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Characterization and Formation Mechanism of Six Pointed Star-Type Stacking Faults in 4H-SiC

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Synchrotron white-beam x-ray topography (SWBXT) studies of defects in 100-mm-diameter 4H-SiC wafers grown using physical vapor transport are presented. SWBXT enables nondestructive examination of thick and large-diameter SiC wafers, and defects can be imaged directly. Analysis of the contrast from these defects enables determination of their configuration, which, in turn, provides insight into their possible formation mechanisms. Apart from the usual defects present in the wafers, including micropipes, threading edge dislocations, threading screw dislocations, and basal plane dislocations, a new stacking fault with a peculiar configuration attracts our interest. This fault has the shape of a six-pointed star, comprising faults with three different fault vectors of Shockley type. Transmission and grazing topography of the fault area are carried out, and detailed contrast analysis reveals that the outline of the star is confined by 30° Shockley partial dislocations. A micropipe, which became the source of dislocations on both the basal plane slip system and the prismatic slip system, is found to be associated with the formation of the star fault. The postulated mechanism involves the reaction of 60° dislocations of $a/3\ \langle\bar{2}110\rangle$ Burgers vector on basal plane and pure screw dislocations of $a/3\ \langle 11\bar{2}0\rangle$ Burgers vector on prismatic plane and cross slip of the partial dislocation from prismatic plane to basal plane leading to expansion of the faults.

Key words: Silicon carbide, stacking fault, micropipe, x-ray topography

INTRODUCTION

The excellent properties of silicon carbide (SiC) provide a solution to realize the application of power devices under severe conditions such as high-temperature performance, high blocking voltage, and high-frequency switching.[1] Intense effort is currently in progress to study and eventually eliminate various defects in SiC in order to improve and stabilize the performance of SiC-based power devices. An active area of research is the origin and expansion of stacking faults in SiC. Although named differently from group to group, three types of stacking faults according to their fault vectors have been reported: Shockley fault with fault vector of $a/3\ \langle 1\bar{1}00\rangle$ type,[2–4] Frank fault with fault vector of $(c/2)$ [0001] or $(c/4)$ [0001],[5] and those comprising some kind of combination of the previous two.[6–10]

Among these faults, Shockley faults have been shown to be associated with the degradation of power devices, as the expansion of such faults in the junction area can impede current flow and, as a result, increase the on-state resistance.[3] In the epilayer, the morphology of the Shockley faults responsible for the device degradation is found to have a rhombus shape with the sides along $\langle 11\bar{2}0\rangle$ directions and angles of 60° and 120°, bounded by 30° partial dislocation loops. The fault expands though a mechanism whereby the Si-core partials

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