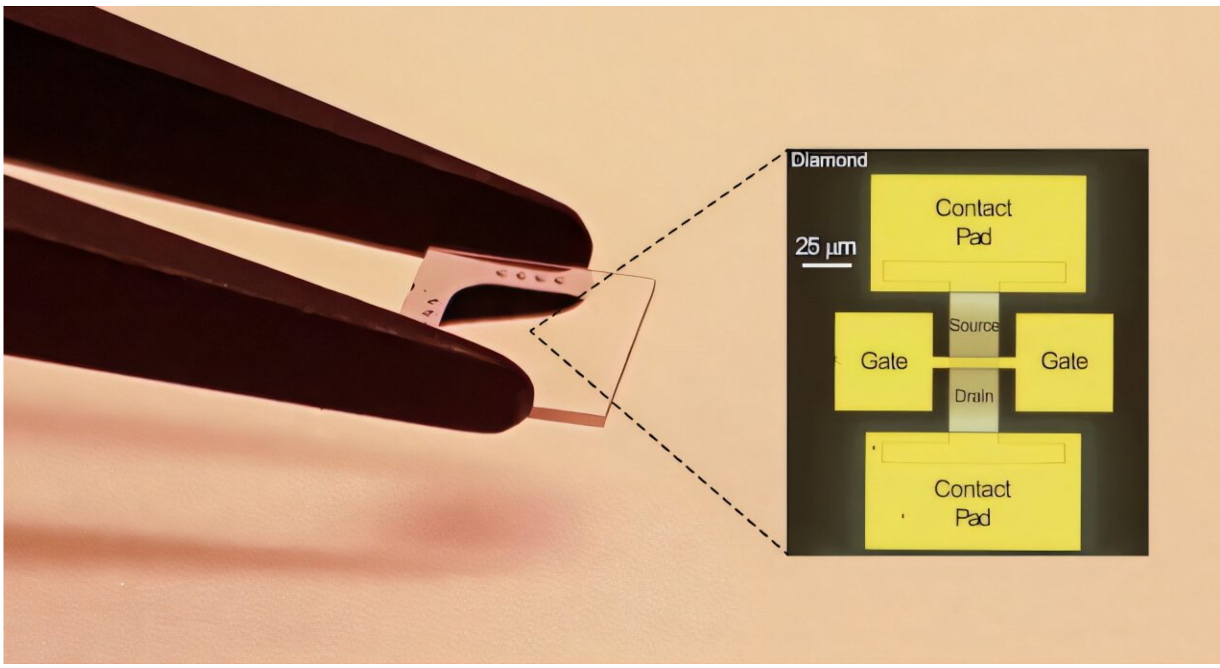
Advance paves way for new generation of diamond-based transistors in high-power electronics

January 30 2025



Credit: University of Glasgow

A landmark development led by researchers from the University of Glasgow could help create a new generation of diamond-based transistors for use in high-power electronics.

Their new diamond transistor overcomes the limitations of previous developments in the technology to create a device much closer to being of practical use across a range of industries that rely on high power systems.

The team have found a new way to use diamond as the basis of a transistor that remains switched off by default—a development crucial for ensuring safety in devices that carry a large amount of electrical current when switched on.

Diamond has an inherent property known as a wide band gap, meaning it is capable of handling much higher voltages than silicon—the material the majority of transistors are made from—before electrically breaking down. In power electronic applications, that means that transistors made from materials such as diamond can withstand significantly higher voltages and deliver higher power than Si transistors.

The team's diamond transistor could find applications in sectors where large voltages are required and efficiency is highly valued, like power grids or electric vehicles.

Professor David Moran, of the University of Glasgow's James Watt School of Engineering, led the research team with partners from RMIT University in Australia and Princeton University in the U.S. Their research is published in the journal *Advanced Electronic Materials*.

Professor Moran said, "Transistors are essentially switches that control electrical current. Devices like computers or smartphones use billions of tiny silicon-based transistors that draw small amounts of power, but power electronics use much fewer switches at significantly higher power levels.

"The challenge for power electronics is that the design of the switch needs to be capable of staying firmly switched off when it's not in use to ensure it meets safety standards, but it must also deliver very high power when turned on.

"Previous state-of-the-art diamond transistors have generally been good at one at the expense of the other—switches which were good at staying off but not so good at providing current on demand, or vice-versa. What we've been able to do is engineer a diamond transistor which is good at both, which is a significant development."

At the University of Glasgow's James Watt Nanofabrication Center, the team used surface chemistry techniques to improve the performance of diamond, coating it in hydrogen atoms followed by layers of aluminum oxide.

Their diamond transistor requires 6 volts to switch on, more than twice the voltage compared to previous diamond transistors, while still delivering high current when activated.

They also improved how efficiently charge moves through the device, achieving twice the performance compared to traditional diamond transistors. In practical terms, this means electrical charge can move more freely through the device, improving its efficiency.

When switched off, the device's resistance is high enough that it measures below the noise floor of the team's equipment in the lab, meaning almost zero current leaks through when it's supposed to be off, a crucial safety feature for high-power applications.

Professor Moran added, "These are really encouraging results, which bring diamond transistors much closer to achieving their potential than ever before. The production cost for diamond is surprisingly low for a material that many people associate with luxury goods, but there are still challenges to be addressed before diamond transistors are ready to be scaled up by the manufacturing industry. We hope that our research will help drive forward the adoption of diamond transistors across industries in the years to come."

More information: Chunlin Qu et al, Extreme Enhancement-Mode Operation Accumulation Channel Hydrogen-Terminated Diamond FETs with Vth Advanced Electronic Materials (2025). DOI: 10.1002/aelm.202400770

Provided by University of Glasgow