The Effect of Copper on Accelerated Life Test Performance of CdTe Solar Cells

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1 Abstract

It is well known (McCandless & Sites [1]) that a back contact to CdTe cells can be achieved by first creating a Te-rich layer via selective etching, followed by application of copper which reacts with Te to form the p+ layer that can be contacted with metal or graphite. But copper has high diffusivity, multiple valence states, and a weak bond with Te, all of which contribute to stability issues. Hegedus [2] and others [3-6] have shown that there are multiple modes of degradation induced by long-term light-soaking at forward bias at elevated temperatures, namely formation of a blocking contact, increased junction recombination, and increased dark resistivity. Asher [7] showed accumulation of copper in the CdS layer.

This paper describes how varying the dose of copper used to form the back contact changes both initial efficiency and performance in accelerated stress testing. All test cells were 1 cm^2, and 12 cells were tested per condition. Figure 1 shows the performance of test cells in the standard "ALT" accelerated life test, which is continuous 0.7-sun illumination at open circuit and 65^{o}C. As shown by Hegedus [2], the higher copper dose leads to increased rate of degradation, driven by both voltage and fill-factor loss. This is shown most clearly in Figure 2. The loss of fill factor is driven by increases in both resistance (Roc) and light-shunt conductance (Gsc), shown in Figure 3.

The use of too little copper results in low-performance but relatively stable devices, most of which exhibit a back-contact barrier. Figure 4 illustrates this by plotting Rmax – the resistance at 0.9 volt forward bias (dV/dJ at 0.9V bias). There is extreme noise in the data for low copper dose, since noise in process conditions results in either a good contact or a very poor one. Higher copper dose is required to reliably form a good contact. Figure 5 shows an example of a good cell and one that is degraded exhibiting lower voltage and rollover. Using more copper eliminates the barrier and increases the initial efficiency. Thus a compromise must be made balancing reproducibility, initial efficiency, and long-term stability.

Figure 1. Degradation vs. ALT time for three copper doses.

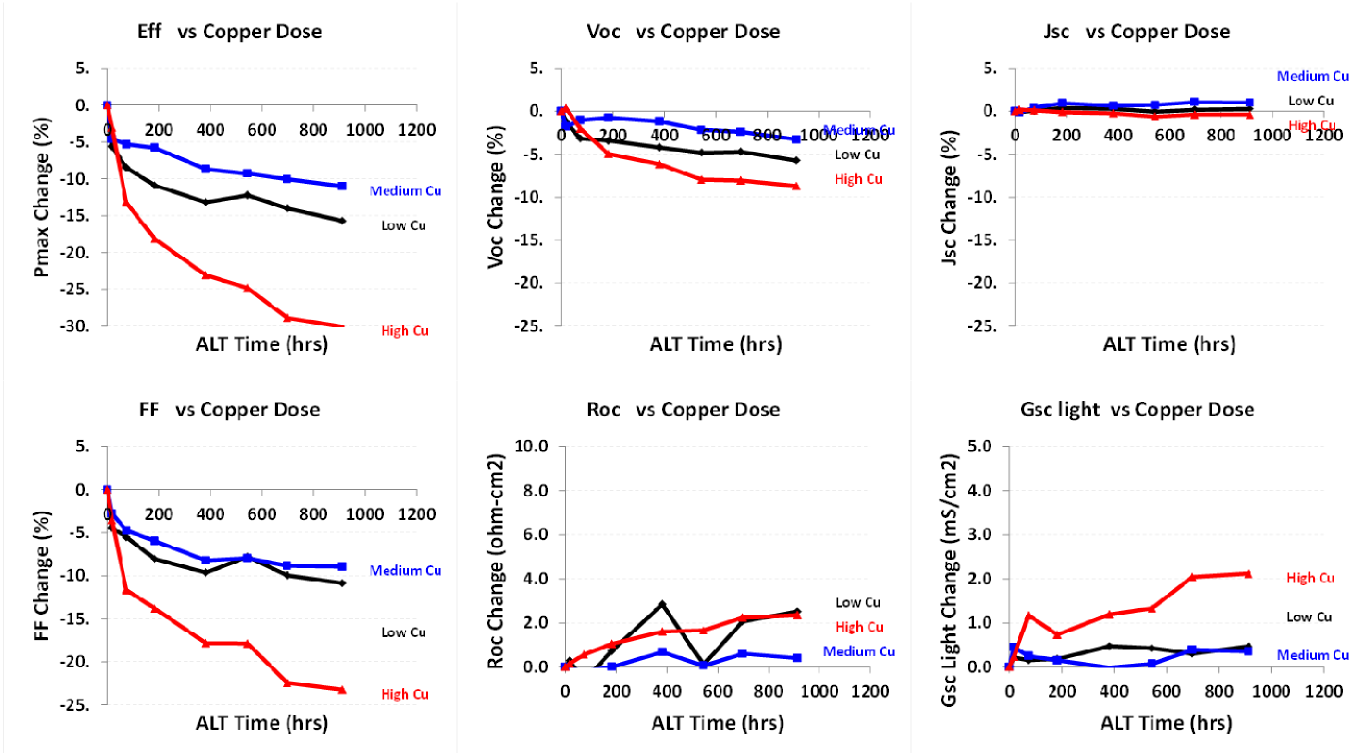


Figure 2. Secondary metrics correlated to efficiency degradation.

