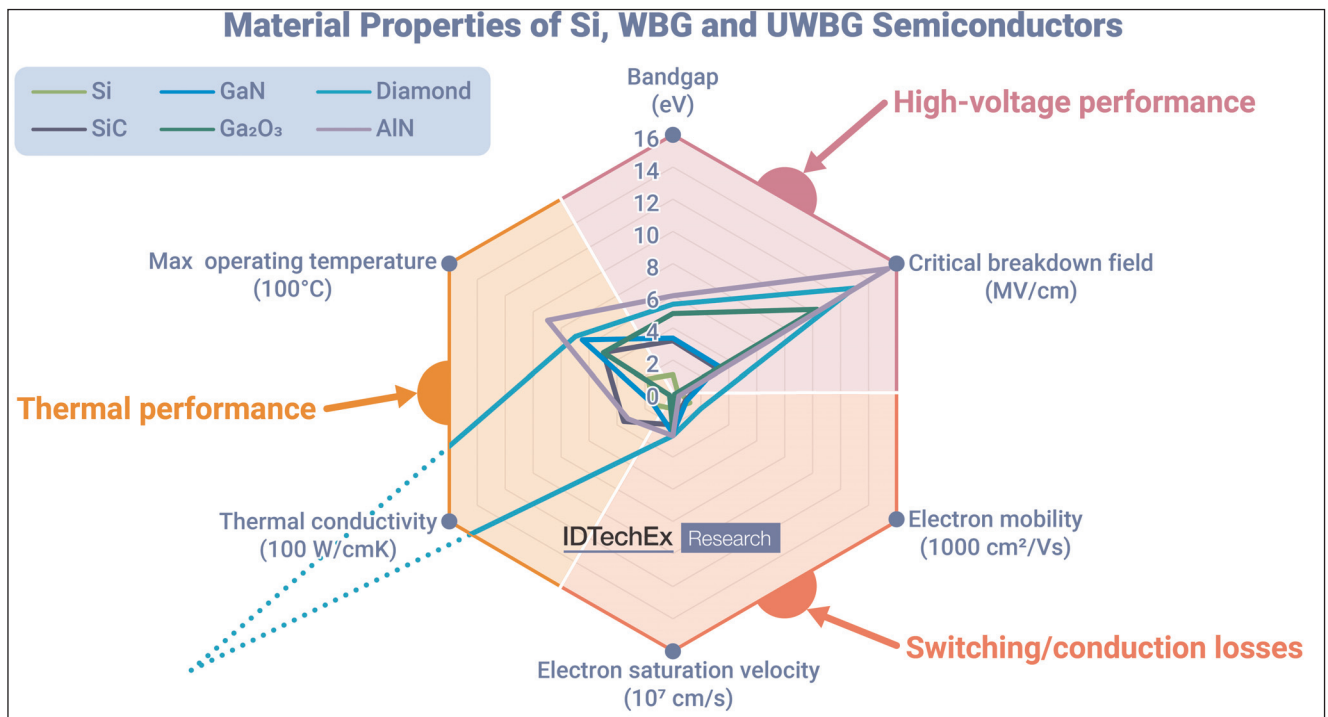
SiC and GaN are certainly dominating the headlines, if not the entire market just yet (IDTechEx does expect SiC to become the dominant power semiconductor material by 2036). However, there remains a strong, steady market for silicon power semiconductors.

One example where players have been more hesitant to switch to wide-bandgap semiconductors is renewable energy, specifically wind turbines. This is especially true offshore, where repair costs would be very expensive if components were to malfunction. The miniaturization benefits are also relatively less important compared to in other industries.

Finally, the wind industry is highly cost conscious; in many cases, the premiums associated with SiC are too high to bear. Altogether, this has resulted in a much slower transition away from incumbent silicon technology. However, early collaborations, such as those between Wolfspeed and Hopewind, are now beginning to emerge, suggesting SiC technology has become sufficiently mature for use in even these more cautious industries. This maturity has been developed significantly by R&D from the EV industry, highlighting the cross-application nature of the power electronics market.

How will ultra-wide bandgaps disrupt the landscape, and when?

UWBGs have so far received much less attention than their wide-bandgap counterparts, and are much earlier in development, with only early device prototypes available for a limited number of materials. IDTechEx provides SWOT analyses on UWBG semiconductor materials and is in contact with key players across the three main UWBG materials: Ga₂O₃, AlN, and diamond.



While all three have the potential to offer advantages over incumbent materials, especially in terms of high-voltage or extreme-environment performance, all three have drawbacks. Ga₂O₃ has very thermal conductivity, effectively doping AlN has proved challenging (though polarization-doping could be an effective solution here), and effectively growing single-crystal diamond to the wafer sizes suitable for commercial power electronics applications has proven challenging and expensive. They each also have key commercial drivers: Ga₂O₃'s relatively straightforward manufacture from melt, AlN's route to commercialization through optoelectronics, and diamond's superior material properties. As such, it remains unclear which material, if any, will 'win' the UWBG race.

However, what is clear is that all three are still a long way from large-scale commercialization. Ga₂O₃, with device prototypes, might be the closest, but even players in this space do not expect commercialization for at least the next five years. It is also clear that the cost premiums that will undoubtedly be associated with these materials will prevent them from taking over the wide-bandgap space. They are more likely to further complement WBGs in extreme and niche applications, such as in aerospace, where the performance improvements justify higher costs.

With semiconductor materials occupying overlapping application areas, the power electronics industry is complicated by materials competing with and complementing each other. In IDTechEx's report, key semiconductor materials are benchmarked and compared, and their use across the most pertinent application areas: data centers, EVs, and renewables, are evaluated to provide clarity and detail. ■

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