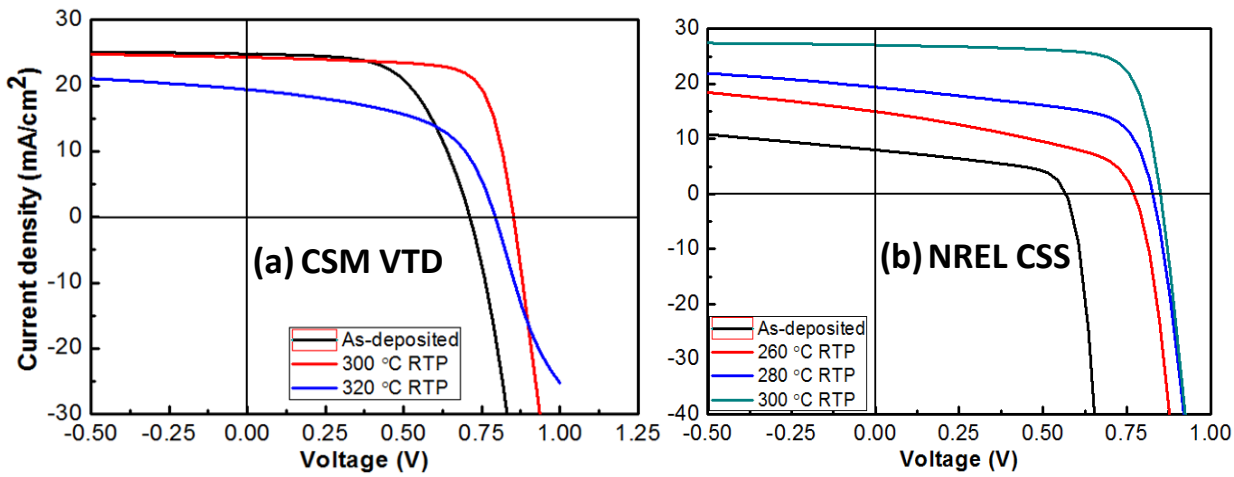
BAPVC Annual Project Report

Project Title: Non-Equilibrium Processing of CdTe Absorbers

PI: Colin A Wolden, Colorado School of Mines
E-mail: cwolden@mines.edu

Summary: A new ZnTe:Cu back contact procedure was developed using rapid thermal processing that enables both high V_{oc} (>850 mV) and fill factor (FF>75%) without compromising J_{sc}. This robust process has been validated using absorbers fabricated by both vapor transport deposition (VTD) at CSM and close space sublimation (CSS) at NREL. A novel plasma-enhanced VTD reactor has been fabricated and assembled for extrinsic doping studies.

Key Accomplishments: Figure 1 displays the J-V performance under standard AM1.5 illumination of devices made using the RTP back contact procedure developed at CSM. The curves in Fig. 1a are from devices employing VTD absorbers at CSM. These cells initially show good J_{sc}, and application of an optimized 30 s RTP treatment dramatically improves FF and V_{oc}. Excessive heating results in device degradation. This technique was also applied to absorbers deposited at NREL using CSS. In contrast, these devices display poor current density initially because the absorbers are highly resistive. In this case all 3 parameters systematically improve, and it is presumed that the RTP treatment both dopes the CdTe absorber and reduces the back contact barrier. The table summarizes device parameters under optimized conditions. The V_{oc} and FF are nominally identical, and the higher J_{sc} value is attributed to CdS consumption during CSS deposition that occurs at higher temperature than VTD (600 vs. 450 ºC). Detailed studies are underway to fully characterize these devices in order to establish the fundamental process-property-performance relationships in these systems.



Absorber	V_{oc} (mV)	FF (%)	J_{sc} (mA/cm²)	η (%)
CSM VTD	851.9	73.72	24.30	15.26
NREL CSS	850.6	75.02	27.05	17.26

Fig. 1: J-V curves of obtained using sequential RTP processing using absorbers produced by (a) VTD at CSM and (b) CSS at NREL. The table summarizes parameters of optimal devices.

Future Work: The robust RTP back contact procedure described above has been optimized empirically and a goal in the next year is to complete the advanced characterization that is underway and produce a number of peer-reviewed papers on this topic. The studies described below are being carried out at CSM, our BAPVC partners at the University of Oregon, and at NREL through a recently awarded Non-Proprietary Partnering Opportunity (NPO).

- Measurements of composition and microstructure (TEM, SIMS, APT)
- Correlation to advanced opto-electronic characterization including QE, TRPL, low temperature PL, transient photocurrent/photocapacitance, temperature- and light dependent J-V
- Reliability studies as a function of bias, illumination, temperature and potentially humidity through collaboration with those working on encapsulation.

We expect to commission the PE-VTD within the next quarter. First studies will be baselines PE-VTD materials versus thermal VTD. A key issue is that our current VTD material appears to produce unintentionally doped CdTe (Fig. 1a), perhaps due to exposure of heater wires within the VTD system. This issue should be mitigated as all heating elements for CdTe vaporization are external and IR lamps are used for substrate heating in the new VTD system. Once intrinsic CdTe has been established we will systematically investigate doping and passivation through the introduction of group V elements such as N_2 and in situ passivation using H_2S or HCl.