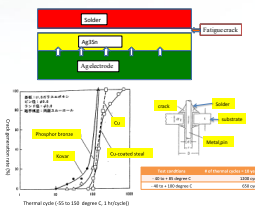


Risk of PV fire caused by solder bond failure Ag dissolution into solder in the interconnection between Ag electrode and Cu ribbon

Uichi Itoh¹, Manabu Yoshida¹, Hideo Tokuhisa¹, Kohichi Takeuchi² and Yasuyuki Takemura²
1 National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Ibaraki 305, Japan
2 Ite cooperation, Ritto, Shiga 520-3531, Japan

Motivation

- Ag dissolves into solder even in low temperature [1,2]
 - Solder bond connection on Ag electrode is not allowed in consumer electronic assembly when considering long term reliability more than 2 years.
 - Brittle Ag-Sn compound is formed when Ag dissolved into solder.
 - Cracks at the interface of solder and Ag-Sn compound >> arc discharge >> risk of fire
- Long-term solder bond failure
 - Metals composed of solder alloy tends to separate into individual metal grain for long term. Grain size becomes large when shaking.
 - Cracks generated at the boundary of grain with different mechanical character >> arc discharge >> risk of fire



Solder Bond Connection in Crystalline Si PV module

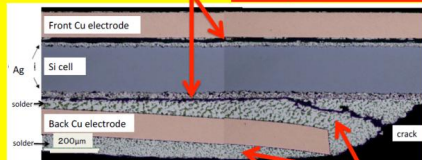
- Cu ribbon-solder-Ag electrode-Si Cell
- Cu ribbon-solder-Cu ribbon
- By-pass diode connection at junction box
- Circuit board at inverter

Background

- Solder Bond Failure in Consumer Electronics
- CRT TV fire
 - Crack at solder bond and insulation failure at fry-back transformer
- Fluorescent lamp fire
 - Crack at solder bond at inverter. It may be caused by long-term thermal cycle of solder.
- Hot-water supply system leads city gas leak
 - Crack at solder bond at sensor circuit. It induces to open the gas valve

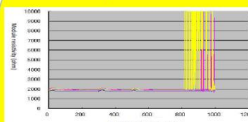
Crack at the interface of solder and Ag electrode caused by Ag fretting

Cross section view of Si solar cell after 1000 thermal cycles (+85 to -40 degree C)

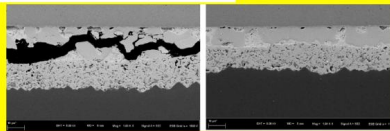


Solder bond failure due to growing metal grain induced by shaking caused by the large TEC difference of Si and Cu.

Resistivity vs thermal cycles of PV module



There are connecting and disconnecting areas at the interface of solder and Ag electrode.



Disconnecting area

Connecting area

Conclusion

- Ag dissolution into solder (PbSn, SAC) >> AgSn compound formed >> crack is generated at the interface of AgSn and solder >> hot spot [3] >> arc discharge >> risk of fire
- Metal grain of solder grows by shaking >> uniformity of adhesiveness of solder grain >> crack is generated >> arc discharge >> risk of fire

Acknowledge

This work is supported by New Energy and Industrial Technology Development Organization (NEDO) project "Development of Next-generation High-performance Technology for Photovoltaic Power Generation System"

References

- W.G. Bader "Dissolution of Au, Ag, Pd, Pt, Cu and Ni in a molten Tin-Lead solder" Welding Journal Welding Research Supplement, Dec (1969) p551s-557s.
- G. Cuddalorepatta, A. Dasgupta, S. Sealing, J. Moyer, T. Tolliver and J. Loman, "Durability of Pb-free solder between copper interconnect and silicon in photovoltaic cells" Prog. Photovolt. Res. Appl. 18, 168-182 (2010)
- K. Kato, "PV ResQ: PV module failure observed in the field" Photovoltaic Module Reliability Workshop 2012.