Research on High-Efficiency and Low-Cost Thin Film Silicon Solar Cells

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In order to realize mass use of solar cells, more attention should still be paid on both high efficiency and low cost. To exploit the sunlight spectrum as much as possible is one of the core technologies to increase efficiency. The multi-junction solar cells based on disordered amorphous silicon and ordered microcrystalline silicon broaden the spectrum response in comparison with the conventional thin film silicon solar cells. And the light trapping composed of the front and back electrode within the solar cells further increases the effective use of sunlight. At the same time, the high rate deposition of silicon thin films and the single chamber technology are promising to lower cost effectively.

This paper is based on the amorphous/microcrystalline silicon tandem solar cell structure, and studies the light management using the wide spectrum transparent conductive front electrode and the compound back reflective electrode, aiming at make full use of the sunlight spectrum within 1100nm, the response limit. In particular, the multi-scale textured transparent conductive thin films are proposed and fabricated to make sure of effective light trapping of both short and long wavelengths.

Following the technology road of combing very high frequency, high pressure and high power, we succeeded in obtaining microcrystalline silicon with a deposition rate of over 20Å/s and introduced high crystallinity interface layer and power profiling method, and made single-junction microcrystalline thin film solar cell achieve an efficiency of 9.78% (with deposition rate 15Å/s).

Single chamber technology could lower the equipment cost. However, it will introduce contamination from doped layers to active layers. With the aid of SIMS measurement, we studied contamination problems in different processes and in terms of that we proposed methods to reduce contamination to fabricate the single chamber-deposited amorphous silicon/microcrystalline silicon tandem solar cells with an efficiency of 10.59%.

Based on the research results above, we succeeded in upgrading the production line from the amorphous silicon/amorphous silicon germanium tandem solar cell modules to amorphous silicon/amorphous silicon germanium/microcrystalline silicon triple-junction solar cell modules. The highest efficiency of the triple-junction module has achieved at 9.59% (NREL, 0.79m2) and increased by 20%.