Carbon contamination during the solidification of silicon for photovoltaic applications: *ex-situ* and *in situ* X-ray imaging characterization

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In order to improve the PV efficiency of crystalline silicon (Si) solar cells, research focuses on several key targets, which include the understanding of structural defect generation during the solidification. Indeed, the industrial processes all face challenges to decrease the defect density, e.g. dislocations and sub-grains, and to understand their interaction with the impurities from diverse origin including processes and recycling during solidification to ultimately improve solar cell electrical properties.
Several samples all contaminated with carbon (C) are studied in this work: samples directly extracted from industrial ingots and model samples. The effect of C on the grain nucleation, grain boundary types, distortions and structural defects at several scales is analysed in details *ex situ* and *in situ* during the Si solidification. *In situ* X-ray imaging is performed in a unique device named GaTSBI (Growth at high Temperature observed by X-ray Synchrotron Beam Imaging) operated at ID19/ESRF (European Synchrotron Radiation Facility). Two imaging techniques are combined during solidification: radiography and Bragg diffraction imaging (topography) [1]. They reveal the morphology and the kinetics of the solid/liquid interface, the defect formation and crystalline structure distortion dynamics. Rocking Curve Imaging (RCI) [2] is performed at BM05/ESRF *ex situ* after solidification to characterize quantitatively the crystalline structure distortions and misorientations.

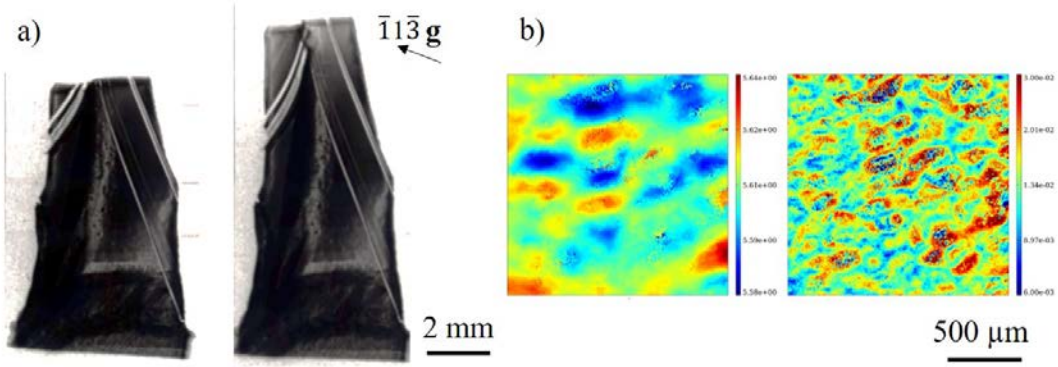

Figure 1: Sample contaminated with C (10^{17} at/cm^3): a) *In situ* topographs at two instants during solidification. b) Transmission RCI maps. Left: Peak-Position, in degree. Right: Full Width Half Maximum, in degree [3].

Crystal structure distortion is evidenced at several scales both *in situ* and after cooling down in the presence of C. Figure 1 shows topographs during solidification (Fig. 1.a) and RCI peak position and full width half maximum maps (Fig. 1.b) for a sample contaminated with C (10^{17} at/cm^3). We propose a mechanism related to the presence of C during Si solidification to explain the formation of these distortions and of sub-grains in the crystalline structure [3].

References

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