Experimental results on c-Si PV modules delamination using thermal approach
Background - The Growing PV Capacity

Background – PV recycling technology generation

Generation 1
• Down-cycling: recycling PV module using mechanical process (similar to WEEE recycling process).

Generation 2
• Hybrid down-cycling & up-cycling: delamination of PV modules for recover whole piece of glass, other contents goes to mechanical process (e.g. WEEE recycling process)

Generation 3
• Up-cycling: recover all the valuable components of a PV module for their direct reuse or recycling
General Generation 3 Recycling Process

Diagram showing the process:
- PV modules
  - Remove junction box & Al frame
  - Junction box & Al frame
- Module Delamination (Thermal treatment)
- c-Si Cell
- Chemical Etching
- Clean Si wafer
- Glass
- Wastes
- Metals (Ag, Pb, Cu, Sn)
Delamination – Removal of EVA (ethylene vinyl acetate)

Thermal treatment – high Temperature
Thermal treatment – Pyrolysis of Module components

- Thermo gravimetric analysis (TGA)
- The amount of weight change during the process as a function of increasing temperature will be measured during from beginning to end.
Thermal treatment – Pyrolysis of EVA & Backsheet

EVA: 300°C ~ 500°C

Backsheet: 350°C ~ 600°C
Thermal treatment – Pyrolysis of c-Si module

Annealing Temperature:
~ 500°C
Experiment – Dual chamber furnace (SMaRT center)

Dual chamber furnace

Module Samples

One-cell Module (20 x 20 cm)
Thermal treatment – Double-glass module (5 x 6 cm)

Before

After

Ramp-up rate: 5 deg C/min
Maximum Temp: 480 deg C
Thermal treatment – One-cell module (glass-backsheet)

Ramp-up rate: 5 deg C/min
Maximum Temp: 480 deg C
Thermal treatment – One-cell module (glass-backsheet)_1
Thermal treatment – One-cell module (glass-backsheet)_2

Ramp-up rate: 5 deg C/min
Maximum Temp: 450 deg C
Two Stages of the Decomposition of EVA

1. The first stage is when the acetic acid starts to be removed from the main chain.
2. The second stage is the remaining polyethylene co-polyacetylene starts to degrade.

Thermal treatment – One-cell module (glass-backsheet)
Thermal treatment – One-cell module (glass-backsheet)
What can we do to eliminate the breakage?
During the process: Step heating

- Slow down the production of gas
- Leave time for gas to release
Before the process: Fixture / Pretreatment

Module preference: double-glass module
Thank you

Any questions?

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