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Figure 2 shows that GaN has a much higher critical electric field and energy gap—roughly 3x that of GaAs, Si and InP—and it has a saturation velocity nearly that of InP. These indicate GaN should be well-suited to fabricating high-power and high voltage mmWave devices, as the higher critical electric field and energy gap enable higher breakdown voltage and, thus, operating voltage. The higher saturation velocity leads to the maximum current density the semiconductor can handle.

These factors and GaN's ability to withstand a wide temperature gradient and many thermal cycles supports its suitability for mmWave applications, where intrinsic device losses are higher and heat is generated during amplification and switching. As GaN's thermal conductivity (~1 to 3 W/cm K) is greater than the conductivity of GaAs and InP, GaN devices are inherently better at heat dissipation at high-power levels.

For the same output power, a GaN device will be a fraction of the size of GaAs and InP devices. Substantially reducing device size reduces on-chip routing and combining losses when multiple transistors are integrated on the same die. GaN's size and power advantages are dramatic (see ***Figure 3***).

Vertical Transistors

Typically, GaN devices have been fabricated as lateral heterojunction AlGaN/GaN HEMTs on Si or SiC substrates. Lateral GaN technologies are becoming mature and potentially reaching their voltage and power limits. At high voltage and power, lateral devices require substantially more chip area than vertical devices. Generally, vertical devices can provide higher power from a smaller area, as vertical devices withstand higher blocking voltage in the vertical direction into the bulk material.[4,12] Other arguments for vertical devices are potential benefits from current spreading and thermal management.

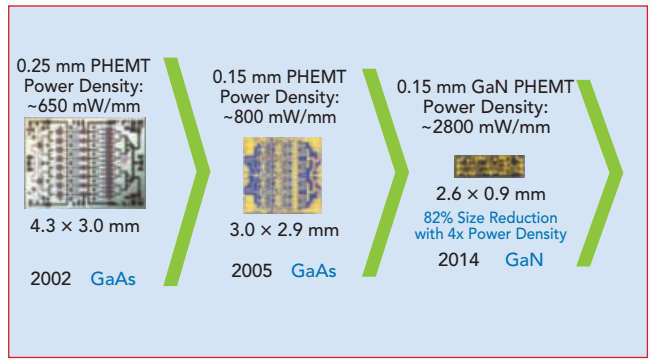

Fig. 3 MMIC PA evolution from PHEMT to GaN.[8]

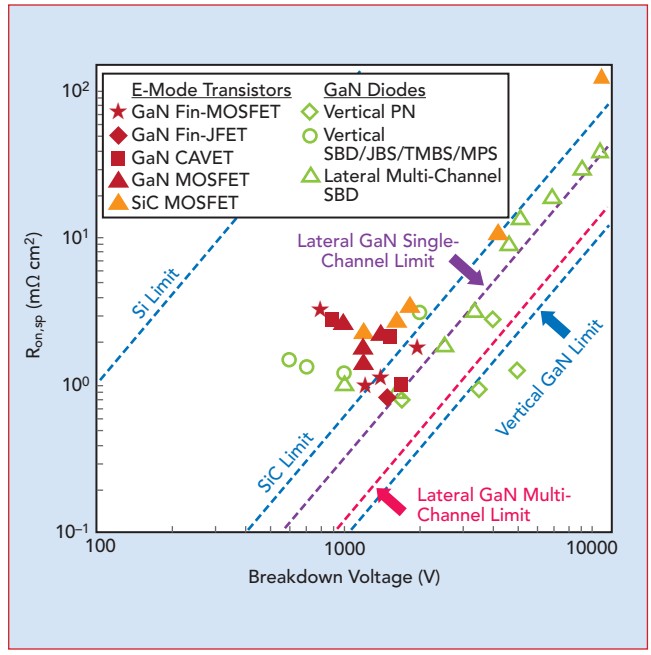

Fig. 4 R_{on} vs. breakdown voltage of state-of-the-art vertical and lateral GaN diodes and transistors.[12]