15B,15C / 2002G053

Dislocations propagated from substrate to epitaxial layer in 4H-SiC observed by X-ray topography

Toshiyuki OHNO[1†], Hirotaka YAMAGUCHI[2*], Satoshi KURODA[3], Kazutoshi KOJIMA[1,3], and Kazuo ARAI[3]

[1]Advanced Power Device Laboratory, FED, *c/o* AIST, Tsukuba, Ibaraki 305-8568

[2]Nanoelectronics Research Institute(N*e*RI), AIST, Tsukuba, Ibaraki 305-8568

[3]Power Electronics Research Center (PERC), AIST, Tsukuba, Ibaraki 305-8568

Introduction

Silicon carbide (SiC) is a promising material as wide-gap semiconductor for use under extreme conditions, such as high power, high temperature and high frequency. The degree of crystalline perfection of commercial 4H-SiC wafers has improved remarkably, but their dislocation density is still high. In particular, propagation of dislocations from wafer to epitaxial layer is a serious impediment to device fabrication. In this study, we have investigated the dislocations in 4H-SiC epitaxial layers by X-ray topography using an extremely-asymmetric diffraction geometry with grazing incidence. The probe depth was controlled by the incident angle as a function of wavelength of X-ray beam for a certain diffraction plane. The dislocations in epitaxial layers were successfully observed in distinction from those in substrates. Comparing the topographs with etch pit images, we characterized the dislocations, and discussed a propagation rule of the dislocations from the substrate to the epitaxial layer.

Experiment

Substrates were n-type Si-face 4H-SiC (0001) wafer off-oriented 8° toward $\langle 11\bar{2}0 \rangle$. The growth was performed using a horizontal hotwall-type CVD system.

Grazing incident geometry for the 1128-reflection was employed for X-ray topography. The topographs were recorded on Ilford L4 Nuclear Emulsion plates. After the topograph observation, KOH etchings for epitaxial wafers were performed to directly compare the dislocations in the topographs with the etch pits.

Results and Discussion[1]

Figure 1 is a direct comparison of the topograph and the etch pit image of the same area. Comparing topographs taken with different wavelength X-ray beams, we found some typical behaviors of the dislocations. Screw dislocations and threading edge dislocations, both parallel to the *c*-axis, and basal plane dislocations parallel to the {0001} plane were observed in substrate and epitaxial layer.

The most marked differences of these dislocations in between substrate and epitaxial layer are observed in shape and direction of basal plane dislocations. The basal plane dislocations in the substrate are arc-shaped with random direction whereas those in the epitaxial layer are elongated in straight lines along the off-direction. All of the screw dislocations in the substrate are propagate directly into the epitaxial layer. Most of the threading dislocations in the substrate propagate into the epitaxial layer, and major portion of the basal plane dislocations in the substrate are deflected as threading edge dislocations. As a result, the density of the threading edge dislocations in the epitaxial layer becomes markedly higher than that in the substrate.

Influence of 4H-SiC epitaxial growth conditions, such as C/Si ratio, growth temperature and growth rate, on propagation of the basal plane dislocations from the substrate were also investigated. The results will be published[2].

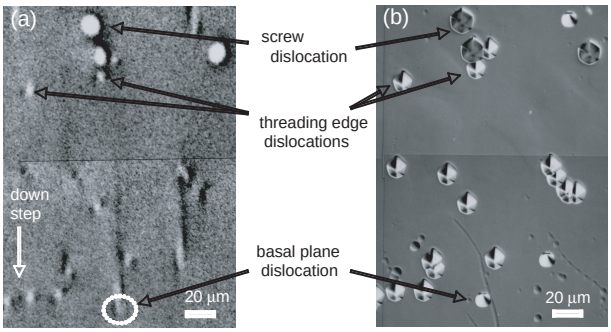

Figure 1: Comparison of X-ray topograph (a) and etch pit image (b). The topograph is taken with 1.541-Å-X-ray. The thickness of epitaxial layer is 30 μm.

References

[1] T. Ohno, H. Yamaguchi, S. Kuroda, K. Kojima, T. Suzuki and K. Arai, J. Cryst. Growth **260**, 209 (2004).

[2] T. Ohno, H. Yamaguchi, S. Kuroda, K. Kojima and K. Arai, J. Cryst. Growth, To be published.

†Present address: Hitachi Research Laboratory, Hitachi Ltd., 7-1-1 Omika, Hitachi, Ibaraki 319-1292

*yamaguchi-hr@aist.go.jp