Fe mapping in mc-Si solar cell by Mössbauer spectroscopic microscope*

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We have developed a mapping technique in Mössbauer spectroscopy [1-5], which enables us to observe the Fe distributions of different components, such as interstitial Fei0, Fei+, and substitutional Fes0 separately in Si, with a space resolution down to 50 μm. Mössbauer spectroscopy is based on a recoil-free nuclear resonant absorption and emission of γ-rays. Accordingly, the measurement itself will not induce any changes in the lattice sites and the electronic states of Fe impurities, which differentiates this technique from other conventional evaluation techniques. 57Fe Mössbauer experiments are performed on a mc-Si wafer which is intentionally contaminated with a 3 nm-thick 57Fe from the n-layer surface. Figure 1 shows the Mössbauer spectra (a) before, (b) under, and (c) after electron beam irradiation. Each spectrum is measured at room temperature for three days. The spectrum consists of three components with different isomer shifts: substitutional Fes0 at the most left hand site, interstitial Fei0 at the middle, and interstitial Fei+/2+ at the right hand site. The isomer shift is proportional to the charge density at the Fe nucleus, providing a possibility to distinguish the charge states and the lattice sites of Fe atom. The spectra (a) and (c) shows a line broadening due to a charge fluctuation between +1 and +2 states within the life time of 14.4 keV nuclear level of 57Fe, i.e., 100ns. The charge fluctuation must be related to the excess electron trappings on the Fe interstitial atoms, leading to "a motional averaging". This interstitial component of Fei+/2+ in the spectrum (b), however, becomes sharper than those of (a) and (c). The isomer shift is at the position of Fei+ component, indicating that the electron trapping rate on interstitial Fei2+ is much faster because of the electron injections. In Fig. 2 the mapping images corresponding to interstitial Fei2+ in 2×2 mm area are presented for both cases (a) with/ (b) without electron beam. The images are overlapped on the mc-Si wafer photo. The interstitial Fei2+ atoms appear to distribute differently in different grains, suggesting that the interstitial Fei2+ components are associated with defects in mc-Si.

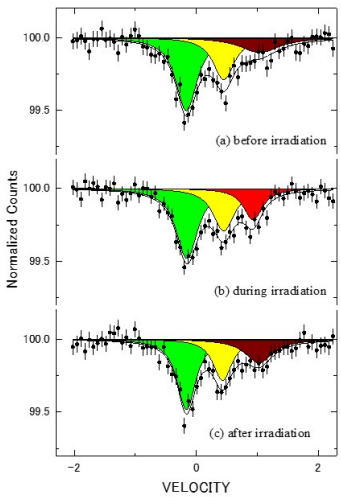

Figure 1: Mössbauer spectra (a) before, (b) under, and (c) after electron beam irradiation.

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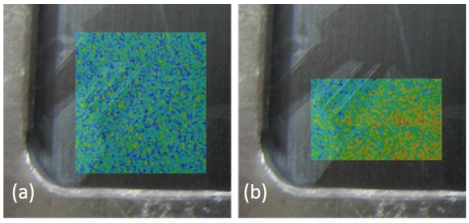

Figure 2: Mapping images corresponding to interstitial Fei2+ in 2×2 mm area are presented for both cases (a) with/ (b) without electron beam.

References

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