Relation between deep-level photoluminescence and structure of small-angle grain boundaries in multicrystalline Si*

F. Okayama [1,2], M. Tajima [1,2], N. Miyazaki [2], R. Hirano [1], G. Kato [1,2], H. Toyota [1] and A. Ogura [2]

[1] *Institute of Space and Astronautical Science/JAXA, Sagamihara, Japan*
[2] *Meiji University, Tama, Kawasaki, Japan*

Evaluation of small-angle grain boundaries (SA-GBs) is important for improving the quality of multicrystalline Si (mc-Si) solar cells because they decrease the minority carrier lifetime. We have been studying the deep-level Photoluminescence (PL) which is useful for the defects analysis. In this study, we carried out microscopic deep-level PL analysis on the SA-GBs which have different orientation angles and major rotation axes to clarify their detailed electronic properties in relation to the structural character.

A measured sample was a p-type B-doped mc-Si. PL spectroscopy and mapping were performed at 20 K and room temperature (RT) under the excitation of a 532 nm laser with the beam diameter of about 10 μm. PL spectroscopy was also done at 4.2 K with the beam diameter of about 3 mm. The character of the SA-GBs was analyzed by electron backscattered diffraction (EBSD).

Intensity mapping of band-to-band (BB) emission at RT revealed SA-GBs as dark-lines, as shown in Fig. 1. EBSD disclosed that the SA-GBs as marked by circles A and B have a tilt and twist axis, consisting of edge and screw dislocation clusters, respectively. Correspondingly, dislocation-related D1 and D2 peaks were observed dominantly in PL spectra at circles A and B, respectively (Fig. 2). This result is consistent with the previous report that D1 and D2 are ascribable to edge and screw dislocations, respectively, in Czochralski-grown Si [1, 2]. We have further shown that D1 and D2 peaks have different polarization properties (Fig. 3), which are believed to reflect dislocation structures in SA-GBs [3].

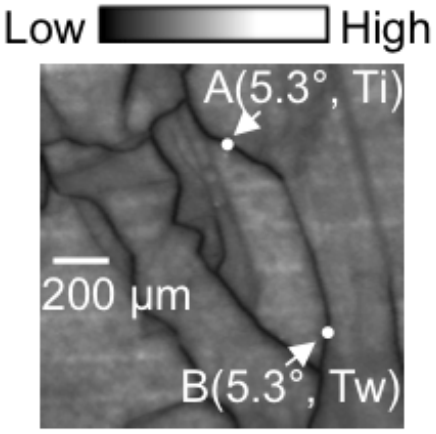

Figure 1: PL mapping of band-to-band emission at RT. ”Ti” and ”Tw” indicate tilt and twist boundaries, respectively.

References

[1] M. Tajima, et al.: Jpn. J. Appl. Phys. 22, L589 (1983).
[2] W. Wijaranakula: J. Appl. Phys. 70, 3018 (1991).
[3] M. Suezawa, et al.: Jpn. J. Appl. Phys. 20, L537 (1981).

*This work was supported by the NEDO under the METI.

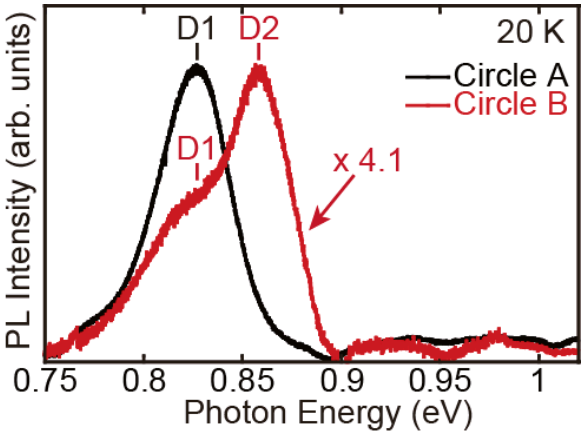

Figure 2: Deep-level PL spectra at 20 K at circles A and B in Fig. 1. Symbol "x 4.1" denotes amplitude factor.

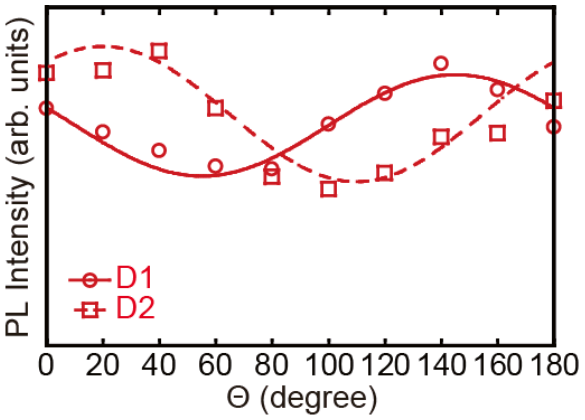

Figure 3: Polarization of D1 and D2 at circle B. Horizontal axis indicates angle of electrical field of luminescence to horizon in Fig. 1.