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Nitride semiconductor material growth by rf-MBE for electronic device applications

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Gallium nitride and related materials are now beginning to realize their potential for electronic device applications, including high electron mobility transistors (HEMTs). Rf-plasma-assisted MBE is an attractive method of growing these materials due to its low background impurity incorporation, and recently there have been impressive results on MBE-grown electronic devices. However, significant growth issues remain, including the elimination or reduction of buffer conduction, threading dislocation densities, and trapping in or near the two-dimensional electron gas (2DEG) at the AlGaN/GaN interface. Recent work at the U.S. Naval Research Laboratory has addressed these issues, including the use of Be-doped GaN to reduce buffer conduction, the effect of the AlN nucleation layer on buffer conductivity and dislocation density, homoepitaxial growth of GaN on free-standing GaN substrates to reduce the threading dislocation density, and the investigation of trap states in AlGaN/GaN HEMT structures. For example, we have observed that buffer conduction can be reduced by several orders of magnitude by using Be-doped GaN layers and that the detailed growth conditions of the AlN nucleation layer on SiC substrates can significantly affect buffer conductivity and Hall mobilities in the 2DEG. Further, we have achieved room-temperature Hall mobilities of 1920 cm^2/V-s in AlGaN/GaN HEMT structures grown on free-standing GaN substrates.