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ScienceDirect

Energy Procedia 77 (2015) 414 – 419

Energy Procedia

5th International Conference on Silicon Photovoltaics, SiliconPV 2015

# Impact of cell texturing quality on cell to module losses

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**Abstract**

This work is related to a detailed study on the influence of the quality of solar cell texturing on the electrical performance after encapsulation. The effect of texturing on cells front side reflectance was studied for alkaline texturing on Cz wafer materials and processes, acidic textured Cz wafers as well as polished Cz wafers and correlated to the electrical characteristics after encapsulation. The electrical performance on module level was studied indoor at STC (standard test conditions) with varying incident light angles and outdoor during one year of outdoor exposure at a location in southern Germany. To consider for optical effects of glass surface on module performance solar glass with various deep surface texture resp. a flat surface (float glass) were processed and characterized. We show that the degree of texturing hence the front side cell reflection has a small influence on the electrical performance after encapsulation with no measurable incident light angle dependency. Furthermore do we show that even for various textured glasses the cell texturing has no effect on the module performance, neither at STC nor at varying incident light angles. The annual electrical yield study revealed even a better performance for the acidic textured cell modules if compared to the alkaline (hence well textured) cell modules.


Peer review by the scientific conference committee of SiliconPV 2015 under responsibility of PSE AG

*Keywords:* Solar modules; cell texture; performance; outdoor testing

## 1. Introduction

There is no doubt on the positive effect of cell texturing on solar cell performance determined at STC conditions. The more advanced the level of texturing the less is the reflectance on the solar cell front side resulting in strong efficiency gains. This statement is valid as long as the solar cell is measured under air. For encapsulated cells an increasing degree of texturization leads to a decrease of the optical encapsulation gain hence increasing the cell to module losses [1]. In general it can be stated that cells reflectance is the major loss in air and in the module. Geipel et al. performed a study on 6” mc solar cell modules in which cells were chemically etched by alkaline and acidic processes [2]. Even though the acidic etched solar cells did show a 2.6% higher efficiency if compared to the

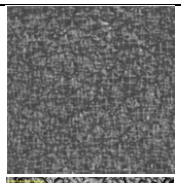
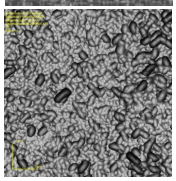
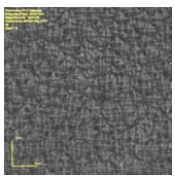
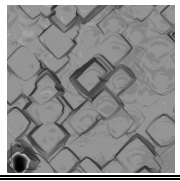

Peer review by the scientific conference committee of SiliconPV 2015 under responsibility of PSE AG
doi:10.1016/j.egypro.2015.07.058

alkaline treated cells no measureable difference in modules STC power and negligible differences for the electrical energy yield were found. The encapsulation losses actually were 2% higher for cells with a higher degree of texturization. Literature data on the modules energy yield and angle dependency is available on a comparison between non-textured mc cells versus textured Cz cells on flat and textured glass and shows that the texturization of cells has none or very little influence on the annual yield for flat and textured solar glass [3]. On the other hand no information is publicly available on how specifically Cz wafer material of different texturing degree if combined with various solar glass (textured, non-textured) electrically performs and influences the cell to module losses. Specifically this knowledge will add to the existing experience on how important the quality of solar cells texturing to the module performance is and aims to questions the attempt of solar cell industry to increase cells performance by optimizing the cells texture further. For this reason mono-crystalline solar cells comprising various texturing levels (weak, strong and polished) were processed and beside the cell to module losses (CTM) the angle dependency and outdoor performance studied in detail. To study further the effect of glass surface on module performance solar glass with various deep surface texture resp. a flat surface were processed and characterized. Furthermore were the reflection on wafer and module level determined.

## 2. Sample preparation

Cz wafer material was textured with various chemical surface treatments: standard and double texture etching time, acidic etching and polishing to achieve varying levels of texturization. The wafer material was further processed in a standard industrial solar cell process and screen printed with a three busbar front and three pad rear metallization layout. The reflection was determined by a spectrometer after chemical treatment on wafer and module level. For averaging the reflection measurement was taken on four points over the surface (on up to 10 samples) and averaged. Table 1 give an overview on the individual groups, mean reflection on wafer and module level as well as showing the wafer surface after etching.

Table 1. Mean reflection of wafers and modules for four different chemically etched groups.

| Group | Note | Wafer surface after etching | Mean Reflection Wafer [%] | Mean Reflection Module [%] |
|---|---|---|---|---|
| H1 | Alkaline etched (standard) |  | 12.85 | 7.07 |
| H2 | Acidic etched |  | 30.44 | 8.61 |
| H3 | Alkaline etched (double) |  | 12.68 | 7.02 |
| H5 | Chemically polished |  | 39.71 | 13.68 |