Understanding the role of Chlorine at the front interface in limiting Solar cell efficiency

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- **AIM**: Doping in CdTe is multi-dopant, multi-configurational, multi-level , non-shallow as well as mobile. It is well known that both copper and chlorine treatments are crucial to obtain high conversion efficiencies. However the exact roles of copper and chlorine in limiting CdTe solar cell efficiency are still under debate as many explanations and mechanisms have been proposed. These species are of a mobile nature under an electric field and hence they can drift across the bulk. Chlorine is introduced in the CdTe bulk structure through the different processes while processing CdTe TFSC. Although these processes involving chlorine are essential for high efficiency thin film cadmium telluride photovoltaic devices, these processes are very parameter sensitive and if not controlled can lead to a buildup of Chlorine at the front interface. This Chlorine segregation at the front interface appears to damage the heterojunction but the mechanisms involved are not fully understood [1][2]. In this study, we investigate this segregation of Chlorine at the front interface and its role in limiting the cell conversion efficiency.

- **APPROACH**: Chlorine was introduced to CdTe solar cells during the Cadmium chlorine annealing and back contact formation processes. Chlorine was then driven to the front interface using a reverse bias stress for extended periods of time. The change in acceptor concentration was measured before and after the applied stress. An Increase in Acceptor concentration is indicative of narrowing of the device depletion width, which will then affect the collection efficiency of the device as photons absorbed in the neutral CdTe bulk will not be collected entirely due to an absence of a field.

- **SCIENTIFIC INNOVATION AND RELAVANCE**: These studies help gather a better understanding of the features of a CdTe solar cell, specifically the mobile nature of doping in CdTe Thin film solar cell, which affects the solar cell performance and stability. Gaining a better understanding of these concepts is important for improving the CdTe cell structure to achieve higher efficiency devices with improved stability.

- **RESULTS /PRELIMINARY RESULTS /CONCLUSIONS**:

  Given below is a set of characteristic J-V data before and after the reverse bias voltage stress

