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TÉMA

LASER CRYSTALLISED SILICON THIN FILMS AND SOLAR CELLS ON GLASS: SIGNIFICANCE OF THE INTERFACE

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Liquid-phase crystallisation of a few micron thick Si films on glass (LPCSG) allows obtaining a high crystal and electronic quality material which is a promising alternative to c-Si wafers for photovoltaics. Potentially capable of matching c-Si wafer cell performance, LPCSG needs no wafering process and can also benefit from monolithic cell-module integration typical for thin-film technologies. Crystallisation can be conducted either by line shaped e-beam source (in vacuum) or by line-focused diode laser (in air). The resulting material consists of tens of millimetres long and up to a millimetre wide linear grains roughly aligned in a scan direction. Intragrain defect density is less than 1E7 cm-3 and the carrier mobility is as high as 410 cm2/Vs, both comparable to respective values in mc-Si wafers. Solar cells made of LPCSG films have achieved open circuit voltages up to 630 mV and efficiencies of 11.7%, and improvement in the cell performance continues at a fast rate since the material introduction in 2011.

Quite surprisingly, the most of the performance improvement is achieved due to development of an intermediate layer between glass and Si. Regarding the Si film material itself, as long as crystallisation in conducted in a laser parameter range between full melting and dewetting, no significant effects of various process parameters on the material quality and cell performance are observed. The intermediate layer is thus most critical to cell fabrication and it has to satisfy a few very important requirements: very high temperature stability; wetting and adhesion; transmission and antireflection; impurity diffusion barrier; dopant source; interface passivation. High melting point transparent dielectrics, such as SiCx, SiNx and SiOx have been studied as intermediate layers. It is found than no single layer can perform all functions. SiCx is the best adhesion layer but it has high absorption, poor barrier and interface passivation properties; SiNx is good for transmission and antireflection but the worst for adhesion and impurities; SiOx is the best for transmission, passivation, as an impurity barrier and provides reasonably good adhesion but it has no antireflection effect. Only a carefully designed combination of dielectric layers can deliver both the robust fabrication process and well-performing cells. Triple-layer stacks of SiOx/SiCx/SiOx and SiOx/SiNx/SiOx are developed where the middle layer is for antireflection while the outer layers are for adhesion, impurity blocking and interface passivation. The presentation gives more details on laser-crystallised Si film and solar cell fabrication and associated effects of the intermediate layer.

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