

Accelerated Ageing and Reliability of CIGS Thin Film Solar Cells

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Abstract:

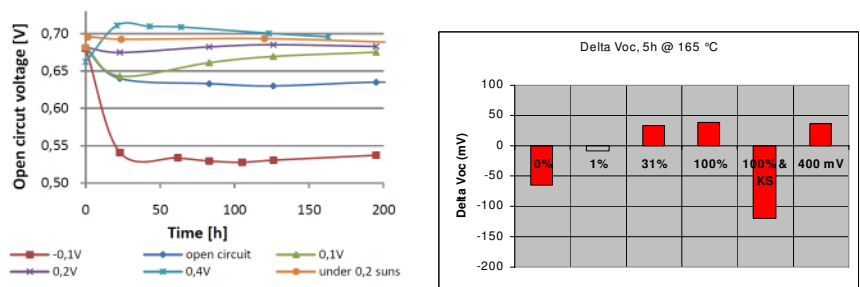
Solar cells based on CIGS play a significant role in thin film PV due to conversion efficiencies exceeding 20 %¹. However, not only the efficiency but also the long term stability is crucial for the assessment of a PV technology. Within the project “RECIS” (funded by the German Government) the reliability and long term stability of CIGS based solar cells have been investigated. The well known metastability of the CIGS material is addressed.

In order to assess the long term behavior of high efficiency solar cells (14 – 16 %) accelerated ageing experiments under different conditions were carried out. Parameter drifts of Voc, ff, reverse characteristics and luminescent (EL, PL) properties were monitored during high temperature operation (85 – 205 °C) and analyzed. From these parameter drifts activation energies were extracted allowing the extrapolation and prediction of parameter drifts under real field conditions. In a second step the physical reasons for the observed parameter drifts were investigated and operation conditions for an improved stability were established.

Results:

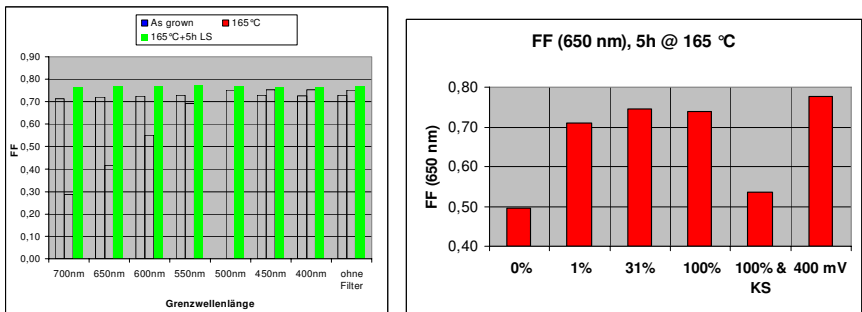
Voc parameter drifts:

For a dark anneal we observed a Voc drop of about 5 -10 %. The activation energy for the initial drop ranges around 1 eV followed by a saturation of the parameter drift. This parameter drift can be associated to a decrease of negative charge in the absorber as a result of the dark anneal. An illumination intensity as small as 1-10 % of one sun (i.e. 10W/m² - 100W/m²) during the high temperature anneal is sufficient to stabilize or even enhance Voc slightly (lightsoak). Alternatively a positive bias of 100-200 mV applied externally to the device leads to a similar result indicating that rather the splitting of the quasi fermi levels than the light absorption seems to be responsible. It should be noted that the application of a negative bias leads to a drop of Voc. This drop seems to be reversible. Thus such *continuous* operation conditions should be avoided, consequences for reliability issues are further investigated.



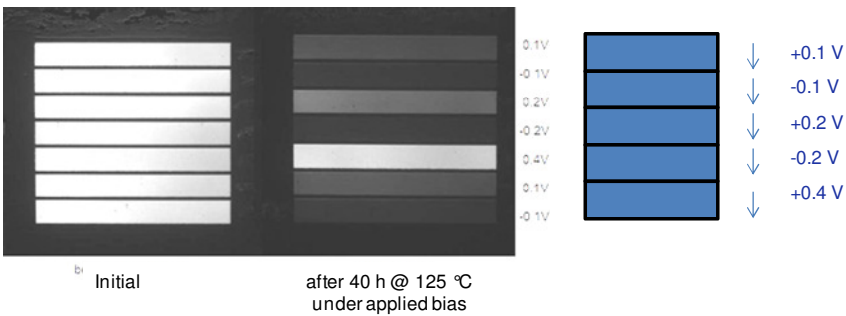
FF parameter drifts:

The parameter drift of the ff also exhibits a thermally activated behavior with a similar activation energy (~1eV), however, with a much higher prefactor, resulting in a significant slower ageing process compared to Voc. The drift of the ff can be associated to the so called “blue metastability” which is due to a change of interface properties probably related to the existence of negative interface charges. The expression “blue metastability” stems from the fact that hole generation in the CdS can cancel the ageing due to charge compensation at the interface. Therefore, compared to Voc the ff is a less relevant reliability parameter. Nevertheless, illumination or application of a positive bias further stabilizes and eventually enhances the ff.



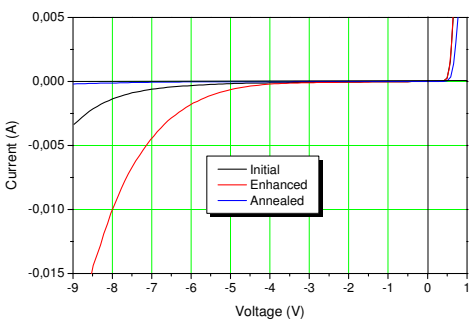
Luminescence properties:

Ageing of CIGS Cells in general also affects EL and PL by interface and bulk properties (see above). Therefore, these imaging techniques are a suitable and fast method to assess the ageing state of CIGS-based devices.

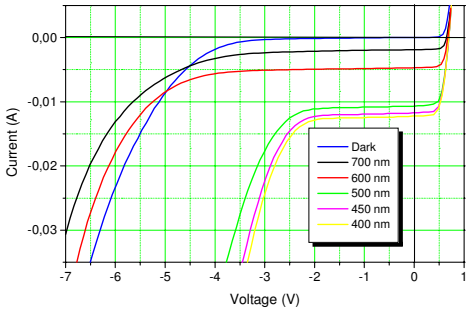


Reverse characteristics:

The reverse characteristics play an important role for the partial shadowing in an interconnected module. These reverse characteristics are also strongly affected by the ageing – i.e. the conditioning status - of the devices as negative interface charges influence the field distribution in the junction under reverse bias and impact consequently breakthrough currents.



Impact of conditioning status of the cell



Impact of spectrum

Illumination of window layer significantly reduces hot spot risk (close to “real life”)

Summary:

In summary it can be stated that especially under illumination or application of a positive bias the investigated devices exhibit a high degree of stability. A critical parameter with respect to the reliability seems to be the existence of a permanent negative bias across the junction. Application of continuous negative operation conditions is under further investigation.