

高感度エミッション顕微鏡とシンクロトロン X 線トポグラフィーによる HVPE (001) β 型酸化ガリウム SBD のリーク電流の起源になるキラークラックの同定

Killer Defects Responsible for Leakage Current in HVPE (001) β -Ga₂O₃ SBD Observed by Emission Microscopy and Synchrotron X-ray Topography

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1. Introduction

β -gallium oxide (β -Ga₂O₃) is a promising material for power device application owing to large bandgap (4.8 eV) and electric field (8 MV/cm). The availability of its high-quality substrate has accelerated the development of vertical β -Ga₂O₃-based power devices; for instance, Schottky barrier diodes (SBDs). However, killer defects degraded the performance of these devices. [1,2] Therefore, we have identified the killer defect in halide vapor phase epitaxial (HVPE) (001) β -Ga₂O₃ SBDs that served as leakage path by mainly using ultra-high sensitive emission microscopy.

2. Experimental Procedures

An n-type β -Ga₂O₃ epitaxial layer grown by HVPE on a 4" EFG-grown (001) single-crystal substrate. The net donor doping density, $N_D - N_A$, is ca. 10^{16} cm⁻³. The epitaxial thickness is approximately 10 μ m. Vertical-type SBDs were fabricated. For the ohmic contact, Ti/Au was evaporated on the entire back face, whereas for the Schottky barrier contacts, Ni/Au was evaporated on the surface. The SBDs were observed by Synchrotron X-ray topography, emission microscopy, SEM and STEM.

3. Results and discussion

Figure 1 shows emission microscopy image of SBD #J0516c at a reverse bias of -100 V the leakage current of -0.46 μ A. Here, five emission patterns were observed and indicated by the arrows which corresponds to the reverse leakage path.

Figure 2 (a) shows SEM image of #1 of the emission pattern. Here, a surface defect accompanies (100) cracks with a straight line along [100] was observed. Same type of defect was also

observed at #2–#5. Next, cross-sectional STEM was performed as showed in Fig. 2(b). Dislocations propagate along [100] direction at a depth of 0.5 μ m below the surface were observed.

4. Conclusion

We have found a killer defect which contains (100) cracked as leakage current path in HVPE (001) β -Ga₂O₃ SBD. This defect contains (100) cracks and dislocations along [100] direction.

Acknowledgements

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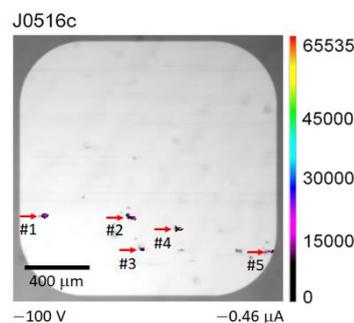


Fig. 1. Emission microscopy image of SBD #J0516c.

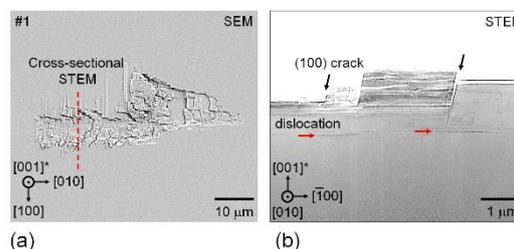


Fig. 2. (a) SEM image of emission spot #1 and (b) its cross-sectional STEM observation.

[1] S. Sdoeung, M. Kasu, et al., APL. **120**, 092101 (2022).

[2] S. Sdoeung, M. Kasu, et al., APL. **120**, 122107 (2022).