HIGH-ELECTRON-MOBILITY TRANSISTORS

Gate dielectrics improve gallium nitride devices

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Credit: W.-Z. Xu

Gallium nitride (GaN) heterostructures are of potential use in the development of high-power electronic devices, such as high-electron-mobility transistors (HEMTs). To achieve control over the gate leakage and channel electrostatics of GaN-based HEMTs, a gate insulator, such as hafnium oxide (HfO_2), can be introduced. However, bonds between oxygen and gallium atoms degrade the interface quality between the GaN and the HfO_2 , which limits device performance. The quality of the interface can be improved by inserting a high- k gate dielectric between the two materials, and Wei-Zong Xu, Hai Lu and colleagues have now shown that high- k yttrium oxide (Y_2O_3) can be used to create high-quality insertion layers because of its low oxygen permeability.

The researchers — who are based at Nanjing University — used the bilayer $\text{Y}_2\text{O}_3/\text{HfO}_2$ dielectric stacks to fabricate GaN-based metal–insulator–semiconductor HEMTs on silicon. To confirm the quality of the interface between the dielectric and GaN, measurements were carried out that showed a low interface density of states ($10^{12} \text{ cm}^{-2} \text{ eV}^{-1}$). The transistors exhibited a low subthreshold swing of 70 mV dec^{-1} because of the small effective oxide thickness (2 nm) of the oxide layers. Compared with transistors based on other gate dielectric materials, the bilayer dielectric stacks result in a lower gate leakage of $10^{-12} \text{ A mm}^{-1}$.

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