Atom Probe Tomography Study of Electrically Characterised Defects in Gettered High Performance Multicrystalline Silicon

Tweddle, D.[1]

[1] University of Oxford, United Kingdom

The performance of multicrystalline silicon solar cells, which currently represent around 60% of the world's photovoltaic module production, is strongly limited by their impurities. These impurities, primarily transition metals, are present in the raw material and can also be introduced from the production environment. Transition metals are known to segregate to crystallographic defects, such as dislocations and grain boundaries, which then act as strong recombination centres. Gettering, notably phosphorus diffusion gettering, is a common industry technique used to minimise the effect of such impurities. However, this process is not completely effective and the reasons for this are not well understood. This is as a result of the very low concentrations of impurities associated to specific isolated microstructural features that can dramatically influence the electrical properties of the material. Hence, this represents a significant microscopy challenge to characterise the atomic scale distribution of these trace elements and correlate this with material performance.

This study develops a complementary Atom Probe Tomography (APT), Electron Beam Induced Current (EBIC) and Photoluminescence (PL) approach to characterise and compare the electrical and chemical properties of specific microstructural defects in multicrystalline silicon pre and post gettering treatment. To this end, a novel Focused Ion Beam (FIB) lift-out method which enables correlative Transmission Electron Microscopy (TEM) and atomic scale APT analysis of large targeted sections of grain boundaries is presented.

In order to investigate this effectiveness of the gettering process in removing impurities and simultaneously provide new insights into the influence of specific transition metals on photovoltaic performance, the same grain boundary, in sister wafers (wafers taken directly above each other) which have undergone various processing, are analysed using APT and related to their electrical activity. This allows for insightful quantitative comparisons between grain boundary chemistry of samples before and after gettering.

Additional correlative microscopical techniques are also incorporated, including the application of Electron Back Scattered Diffraction (EBSD) to determine the grain boundary type. The type of grain boundary, e.g. twin or random angle, is then correlated to the electrical activity before and after gettering and ultimately grain boundary chemistry. Finally the study intends to implement Transmission Kikuchi Diffraction (TKD) on needles during FIB fabrication as both an aid to ensuring the grain boundary is within the APT dataset and to determine grain orientations prior to APT, which is then used to calibrate the reconstruction.