Investigation of the role of $CdCl_2$ treatment on CdTe polycrystalline thin films using cathodoluminescence

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Many efforts have been made recently to improve the efficiency of CdTe solar cells and make them competitive with Si. Record efficiency of CdTe solar cell is 22.1%, but it still suffers from a high V_{oc} deficit, which originates from a low doping level and low minority carrier lifetime. A common way to improve the quality of CdTe thin films is to use a $CdCl_2$ post deposition treatment (PDT), and it was found that the optimal annealing temperature is in the 420-440°C range. However, the exact role and effect of this PDT is still under unknown.
We have studied a series of CdTe samples with different $CdCl_2$ annealing temperatures from 400°C to 460°C. We have performed high-resolution cathodoluminescence mapping measurements at room- and low-temperature (10K) on the same surface area. We combine quantitative, statistical and local analysis of the CL maps over numerous grains. We also correlate the luminescence intensity (radiative efficiency) and diffusion length characterized at room-temperature with the defect densities measured at low temperature.
We reveal that the $CdCl_2$ annealing decreases non-radiative recombination at grain boundaries (GB), and increases the grain size, the radiative efficiency and the homogeneity of the CdTe thin film for temperature up to 420°C. For higher temperature, the increase of grain size is counter-balanced by an increased density of bulk defects induced by Cl diffusion in grain interiors (GI), leading to a decrease of the diffusion length and cell efficiency.
Similar CL mapping analysis can be applied to other polycristalline thin films.

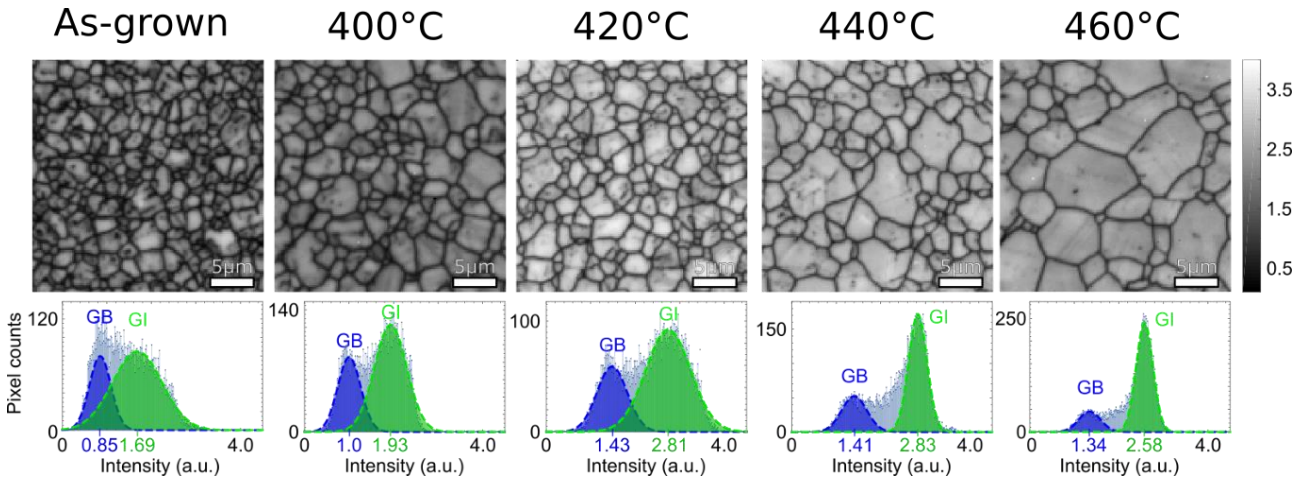

Figure 2: CL Panchromatic maps (128*128 pixels) of CdTe samples with different $CdCl_2$ post deposition treatment a) No $CdCl_2$ b) 400°C c) 420°C d) 440°C e) 460°C. All images have been normalized on the same gray scale. (5µm white scale bar). On the bottom row, room temperature intensity histograms for each sample with a two-gaussian function fit for f) No $CdCl_2$ g) 400°C h) 420°C i) 440°C and j) 460°C.