Impact of crystal quality of AlN nucleation layer on the vertical direction breakdown voltage of AlGaN/GaN high-electron-mobility transistor structures on Si

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In this study, we present the characterization results of the vertical direction breakdown voltage (VDBV) of AlGaN/GaN high-electron-mobility transistors (HEMTs) on Si(111) substrate for power electronic device applications. The VDBV is an important device parameter that provides information on device reliability. Increasing the total thickness is a possible technique to increase the VDBV [1]. However, the total thickness is limited by the bowing or cracking of the Si wafer. AlN is used as initial layer for GaN on Si substrates because it acts as passivate to avoid Ga melt back etching which reacts with Si. We found that the breakdown voltage of an AlN single layer is still low as compared to the ideal value [2]. We investigated the relationship between the VDBV of HEMTs and characteristics of the AlN nucleation layer of the AlGaN/GaN HEMTs.

AlN single layers and AlGaN/GaN HEMT structures (with a total thickness of 3.2 micron) were grown on 8-inch p-type Si substrates through metal-organic chemical vapor deposition (MOCVD) (UR26K, Taiyo Nippon Sanso Corp.). Moreover, 150-nm-thick AlN nucleation layers were grown on Si(111) prior to the growth of HEMT structures. The same growth conditions as those of single AlN layers were applied to the process condition of the AlN nucleation layer in HEMT structures. The *I-V* characteristic was used to determine the VDBV. By minimizing the full width at half maximum (FWHM) of x-ray rocking curve for the AlN (002) direction from 2038 arcsec to 1472 arcsec, the average vertical direction breakdown voltage was improved, which was 585 V instead of 175 V (Fig. 1). Simultaneously, wafer bowing also changed from concave-shaped 144 micron to 32 micron, which was due to the increase in the tensile stress during the cooling after the growth.

[1] I. B. Rowena, et al., IEEE Electron Device Letters, Vol. 32, No. 11, November 2011
[2] Y. Yamaoka., et al., ISPlasma2016/IC-PLANTS2016, Nagoya University, Nagoya, Japan March 6-10, 2016, 09aC050.

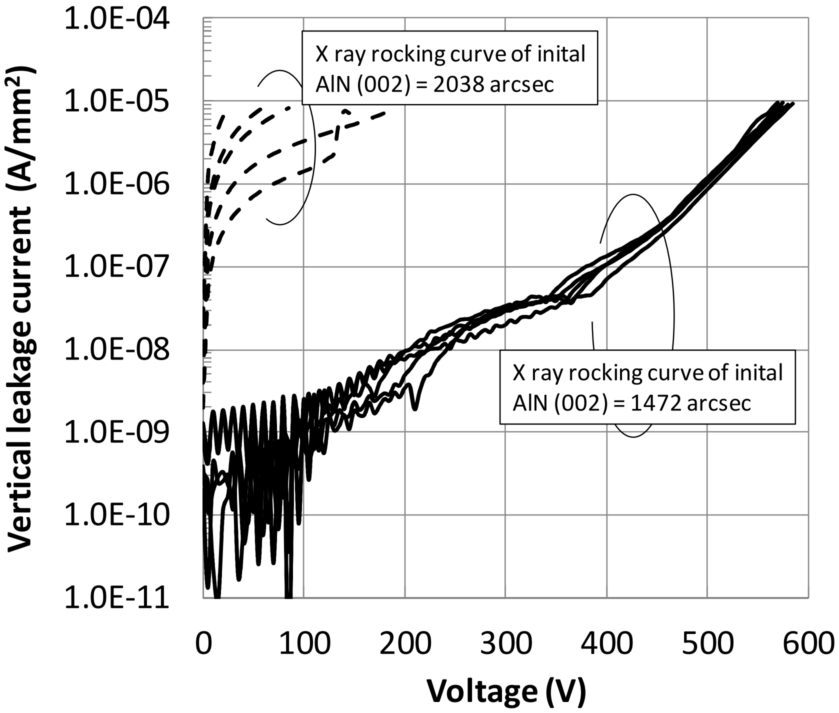

Fig. 1 Current-voltage curve characteristics of HEMT structures