Breakout session: Metastabilities of Thin Films

Discussion leader: Jim Sites

1:00 – Jeff Yang (Uni-Solar) – Metastability of Amorphous Silicon – Historical Perspective and Real-Life Performance

1:30 – Dave Albin (NREL) – Metastable Effects in Polycrystalline Thin Film Cells and Correlations with Performance and Reliability

1:50 – Joe delCueto (NREL) – Comparison of Injection of Carriers Through Light Soaking and Forward Bias in Dark

2:10 – Discussion: How do we differentiate reversible from irreversible changes? How does a-Si experience with the Staebler-Wronski effect help with CIGS/CdTe issues? Can we use the same pre-conditioning test for all thin-film modules?

Jeff Yang summary slide

The **Staebler-Wronski effect** is reversible with thermal annealing

The **triple-junction structure** with high quality material results in improved module performance featuring higher kWh/kW

Reliability has been much improved; **25-year warranty** is being offered

Long-term degradation still exists and needs better understanding

Performance prediction should include thermal annealing to reflect real-life conditions

Dave Albin summary slide

NREL **CTO/ZTO** CdTe cells superior to SnO_2-based cells in initial performance, but some fundamental durability problems

C-V hysteresis for CdTe cells increased with stress in cells using "infinite" sources of dopant (Cu).

Additional **hysteresis in CTO/ZTO** cells strongly suggests "decomposition" of the CTO/ZTO layers

C-V hysteresis also increased in **industrial cells**, but decreasing hysteresis observed at longer stress times and higher temperatures.

C-V during ALTs easily implemented as a non-destructive technique to better identify degradation mechanisms in cells and modules

Joe del Cueto summary slide

Both **CIGS and CdTe** show metastable behavior in performance

IEC61646 stabilization, defined as $\Delta\eta \leq 2\%$ between successive increments, may be inadequate to define stability for polycrystalline thin-film PV.

Will deploy same module set outdoors for 6-10 weeks to compare light- and dark-exposure Will start testing **newer CdTe and CIGS** module sets

Implemented **stabilization/preconditioning procedures** for (1) light soak at 1-sun, and (2) voltage-biased dark-soak, at 65°±5°C

CV profiling:

Changes in depletion width and hysteresis with light or thermal anneal

Quantifiyng link to stability is likely different between CIGS and CdTe

For some modules, capacitance profiles are different in light and dark

Discussion summary – Thin-film metastabilities

- What differentiates stability and reliability issues for a-Si, CdTe, and CIGS? Different mechanisms: electronic states, possible ionic movement.
- Seasonable effects: (Joe) 45% phase lag with CdTe
- How does one focus in quickly of metastable effects? Systematic pre-conditioning before measurments recommended.
- Any merit to using biases significantly above V_{MP} for stress tests? Probably, but need care with associated thermal effects.
- Why does a-Si not need a moisture barrier, even though similar TCO's are used? Seems to be true at both Uni-Solar and NREL, and is a mystery.