Paper-thin gallium oxide transistor handles more than 8,000 volts

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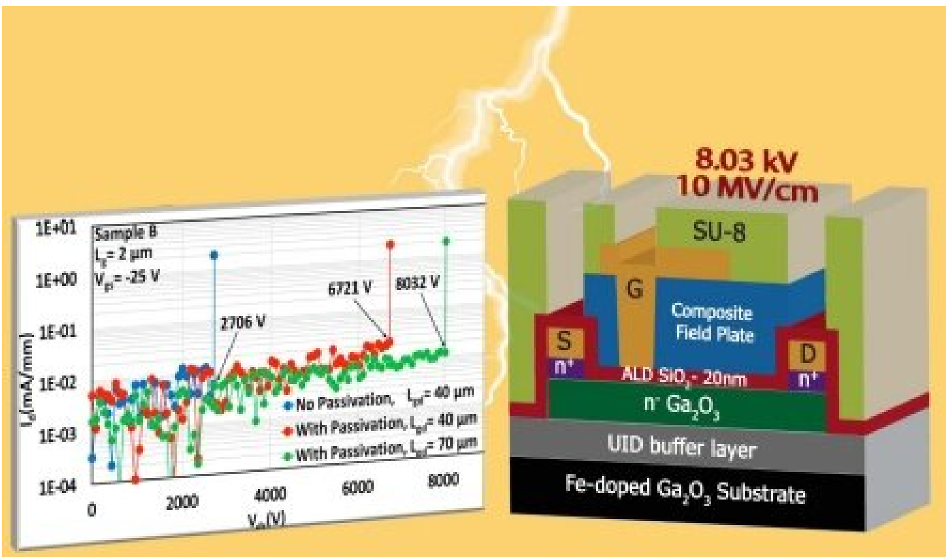

The graph image on the left shows the breakdown voltage of three different versions of the gallium oxide transistor. The illustration on the right shows the configuration and materials that make up the transistor that achieved a breakdown voltage of more than 8,000 volts. Credit: University at Buffalo

People love their electric cars. But not so much the bulky batteries and related power systems that take up precious cargo space.

Help could be on the way from a gallium oxide-based transistor under development at the University at Buffalo.

In a study published in the June edition of *IEEE Electron Device Letters*, electrical engineers describe how the tiny electronic switch can handle more than 8,000 volts, an impressive feat considering it's about as thin as a sheet of paper.

The transistor could lead to smaller and more efficient electronic systems that control and convert electric power—a field of study known as power electronics—in electric cars, locomotives and airplanes. In turn, this could help improve how far these vehicles can travel.

"To really push these technologies into the future, we need next-generation electronic components that can handle greater power loads without increasing the size of power electronics systems," says the study's lead author, Uttam Singisetti, who adds that the transistor could also benefit microgrid technologies and solid-state transformers.

Singisetti, Ph.D., associate professor of electrical engineering at the UB School of Engineering and Applied Sciences, and students in his lab have been studying the potential of gallium oxide, including previous work exploring transistors made from the material.

Perhaps the chief reason researchers are exploring gallium oxide's potential for power electronics is a property known as "bandgap."

Bandgap measures how much energy is required to jolt an electron into a conducting state. Systems made with wide-bandgap materials can be thinner, lighter and handle more power than systems made of materials with lower bandgaps.

Gallium oxide's bandgap is about 4.8 electron volts, which places it among an elite group of materials considered to have an ultrawide bandgap.

The bandgap of these materials exceeds that of silicon (1.1 electron volts), the most common material in power electronics, as well as potential replacements for silicon, including silicon carbide (about 3.4 electron volts) and gallium nitride (about 3.3 electron volts).

A key innovation in the new transistor revolves around passivation, which is a chemical process that involves coating the device to reduce the chemical reactivity of its surface. To accomplish this, Singisetti added a layer of SU-8, an epoxy-based polymer commonly used in microelectronics.

The results were impressive.

Tests conducted just weeks before the COVID-19 pandemic temporarily shuttered Singisetti's lab in March show the transistor can handle 8,032 volts before breaking down, which is more than similarly designed transistors made of silicon carbide or gallium nitride that are under development.

"The higher the breakdown voltage, the more power a device can handle," says Singisetti. "The passivation layer is a simple, efficient and cost-effective way to boost the performance of gallium oxide transistors."

Simulations suggest the transistor has a field strength of more than 10 million volts (or 10 megavolts) per centimeter. Field strength measures the intensity of an electromagnetic wave in a given spot, and it eventually determines the size and weight of power electronics systems.

"These simulated field strengths are impressive. However, they need to be verified by direct experimental measurements," Singisetti says.

More information: Shivam Sharma et al, Field-Plated Lateral Ga2O3 MOSFETs With Polymer Passivation and 8.03 kV Breakdown Voltage,

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