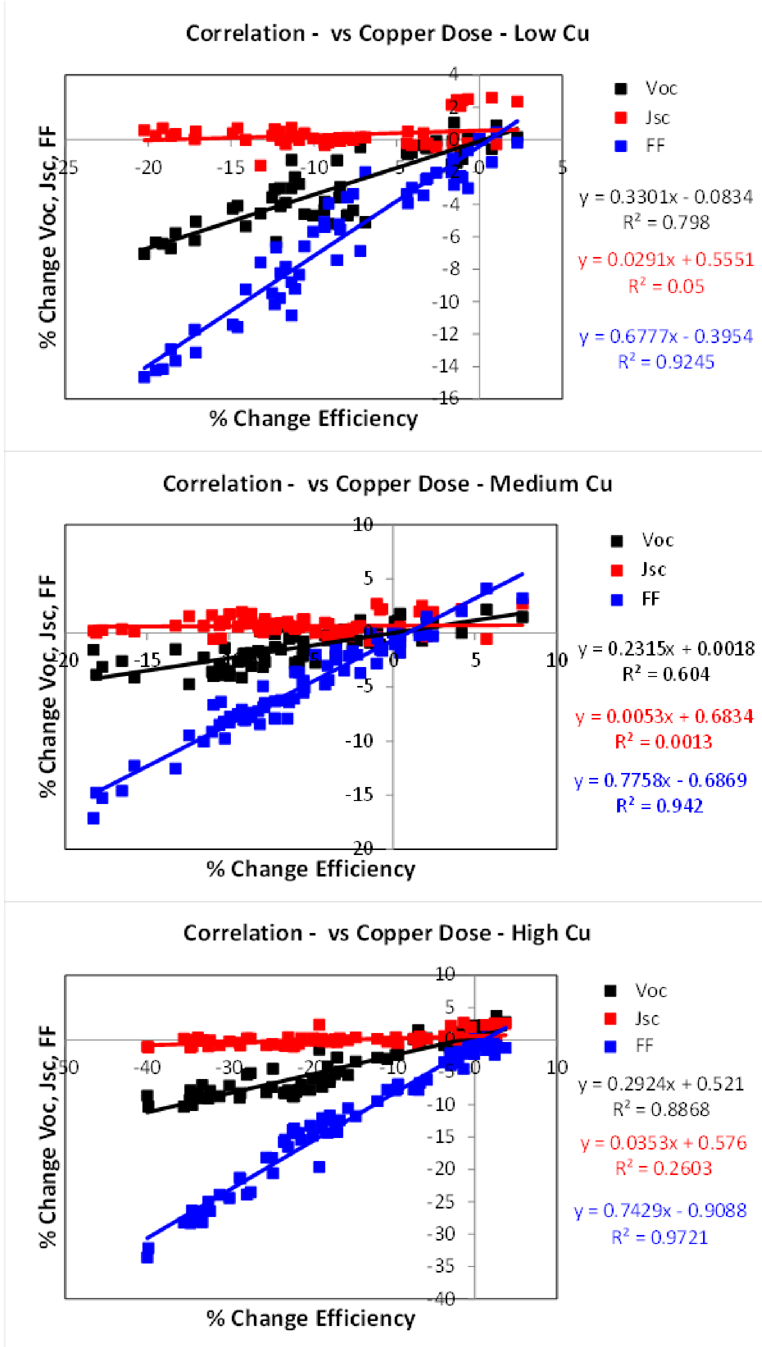


Figure 3. Tertiary metrics correlated to efficiency degradation.

