Diamond - Nitride Semiconductor

~ p-n junction and two-dimensional electron gas ~

SCIENCE PLAZA 2010

Motivation

A nitride/diamond heterojunction is expected for high-efficiency, deep-ultraviolet (deep-UV) light-emitting diodes (LEDs) and high-output-power transistors, because high-efficiency p-type doping in diamond is possible and diamond has the highest thermal conductivity among materials. However, the most difficult issue has been the difference in crystal structures between nitride and diamond.

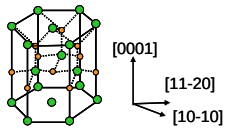
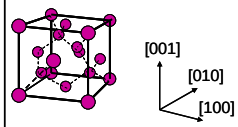
Originality

NTT proposed nitride growth on the diamond (111) plane, which has a similar atomic arrangement to the nitride (0001) plane, and successfully obtained single-crystal aluminum nitride (AlN) on diamond. Using this growth technique, we demonstrated band-edge emission from an n-type AlN/p-type diamond heterojunction LED and the formation of two-dimensional electron gas (2DEG) at the nitride heterojunction on diamond.

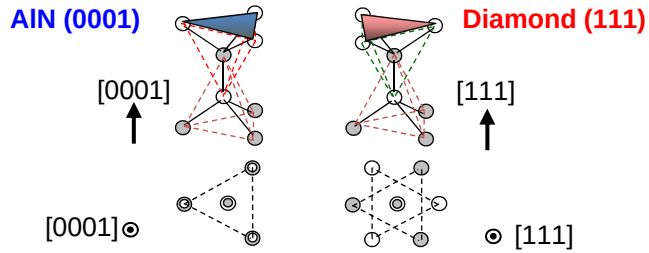
Impact

The nitride/diamond heterostructure will lead to deep-UV LEDs and millimeter-wave power transistors. The deep-UV LEDs can efficiently decompose toxic chemicals, such as dioxin and PCBs. The millimeter-wave power transistors can improve the information-carrying capacity in broadband wireless communications.

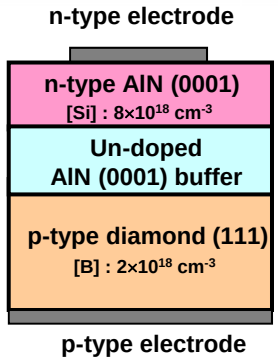
◆ III-V Nitride semiconductor (AlN) and diamond

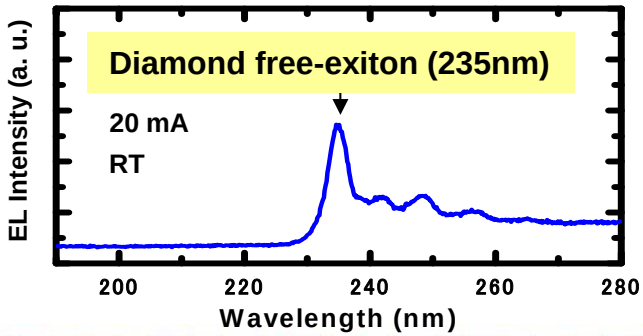
	AlN	Diamond
Crystal structure	Wrutzite structure 	Diamond structure 
Band gap	6.0 eV (direct)	5.5 eV (indirect)
Thermal conductivity	3 W/cm K	22 W/cm K
n-type doping	Si (250 meV)	P (590 meV)
P-type doping	Mg (630 meV)	B (370 meV)

◆ Atomic arrangement: AlN (0001) and Diamond (111) planes



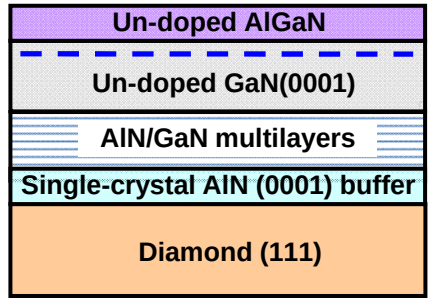
◆ n-type AlN/p-type diamond heterojunction diode



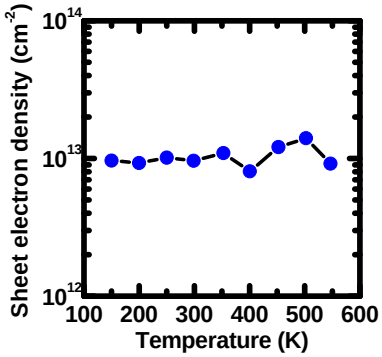


◆ Nitride HEMT structure grown on diamond

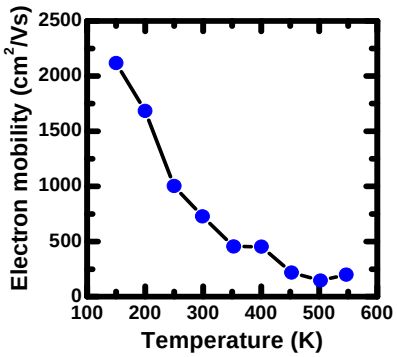
Two-dimensional electron gas (2DEG)



High carrier density



High electron mobility



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