Achievements and Challenges of Solid-Phase Crystallization of Amorphous Silicon for Thin-Film Solar Cell Application

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Polycrystalline silicon (poly-Si) thin film solar cells based on high-rate electron beam (e-beam) evaporation of amorphous Si and a subsequent solid phase crystallization (SPC) process at approximately 600 °C feature the potential for high conversion efficiencies at considerably low production costs. A conversion efficiency record of 6.7% was recently achieved for poly-Si minimodules on planar SiN-coated glass fabricated by e-beam evaporation with a deposition rate of 600 nm/min [1]. The additional implementation of temperature stable ZnO:Al as a front contact layer into this device on a glass superstrate allows for a simple contacting scheme by laser scribing and incorporation of light trapping structures. The material quality of the crystallized Si on ZnO:Al is significantly influenced by the grain size and thus the kinetics of the solid phase crystallization process. In this report we will address the dynamics of the amorphous to crystalline phase transition of Si on ZnO:Al-coated glass. It will be discussed how post deposition treatments enhance the electronic properties of the solar cell materials and, in particular, how they influence the interface properties. One of the main open questions concerning this type of solar cell is the identification of the microscopic processes that limits the open circuit voltage (Voc). Using electron spin resonance it will be shown that the density of point-like defects (dangling bonds) is directly correlated to Voc. It will be discussed how one is able to spectroscopically identify the microscopic location of such defects e.g. grain boundaries or within the grain.

[1] T. Sontheimer et al, Proc. of 24th European Photovoltaic Solar Energy Conference, Hamburg (2009) in press.
[2] T. Sontheimer et al, Appl. Phys. Let t. 95 101902 (2009).