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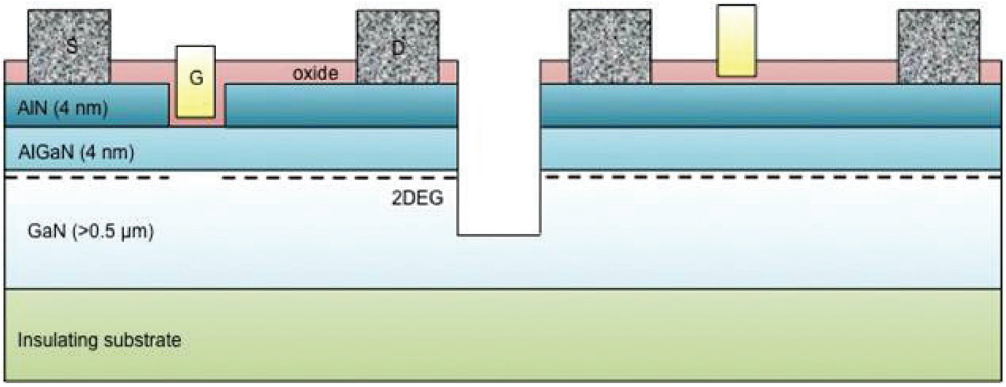
Naval Research Laboratory

GALLIUM NITRIDE



At a Glance

What is it?

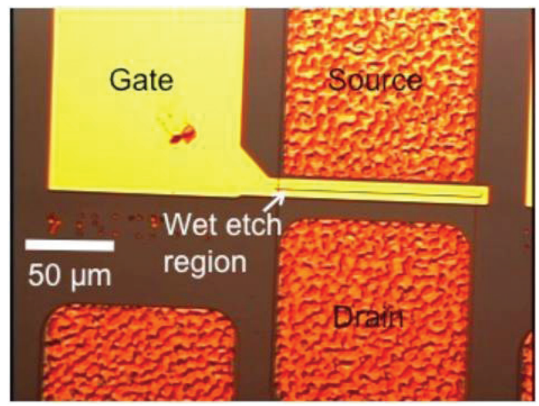
An up and coming III-V semicinductor material system for high-power high-speed applications.

How does it work?

Internal strain and piezoelectric fields give rise to a two-dimensional electron gas by which carriers travel from source to drain.

What will it accomplish?

Smaller size, lower mass. A single Gan-based transistor can replace many GaAs transistors in power amps and MMICs.



NRL GaN HEMTs

Gallium nitride, the high-power *wunderkind*, is used use in applications as varied as high electron mobility transistors (HEMTs), LEDs, solar cells and power amps, operating at frequencies from DC to microwave. It also seems to have the potential to be extremely resistant to displacement- and ionization damage effects. As part of the Naval Research Laboratory's basic research program on radiation effects we want to know why, so we designed an experiment to test our model of how all other non-GaN HEMTs respond to induced damage. The model is conceptually quite simple: Carriers passing from source to drain in a HEMT travel by way of a two-dimensional electron gas (2DEG). When a carrier in that 2DEG encounters a radiation-induced defect it scatters in the ordinary 3-D way and hence nearly always leaves the 2DEG. Once out, though, it is energetically favorable for the carrier to be reinjected. Empirical evidence from many different studies strongly suggests that the reinjection probability is proportional to the depth of the 2DEG below the neighboring conduction band edge. For example, the 2DEG in InAs/AlSb HEMTs is much deeper than in GaAs/AlGaAs HEMTs, and a corresponding difference in radiation hardness is observed. InAs HEMTS are more than 2 orders of magnitude harder.

Enter GaN, whose 2DEG is not the result of careful band gap engineering but of strain and strong internal piezoelectric fields. If the above model based on dimensionality is correct, we should be able to extend it to include GaN because it doesn't depend on why the 2DEG exists, only that carriers can be scattered out of it with high efficiency, then subsequently reinjected. The experiment we're currently performing to find these answers involves hundreds of GaN HEMTs from several government and industry sources, and a wide range of incident particles and particle energies.

To learn more see: B.D. Weaver et al., Appl. Phys. Lett. 87 (173501 (2005).