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Crystal Growth and Evaluation of Nitrogen and Aluminum Co-Doped N-type 4H-SiC Grown by Physical Vapor Transport

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Abstract N-type 4H-SiC crystals were grown by the physical vapor transport (PVT) method with nitrogen and aluminum (N–Al) co-doping. By using aluminum carbide powder preannealed in nitrogen gas atmosphere as an aluminum doping source, we obtained highly N–Al co-doped crystals with a nitrogen concentration higher than that in nitrogen-only-doped crystals. The dislocation densities of N-Al co-doped crystals with a high aluminum concentration ($> 1 \times 10^{19}$ cm^{-3}) were found to become higher than those with a low aluminum concentration ($< 1 \times 10^{19}$ cm^{-3}). Moreover, we investigated the expansion velocities of double Shockley-type stacking faults (DSFs) in the N–Al co-doped and the nitrogen-only-doped crystals. We found that the DSF expansion velocities in the N–Al co-doped crystals were lower than those in the nitrogen-only-doped crystals. This difference in the DSF expansion velocity is discussed with respect to the quantum well action model.

Keyword A1. Defect, A1. Doping, A2. Growth from vapor, B2. Semiconducting silicon compounds

1. Introduction

Silicon carbide (SiC) has excellent physical and chemical properties as a semiconductor for use in high-power electronics. The strong chemical bonding between silicon and carbon atoms provides this material with a wide bandgap and high critical (breakdown) electric field strength. Recently, many devices for high-power electronics have been demonstrated. In the case of SiC metal-oxide-semiconductor field-effect transistors (MOSFETs) with a breakdown voltage of 600 V class, the specific on-resistances of the devices have reached less than 1 mΩcm^2 [1]. However, further on-resistance reduction in such devices is desired. The resistivity