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Grain Boundary Electrical Activity and Growth in Multicrystalline Silicon

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Multicrystalline Silicon (mc-Si) grown by directional solidification is the most widely used material for photovoltaic application, mainly due to its lower costs. However, the major drawback is the lower efficiency due to the presence of extended defects such as grain boundaries (GBs), dislocations and impurities. Recently, higher efficiencies have been reported for mc-Si grown from small randomly oriented grains [1]. In this type of mc-Si, there is a high density of random type GBs. However, random GBs are known to be easily decorated by impurities and enhance carrier recombination. Nevertheless, improved growth design may increase efficiency, for which the growth mechanism and grain boundary interaction needs to be well understood. In our previous study [2], we found that mc-Si grown from small randomly oriented grains forms small spherical grains initially and become columnar with growth as the density of random GBs decrease with grain alignment. However, the impact of grain alignment on the structure of GBs was not well understood. In this study, we investigated the electrical activities of GBs and correlated with grain growth in order to elucidate the grain growth mechanism of mc-Si.

Test ingots of 100mm diameter were grown from seeds with small random grains in a directional solidification setup. The ingot was cut into horizontal and vertical wafers for electron beam induced current (EBIC) and electron backscatter diffraction (EBSD) analysis.

Fig 1. shows EBIC mapping (at room temperature) of vertical wafer (as-grown) near the initial growth region (arrow indicates growth direction). The dark region at the bottom is the seed region while dark lines are electrically active GBs, majority of which are random type. $\Sigma 3$ GBs had almost no EBIC contrast and all random type GBs had a non-uniform EBIC contrast, between 2-30%. It can be seen that initially the grains are spherical and elongates with growth. Contrary to expectation, not all curved GBs had high EBIC contrast and even some straight GBs had high EBIC contrast.

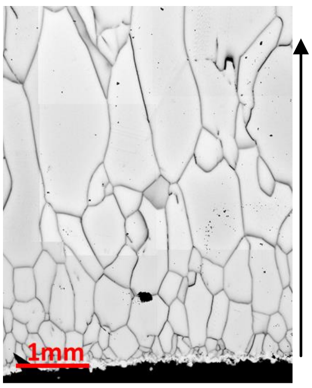

Fig.1. EBIC map @ RT of as-grown mc-Si

It is evident from this study that there are only some random GBs that are highly electrically active while others are not. The understanding and control of the highly electrically active random GBs could lead to further improvement of mc-Si solar cells.

[1] *D. Zhu et al., J. Crystal Growth 386, (2014)*

[2] *R. R. Prakash et al., J. Crystal Growth (2014), http://dx.doi.org/10.1016/j.jcrysgro.2014.01.067*

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