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Characterization of Double Shockley Stacking Fault in 4H-SiC Epilayer

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Abstract : In-grow stacking-faults (IGSFs) in 4H-SiC epilayers can cause increased leakage current and reduce the blocking voltage of 4H-SiC power devices. Double Shockley stacking fault (2SSF) is a common type of IGSF with double slips on the basal planes. In this study, a 2SSF in the 4H-SiC epilayer grown by chemical vaper deposition (CVD) is characterized. The nucleation site of the 2SSF is discussed, and a model for the 2SSF nucleation is proposed. Homo-epitaxial 4H-SiC is grown on a commercial 4 degrees off-cut substrate by a home-built hot-wall CVD. Defect-selected-etching (DSE) is conducted with melted KOH at 500 degrees Celsius for 1-2 min. Room temperature cathodoluminescence (CL) is conducted at a 20 kV acceleration voltage. Low-temperature photoluminescence (LTPL) is conducted at 3.6 K with the 325 nm He-Cd laser line. In the CL image, a triangular area with bright contrast is observed. Two partial dislocations (PDs) with a 20-degree angle in between show linear dark contrast on the edges of the IGSF. CL and LTPL spectrums are conducted to verify the IGSF's type. The CL spectrum shows the maximum photoemission at 2.431 eV and negligible bandgap emission. In the LTPL spectrum, four phonon replicas are found at 2.468 eV, 2.438 eV, 2.420 eV and 2.410 eV, respectively. The Egx is estimated to be 2.512 eV. A shoulder with a red-shift to the main peak in CL, and a slight protrude at the same wavelength in LTPL are verified as the so called Egx-lines. Based on the CL and LTPL results, the IGSF is identified as a 2SSF. Back etching by neutral loop discharge and DSE are conducted to track the origin of the 2SSF, and the nucleation site is found to be a threading screw dislocation (TSD) in this sample. A nucleation mechanism model is proposed for the formation of the 2SSF. Steps introduced by the off-cut and the TSD on the surface are both suggested to be two C-Si bilayers height. The intersections of such two types of steps are along [11-20] direction from the TSD, while a four-bilayer step at each intersection. The nucleation of the 2SSF in the growth is proposed as follows. Firstly, the upper two bilayers of the four-bilayer step grow down and block the lower two at one intersection, and an IGSF is generated. Secondly, the step-flow grows over the IGSF successively, and forms an AC/ABCABC/BA/BC stacking sequence. Then a 2SSF is formed and extends by the step-flow growth. In conclusion, a triangular IGSF is characterized by CL approach. Base on the CL and LTPL spectrums, the estimated Egx is 2.512 eV and the IGSF is identified to be a 2SSF. By back etching, the 2SSF nucleation site is found to be a TSD. A model for the 2SSF nucleation from an intersection of off-cut- and TSD- introduced steps is proposed.

Keywords : cathodoluminescence, defect-selected-etching, double Shockley stacking fault, low-temperature photoluminescence, nucleation model, silicon carbide
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