Application and prospect of electron-beam-induced current technique: from defect characterization to device diagnosis

Chen, J.[1]

[1] National Institute for Materials Science, Japan

Electron-beam-induced current (EBIC) is a unique technique for the electrical characterization in semiconductors. It appeared in the 1950s based on charge collection phenomena in SEM. At the early stage, it was used for the study of dislocations in Si materials. The advantage of this technique is the direct and quick imaging of electrically active defects. However, it is rather difficult to obtain physical parameters of defects. To overcome this drawback, solutions have been proposed: by analyzing the temperature dependence of EBIC contrast, the energy levels of defects can be deduced; or by employing bias voltage, the leakage behavior or mechanism of device failure can be understood.

By varying the factors such as temperature, accelerating voltage, bias voltage, and time, the old-fashioned technique has become a versatile and important approach in semiconductor research. We have developed a multi-functional EBIC system with multiple applications brought forward from Si to a variety of semiconductors (SiC, GaN, $SrTiO_3$, etc.), from conventional bulk defect characterization to advanced device diagnosis [1]. Several topics were selected for the demonstration. The recombination activities of grain boundaries (GBs) and their interaction with Fe impurity in multicrystalline Si are clarified by temperature-dependent EBIC as shown in Fig. 1. The visualization of leakage sites in high-k MOSFETs has been succeeded for the first time. Prospective study for nano electronics and power devices will also be introduced. It is expected that this technique will be helpful for studying novel materials and devices in the future.

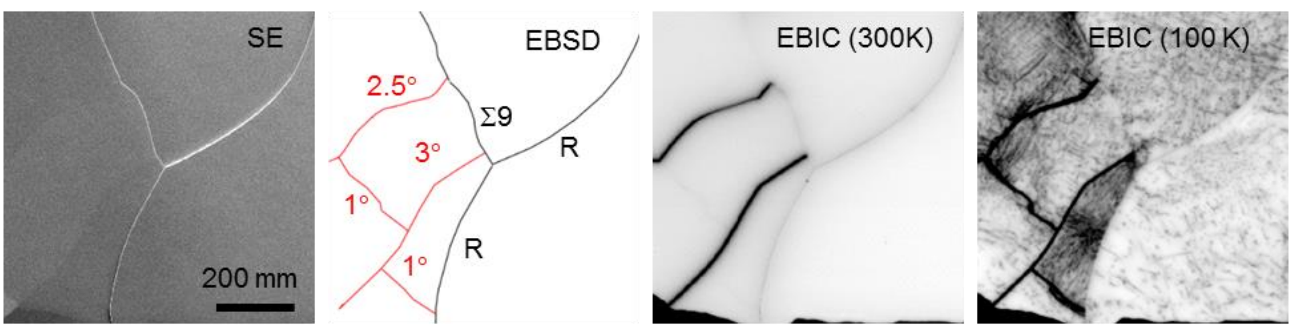

Figure 1. EBIC study of GBs in multicrystalline Si. Large-angle GBs (random and Σ type) are electrically inactive, but small-angle GBs tend to strong recombination centers of carriers.

References

[1] J. Chen and T. Sekiguchi, "Electron-Beam-Induced Current", In book: Compendium of Surface and Interface Analysis (Ed. The Surface Science Society of Japan, Springer, Feb. 2018), and references therein.

Acknowledgement

This research was supported by the World Premier International Research Center (WPI) initiative on Materials Nanoarchitectonics (MANA), and MEXT Program for research and development of next-generation semiconductor to realize energy-saving society. I would also acknowledge Dr. Y. Xuan, Mr. Takase, Mr. S. Ito, Dr. T. Nabatame, Prof. Chikyo and Prof. Sekiguchi for their assistance in experiments and helpful discussions.