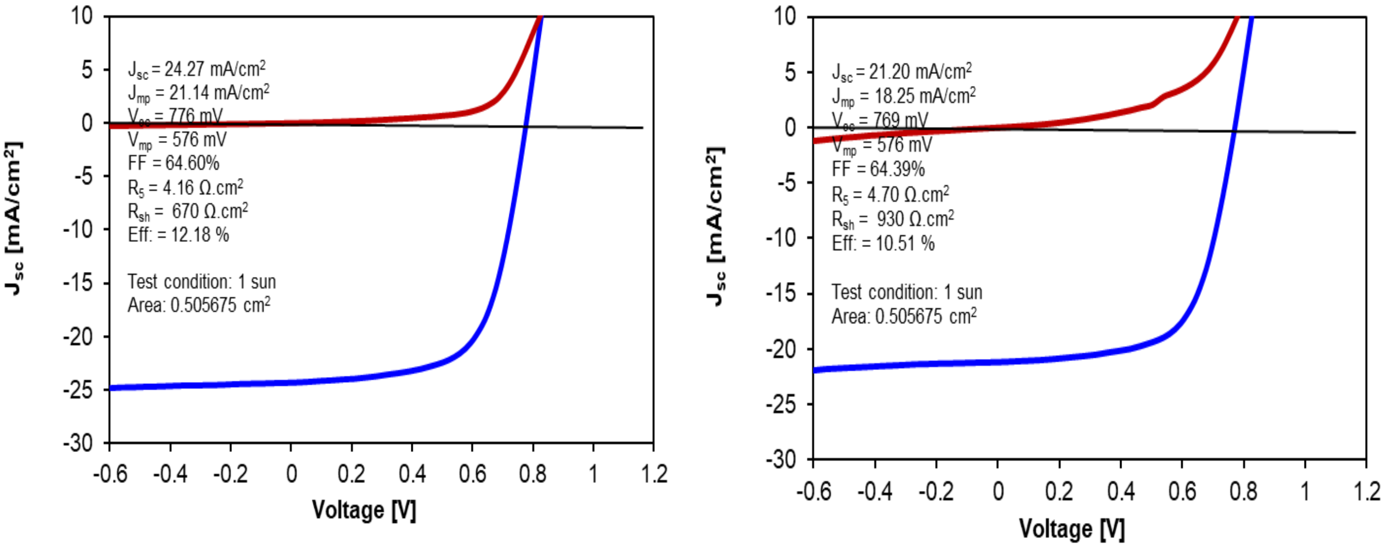
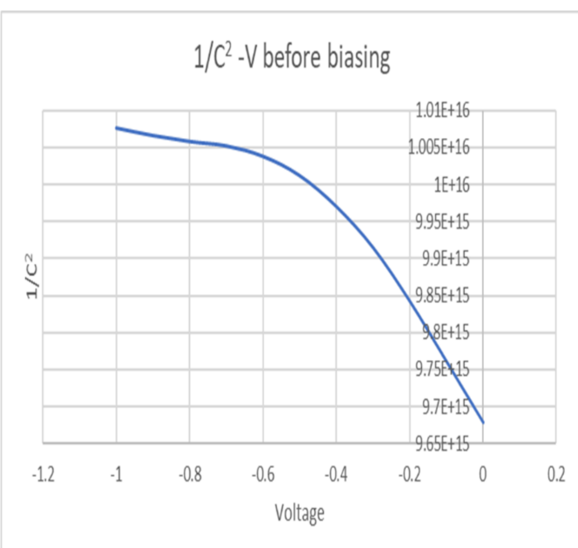
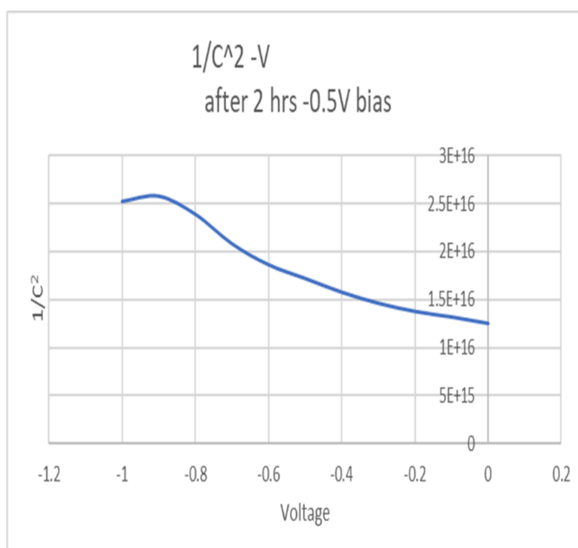


Figure 1:J-V characteristics before(L) and after(R) applied reverse bias stress for extended periods of time

As is known, the Acceptor concentration data can be extracted from the slope of ($1/C^2$) vs V graph and has an inverse relation with the slope.

The applied stress then results in a net increase of Na concentration, as observed by the slope of C-V measurements





This net increase of Na results in narrowing of the device depletion width as it is related as follows

$$N(a) = \frac{2}{qE_s A^2 [d(1/C^2)/dV]}$$

References

1] Abbas, A., West, G. D., Bowers, J. W., Kaminski, P. M., Maniscalco, B., Walls, J. M., ... & Sampath, W. S. (2014, June). Cadmium chloride assisted re-crystallization of CdTe: The effect of annealing over-treatment. In *2014 IEEE 40th Photovoltaic Specialist Conference (PVSC)* (pp. 0701-0706). IEEE.

2] Harvey, S. P., Teeter, G., Moutinho, H., & Al-Jassim, M. M. (2015). Direct evidence of enhanced chlorine segregation at grain boundaries in polycrystalline CdTe thin films via three-dimensional TOF-SIMS imaging. *Progress in Photovoltaics: Research and Applications*, *23*(7), 838-846.