Semiconductor devices for high-temperature environments exceeding 800°C

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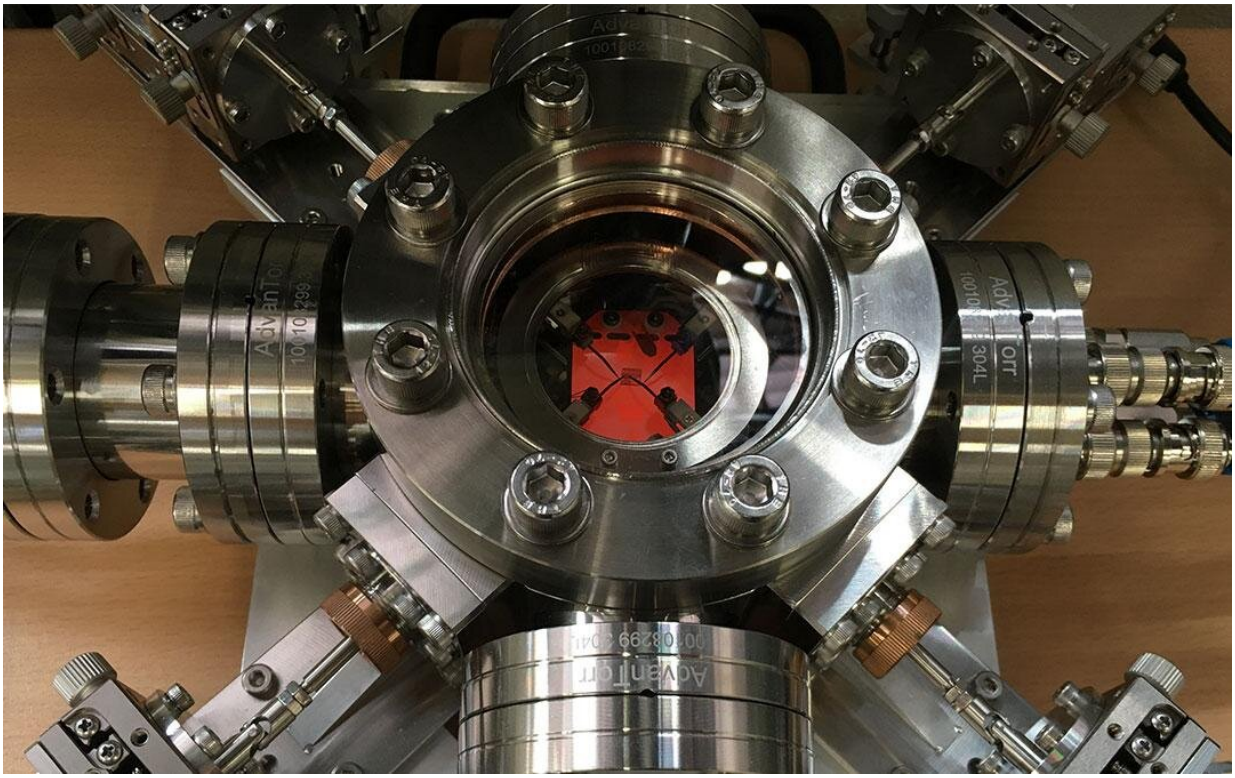

The operational temperature range of Silicon (Si) devices is typically limited to temperatures below ~300°C. However, researchers from the University of Tsukuba succeeded in achieving stable operation of diodes at 827°C and transistors at 727°C using aluminum nitride (AlN) semiconductors. Credit: University of Tsukuba

Silicon (Si) semiconductors are ubiquitous in electrical appliances and

play an essential role in our daily lives. However, in high-temperature environments exceeding 300°C, such as underground resource drilling, space exploration, and engine peripherals, improved semiconductor materials are required because of the limited operational temperature range of Si devices.

Wide-bandgap semiconductors are preferable for high-temperature electronics. Currently, aluminum nitride (AlN) crystals are among the most attractive materials for high-temperature devices because they possess larger bandgap energy in comparison to other semiconductors.

Numerous studies have reported AlN diodes and transistors that can operate at temperatures above room temperature. However, the maximum operating temperatures of these AlN devices are limited to 500°C or lower owing to technical problems associated with electrical characterization systems.

This study, published in *Applied Physics Express*, presents the fabrication and evaluation of high-quality AlN-layered diodes and transistors using a novel electrical characterization system capable of functioning at temperatures up to 900°C.

The researchers achieved a successful demonstration of diode operation at 827°C, surpassing all previous records, and the transistors operated at 727°C. Furthermore, nickel electrodes in AlN devices remained stable even at 827°C. Notably, these AIN devices are practically feasible because the AlN layers are grown on large, low-cost sapphire substrates. Moreover, the AlN devices exhibited a simple structure.

This research has paved the way for operable semiconductor devices to operate in severe environments (>800°C). These AlN devices are expected to be employed in high-temperature industries such as underground mining, steel production, space exploration, and aviation.

More information: Hironori Okumura et al, Temperature dependence of electrical characteristics of Si-implanted AlN layers on sapphire substrates, *Applied Physics Express* (2023). DOI: 10.35848/1882-0786/acdcde

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