Inferring Dislocation Recombination Strength in Multicrystalline Silicon via Etch Pit Geometry Analysis

Motivation

Dislocation clusters are known to decrease minority carrier diffusion length and limit solar cell performance. Recombination strength (Γ) of dislocation clusters can vary by orders of magnitude within the same wafer, presumably due to oxide precipitates or metal-impurity decoration at dislocations. We explore the root cause of variations among different dislocation clusters by combining surface and bulk characterization techniques.

We propose a facile method to assess the relative recombination strength of dislocation clusters by analyzing etch pit surface geometry.

Characterization

Cluster Selection and Electrical Characterization

A p-type mc-Si wafer, from a directionally-solidified boron-doped ingot (1 Ω·cm) was processed into a solar cell.

LBIC map measured and converted into IQE map to identify recombination activity of selected regions. (Fig. 1a)

Dislocation etch pits were revealed by chemically etching with a Secco solution.

Five clusters (A, B, C, D, E) were selected from different grains (Fig. 1b).

Recombination strength for the selected clusters were extracted. Values ranging two orders of magnitude (Fig. 1c)

Surface Characterization

Etch pit geometry approximated by elliptical shapes.

Eccentricity

Values fitted between 0 (circle) to 1 (elongated ellipse) with a MATLAB algorithm. (Fig. 2)

Bulk Characterization

Metal decoration in dislocations from clusters A, C, and E were analyzed via synchrotron-based micro X-Ray Fluorescence (μ-XRF) technique.

Grain orientation and microstructure were analyzed by Electron Backscatter Diffraction (EBSD) and Transmission Electron Microscopy (TEM) respectively.

Results and Discussions

Results show that recombination strength of dislocation clusters increases with increased variation in eccentricity values. (Fig. 3)

Conclusions

The variation in eccentricity values of dislocation etch pits can be used as a proxy to determine relative recombination strength of dislocation clusters.

This proxy is based on the correlation between etch-pit eccentricity variation, and the degree of order and disorder of dislocation line vectors through the bulk.

The framework proposed herein resembles the frameworks for grain boundaries, where impurity decoration is enhanced at defects with higher degree of core-structure disorder (higher Σ values) the Coincident Site Lattice (CSL) model.

References