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Effect of Extended Gettering during the Emitter Formation on the ElectricalPerformance of Multicrystalline Silicon Based Solar Cells

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ABSTRACT

Crystalline silicon (c-Si) wafers are widely used as precursor elements in solar cells manufacturing, and constitute more than 95% of the overall industrial market[1]. The contamination of c-Si wafers, especially the multicrystalline one (mc-Si), by metallic impurities (Fe, Cr, Ni, etc.) is considered as a serious disadvantage. The presence of such impurities can drastically limit the efficiency potential of the solar cells. Nevertheless, most metallic impurities can be partially removed from the whole bulk of the Si wafer, using gettering process. It refers to a thermal treatment step that activates the diffusion of interstitial impurities from the bulk of the wafer to less important superficial regions[2]. In this present work we studied the impact of extended gettering on the electrical performance of Al-BSF solar cells fabricated in our center CRTSE by using mc-Si wafers of different initial qualities.

The wafers used were p-type mc-Si, 1.5 Ω.cm and 300µm. Three sets of sister wafers were taken from top, middle and bottom of the ingot. These wafers were used to fabricate three sets of solar cells; the "set A" is prepared only through n^+ emitter formation at 875°C/20 min, and for "set B" the emitter process was followed by an annealing during 120 min at 850°C, whereas in "set C" a second annealing was added at 670°C for 120 min. After this step, the solar cells of the three sets were fabricated by the same process sequences and in the same conditions. The characterization techniques used were mainly quasi-steady-state photoconductance (QSSPC), Sun-Voc and solar simulator.

The initial effective minority carrier lifetime measured by QSSPC; 9.6 µs (bottom), 3.2 µs (middle) and 2.5 µs (top) are, respectively, associated to the following efficiencies measured by solar simulator: 14%, 13.8% and 12.2%. it is clear that the increment of in lifetime provokes the improvement of solar cells performance. The effect of the bulk lifetime (τ_b), affected by the gettering, on the maximum power density (J_{sc} x V_{oc}) supplied by each solar cell is illustrated in Fig. 1. The findings showed a significant increase of 6 mW/cm^2 when τ_b varies from 5 µs to 50 µs. This result was separately confirmed by PC1D simulation. Using a method based on the modeling of the impurity-limited lifetime (τ_{imp}), we demonstrated that the decrease in the density of Cr, Ni or Zn in the material bulk is the possible cause of the improvement of the solar cells efficiency, and this is through the improvement of τ_b.

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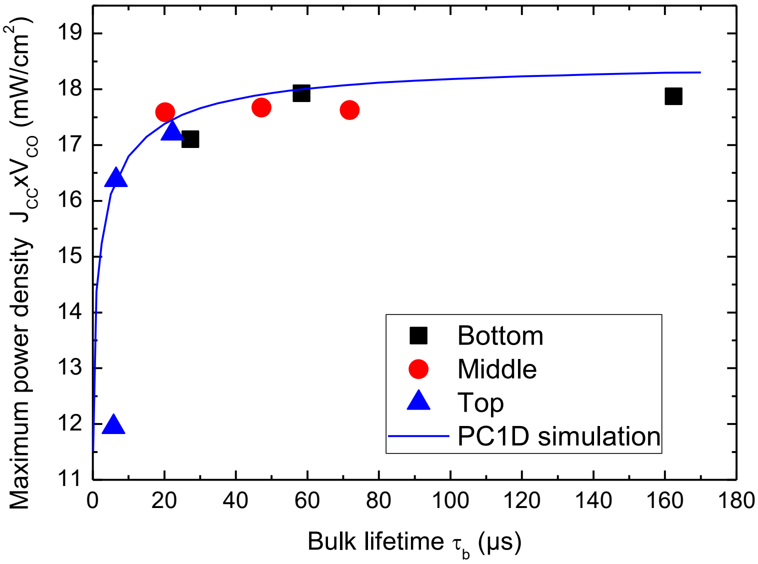

Fig.1: Effect of the bulk lifetime (τ_b) on the aximum power density ($J_{sc}xV_{oc}$) produced by the solar cells.

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