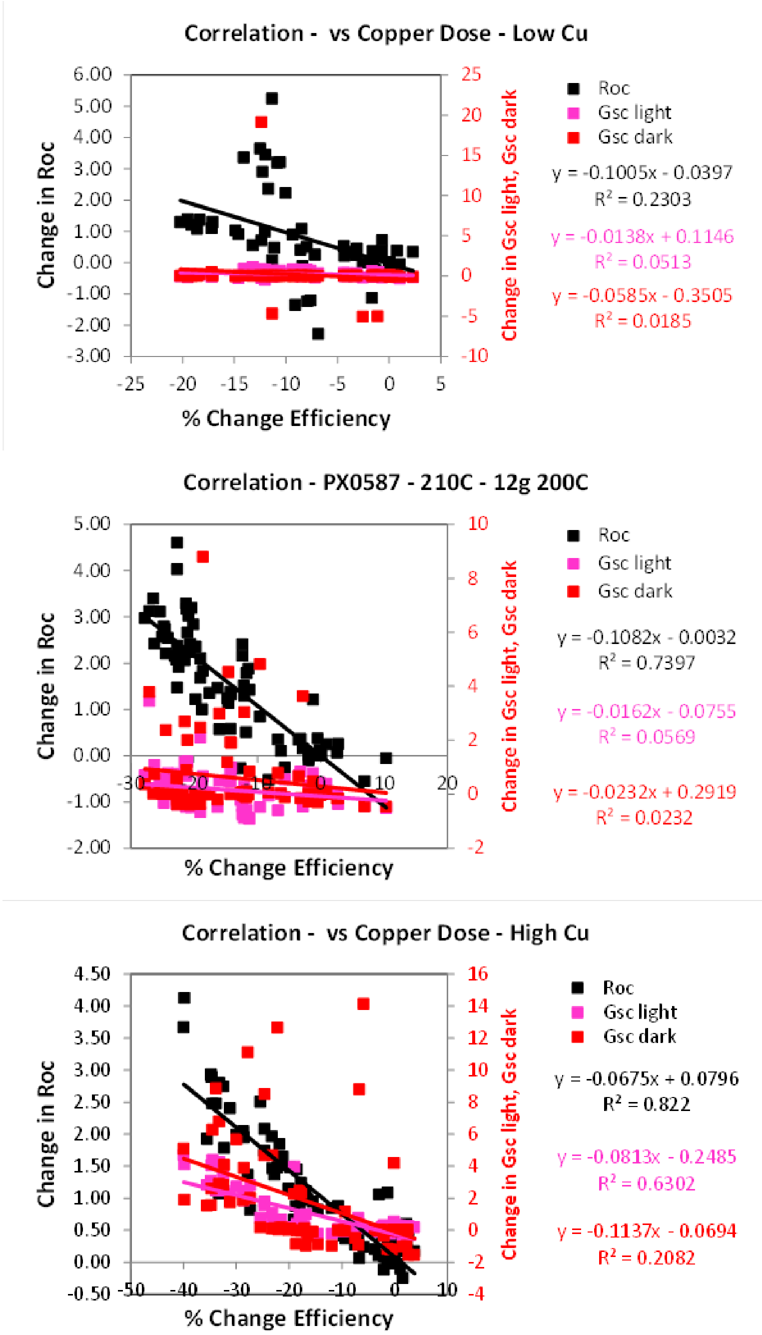


Figure 4. Effect of copper dose on JV rollover, (a) definition, (b) data.

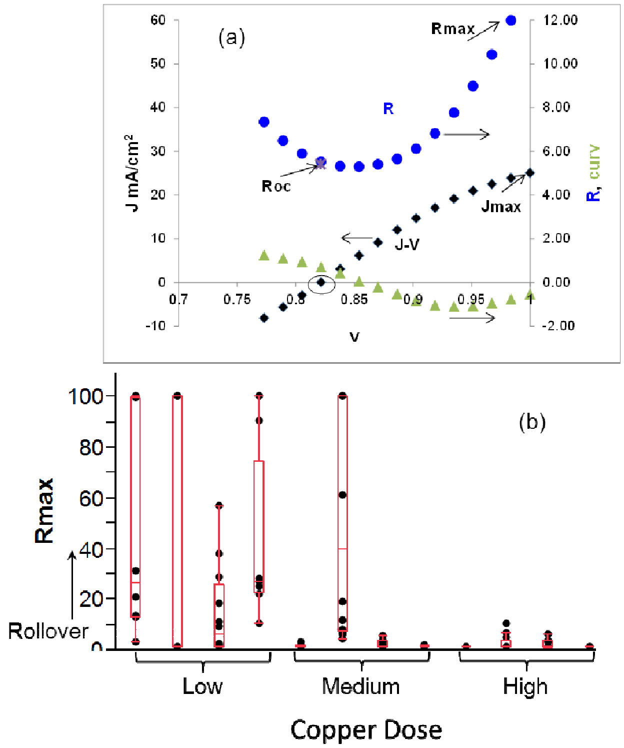
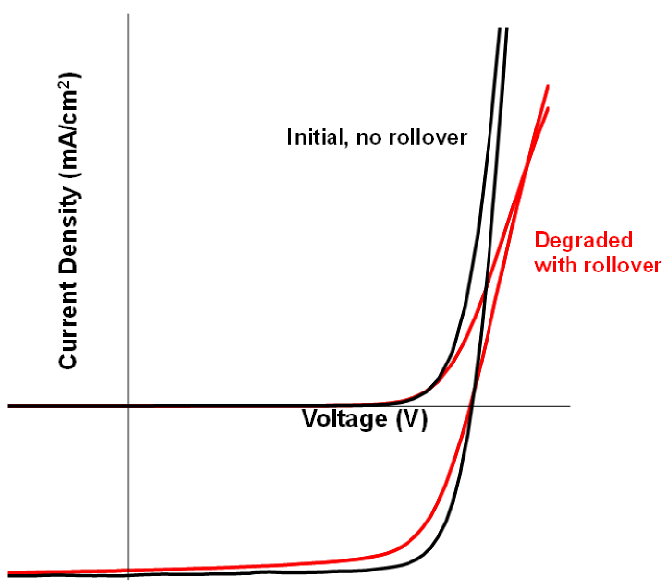


Figure 5. Typical JV curves showing good initial performance and degraded performance with rollover.



2 Literature Cited

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