Enhanced power devices open the way for high-voltage applications

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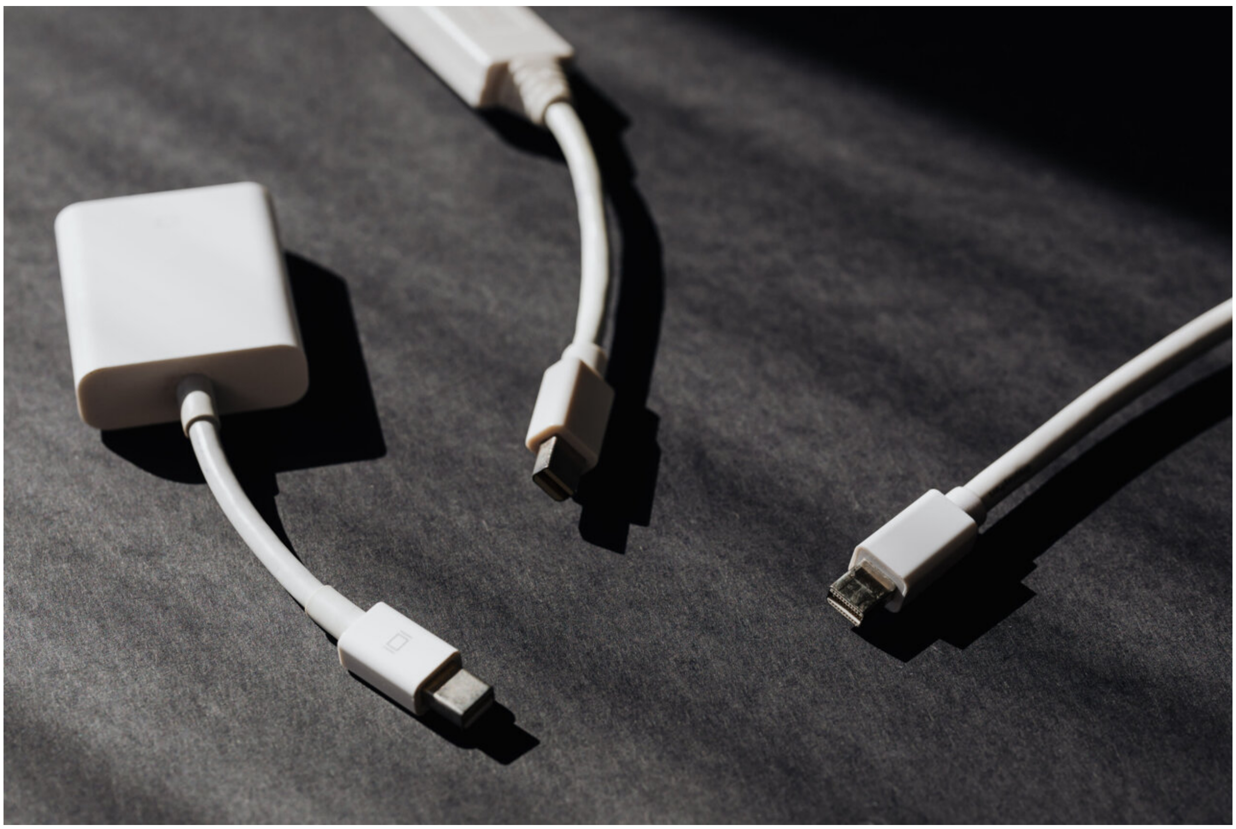

Credit: Karolina Grabowska from Pexels

Power semiconductors play an important role in power conversion in a wide range of electronic equipment we use in our everyday lives, from smartphones and computers to photovoltaics and electric vehicles. Given the extensive and global use of power semiconductors, scientists have been focusing on making them more energy efficient and cost effective.

Great strides have been made towards this goal through PowerBase, a partly EU-funded project with 39 partners from 9 European countries. PowerBase funds also contributed to the development of new gallium nitride (GaN) substrate technology based on which power devices will be able to operate at voltages beyond 650 V. This development was recently announced by an international R&D and innovation hub headquartered in Belgium and an American fabless technology firm. Their joint efforts resulted in this advance towards more efficient power semiconductors.

The new power devices' energy efficiency is achieved through GaN, a promising technology for power semiconductor applications. Heat resulting from power losses is a major side effect in electronics. As they operate, electronic devices and circuits generate heat. The more and faster they work, the more excess heat is created, which eventually compromises performance and leads to their premature failure. With its higher breakdown strengths and faster switching speeds, GaN has the potential to reduce energy loss during power conversion.

Up to now, GaN-on-silicon technology has been used for commercial GaN power devices operating at up to 650 V, with 200-mm buffer layers between the GaN device and the silicon substrate. However, for applications such as renewable energy and electric vehicles, whose needs run beyond 650 V, GaN-based power devices have proved problematic.

The difficulty lies in increasing the thickness of the buffer, which is based on aluminium gallium nitride (AlGaN), to the levels required for higher breakdown and low leakage levels. This is because there's a mismatch in the coefficient of thermal expansion (CTE) between the GaN/AlGaN epitaxial layers and the silicon substrate. Simply speaking, the two don't expand at the same rate with a change in temperature.

Although thicker silicon substrates have been considered as a way to prevent wafer warp and bow for 900 V and above, they give rise to other concerns such as loss in mechanical strength and compatibility issues in some processing tools.

The problem has been solved with the development of high-performance enhancement mode p-GaN power devices on 200-mm CTE-matched substrates. The thermal expansion of the substrates very closely matches that of the GaN/AlGaN epitaxial layers. This lays the foundations for power devices with 900 to 1 200 V buffers and beyond on standard thickness 200-mm substrates, with exciting new prospects for future commercial applications.

Now reaching its conclusion, PowerBase (Enhanced substrates and GaN pilot lines enabling compact power applications) has worked towards advancing current power semiconductor technologies. To achieve this, it has focused on setting up a qualified wide band gap GaN technology pilot line and expanding the limits of today's silicon-based substrate materials for power semiconductors. Other goals included introducing advanced packaging solutions out of a dedicated chip embedding pilot line and demonstrating innovation potential in leading compact power application domains.

More information: PowerBase project website: www.powerbase-project.eu/

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