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Metrology and characterisation of Micro and Nano-scale defects for aluminum oxide barrier film employed in flexible Photovoltaic modules

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Abstract

This paper reports on the recent work carried out as part of the EU funded NanoMend project. The project seeks to develop integrated process inspection, cleaning, repair and control systems for nano-scale thin films on large area substrates. As the PV – photovoltaic industry turns its attention on increasing efficiency and functional lifespan, the need for improved, high resolution and high speed surface inspection for the quality control of the manufacture of large area of flexible PV modules is essential. Inspection and metrology are the basic elements to guarantee maximum quality, longer lifetime and enhanced power yield. Flexible PV films are the newest development in the renewable energy field and the latest films have efficiencies at or beyond the level of Si-based rigid PV modules. These modules are fabricated on polymer film by the repeated deposition, and patterning, of thin layer materials using roll-to-roll technology. The functional layer groupings of the module are shown in fig [1].

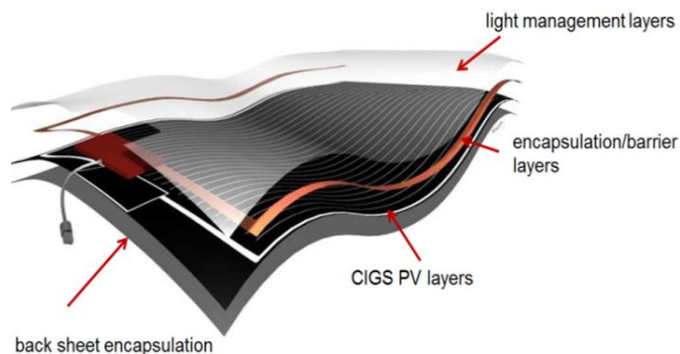


Figure 1: Schematic of the flexible PV Module (Courtesy of Flisom, Switzerland)

These modules at present are however highly susceptible to long term environmental degradation as a result of water vapor transmission through the barrier layers defects to the active layer. To reduce the WVTR the PV modules are coated with a barrier layer of aluminum oxide (Al_2O_3) on a planarised polymer substrate. This highly conformal layer is produced by atomic layer deposition (ALD) technique. Nevertheless water vapour transmission is still facilitated by the presence of micro and nano-scale defects in these barriers which results in decreased cell efficiency and degrades longevity. Therefore, in this study surface metrology techniques including: White Light Scanning Interferometry (WLSI), optical microscopy and Scanning Electron Microscopy (SEM), were used to characterise the water vapor barrier defects. Areal surface texture parameter analysis allows the efficient separation of small insignificant features from significant defects. This parametric analysis is then correlated with the water vapour transmission rate as measured on typical sets of films using Isostatic standard test (MOCON). The outcomes would appear to suggest that small numbers of large defects are the dominant factor in determining WVTR. This result provides the basis for developing roll-to-roll in process metrology devices for quality control.

Significance Statement*: The significance of this work is the first demonstration of water vapour transmission rate (WVTR) properties as a function of defects in the film.