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1. Introduction

A special focus is dedicated to the development of renewable, clean and sustainable resources energy with a special attention to photovoltaic (PV) energy conversion which is growing very rapidly following fast technological improvements and advances. Whatever the material base technology used : monocrystalline silicon, monolike and multicrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide, the main question still what about the crucial long-term reliability of photovoltaic modules to ensure the technical and economic viability of PV as a successful energy source.
Crystalline silicon wafers solar cells dominate more than 90 percent of the total PV market share. Meanwhile, several improvements still needed for both g/W and $/W reduction. Less expensive solutions such as thin-film solar cells with solar cell efficiency lower than 10% are proposed.

2. Present technologies and future challenges

Despite the high cost, the mono-crystalline silicon ingots wafers are widely used due to their well-balanced good crystalline quality and high conversion efficiency compared to the multi-crystalline (mc-Si)ones. The main focus will continue for the next ten years on crystalline silicon to reach a very high efficiency solar cells generation (> 24 %) using a good combination between CCz and MCz mono growth ofboth P- and N-type.
However, as initially shown by Nakajima et al [Fujikawa 2006], improved control of the microstructure of multi-crystalline ingots can be obtained by favouring the initial growth of silicon dendrites along the crucible bottom. This has been applied at the industrial scale and resulted in microstructures containing large twinned grains of good crystalline quality. The control of the grain boundaries type is of crucial importance for the improvement of solar cell performance, namely that coherent grain boundaries should be preferred [Takahashi 2010]: indeed, incoherent boundaries have a higher electrical activity, and can be the source of multiplication of dislocations propagating into the grains. In the case of dendrites growth along the crucible bottom, the coherency of the boundaries depends on the relative angles between the different nucleated dendrites. However, the reproducibility of such a dendritic process, at the industrial scale, may be difficult to control. This is the reason why an alternate route is being studied which consists in starting on one or severa lseeds arranged at the bottom. In the HEM crystallization process [Khattak 1980], a seed is positioned in the center of the crucible base, where preferential cooling is achieved through a heat exchanger with flowing Hegas. However, in order to control the growth from the seed in this configuration, a highly convex temperature field is required, which is hardly compatible with the growth of large size ingots, in particular because of the induced thermo-mechanical stresses The first introduction in 2008 of the mono like technology with seeds covering the whole crucible bottom has shown several advantages of the called Mono2 wafers [Stoddard 2008]. The key solution for this technology goes through the crystallization process control. In particular, for a precise control of the seeding process, the main requirement is a good flexibility in the modulation of the heat flux extracted through the crucible bottom. In addition, a good knowledge of the electrically active defects that may occur, and understanding of their mechanism of formation is required in order to be able to avoid them. Special attention is paid to the structural characterization of the different regions of the ingots (mono-like central part as well as twinned and multi-crystalline border) in order to improve the overall cell performance [Jouini 2011].
A complementary study of the potential technologies for new solar cells concept will be shown with a special attention to the thin film a-Si:H/μc-Si:H tandem solar cells and Si nanowires based solar cells.

3. Conclusions

The mono-like crystalline silicon based cells with other different new cell technologies can be potential candidates for higher material quality combined with a low manufacturing cost for a promising new PV concept which can very attractive for future energy demands satisfaction.

references

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