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INTRODUCTION

Alkali atoms, such as Na and K have been used in CIGS solar cells for years in order to improve their performance. Recent results by Theelen et al. suggest, however, that including alkali atoms into the absorber might be detrimental to the stability of the produced cells, as their efficiency drops dramatically when submitted to accelerated ageing conditions [1]. In order to verify and expand upon the conclusions drawn by Theelen et al., accelerated lifetime testing is performed on un-encapsulated ultra-thin CIGS solar cells doped with Na and/or K. Atom probe tomography is then used to get a unique insight into the atomic constitution of the devices before, during and after degradation.

EXPERIMENTAL PROCEDURE

- KF is deposited by spin coating on the samples selected for potassium treatment.
- The samples are submitted to 85°C/85%RH conditions for up to 1000h to induce ageing.
- IV is measured on the samples.
- Further characterization is performed.

EXPERIMENTAL RESULTS

1. IV Results of accelerated lifetime test

Figure 1: Schematic representation of the finished solar cell stack

2. APT Results: Before and after ageing comparison

Figure 3: Reconstructed APT, before (left) and after (right) accelerated ageing for 1000h. Cu atoms are represented in blue, K atoms are represented by an iso-surface, which makes the grain boundaries visible, and Na atoms are represented in green. Additionally, ions that were identified as $H_3O^+$ are represented in red.

3. IV Results of the recovery experiment

- The samples are annealed at 100°C in N₂ to dry them out and initiate recovery. This should allow to determine if the water can be evaporated and the efficiency restored.

Figure 4: Solar cell parameters as measured all along the recovery through annealing

CONCLUSIONS

- APT results do not suggest any significant movement of the alkali atom when comparing the pictures before and after ageing. Instead, in the present case the inclusion of water into the grain boundaries seems to be the major culprit when it comes to the degradation of the solar cell efficiency. This confirms some of the conclusions drawn by Theelen et al. [1].
- IV results suggest that the degradation of the solar cells is mainly due to a degradation of the window and/or the buffer layer. This is indicated by the heavy correlation between the degradation of the efficiency and the resistances without immediate degradation of the Jsc and Voc.
- Recovery through annealing does not seem possible at this point.

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