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Quantitative Comparison Between Dislocation Densities in Offcut 4H-SiC Wafers Measured Using Synchrotron X-ray Topography and Molten KOH Etching

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Molten KOH etching and x-ray topography have been well established as two of the major characterization techniques used for observing as well as analyzing the various crystallographic defects in both substrates and homoepitaxial layers of silicon carbide. Regarding assessment of dislocation density in commercial wafers, though the two techniques show good consistency in threading dislocation density analysis, significant discrepancy is found in the case of basal plane dislocations (BPDs). In this paper we compare measurements of BPD densities in 4-inch 4H-SiC commercial wafers assessed using both etching and topography methods. The ratio of the BPD density calculated from topographic images to that from etch pits is estimated to be larger than $1/\sin\theta$, where θ is the offcut angle of the wafer. Based on the orientations of the defects in the wafers, a theoretical model is put forward to explain this disparity and two main sources of errors in assessing the BPD density using chemical etching are discussed.

Key words: SiC, molten KOH etching, x-ray topography, basal plane dislocation, dislocation density

INTRODUCTION

As one of the most important wide-bandgap semiconductor materials, silicon carbide (SiC) has shown promising application for a wide range of electronic devices operated under extreme conditions such as high temperature, high frequency, and high power, due to its outstanding intrinsic properties including high breakdown field, large bandgap, and high thermal conductivity.[1] Though great development has been made in both crystal growth of and device fabrication with SiC, widespread commercialization of this material is still hindered by relatively high densities of structural defects that exert negative influence on device performance as well as lifetime. Therefore, it is of great importance to develop precise visualization techniques for those defects in order to understand their growth and propagation mechanisms, and to eventually reduce the densities of or even eliminate these defects.

Four types of defects are mostly observed and studied in SiC substrates: micropipes (MPs), threading screw dislocations (TSDs), threading edge dislocations (TEDs), and basal plane dislocations (BPDs).[2] While significant progress has been made in decreasing the density of MPs,[3] the latter three are attracting increasing attention since they are reported to result in detrimental influence on various SiC-based devices.[2,4,5] Especially for BPDs, a variety of studies have been done regarding the

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