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Adaptation of monocrystalline solar cell process to multicrystalline materials

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Abstract

Due to its low cost and high possibilities, multicrystalline silicon (mc-Si) is an attractive substrate to produce solar cells. Trying to reach high efficiencies with a simple and repetitive method, we adapted a standard monocrystalline process to multicrystalline material. Different gettering methods (Phosphorous, Aluminium and P and Al co-gettering) have been studied. In our laboratory, 15.2% efficiency have been achieved to date. PC1D simulations shows that, with a reduction of bulk recombination and a better front and rear passivation schemes, efficiencies higher than 18% could be obtained.

Keywords: Solar cells; Multicrystalline silicon; Gettering

1. Introduction

The exponential growth in the PV market and the necessity of a material cheaper than monocrystalline make multicrystalline silicon (mc-Si) an important alternative. During the last years, the share of this material in the solar cell market has experimented a big increase, reaching 56.3% in 2003 [1]. One of the reasons is the

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increase experimented on efficiencies achieved with mc-Si. Table 1 shows some of the best results.

Mc-Si wafers are characterized by their different grain sizes, orientations and their higher content of defects and impurities, so this material is more sensitive to thermal processing and cell efficiencies are lower than those of monocrystalline solar cells. Hence, to improve multicrystalline cell results we should rely on reduction of thermal load and implementation of gettering steps.

P and Al solar cells have obtained nice results for high quality materials (FZ) with a somewhat unsophisticated process. The standard process for FZ Si used in our Institute [7], sketched in Fig. 1, has the following steps: We etch the first few microns of the samples with CP4 to eliminate surfaces damage and to obtain 280 μm thick wafers. Then, a wet and dry oxidation at 1000 °C during 5 h is performed to obtain a thick masking oxide. There we defined the active area window using a photolithography step. Then, a texturization is done in a KOH bath obtaining pyramids with heights around 3 μm. A phosphorus pre-deposition is done at 850 °C for 30 min. Later we evaporated, in vacuum, 1.5 μm thick aluminium on the rear side. The P and Al drive-in is done at 1050 °C for 3 h. Front and rear contacts are obtained with evaporation of Ti–Pd–Ag and Al–Ag, respectively, followed by eltectrolytic growth in the front grid. To improve metal adherence and recover surfaces damaged by electron-gun X-rays, an annealing in forming gas at 450 °C is performed. Finally, we grow a double anti-reflecting coating ($ZnS + MgF_2$). A

Table 1
World Records and Notable Results on mc-Si

Efficiency (%)	Description
16.7	25 cm^2 POLIX [2]
17.4	25 cm^2 Eurosolare [3]
18.6	1 cm^2 HEM [4]
19.8	4 cm^2 Eurosolare [5]
17.2	100 cm^2 Sumitomo Sitix [6]

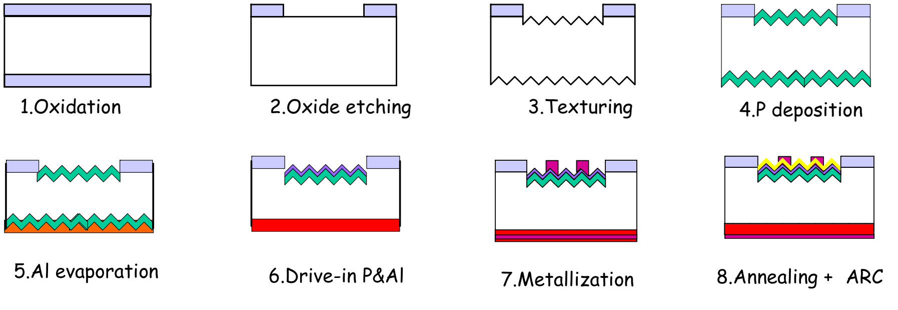

Fig. 1. Standard cell fabrication sequence.