

Dong-Youn Shin^{1*}, Jong-Rok Lim², Yong-Seong Kim², Jeong In Lee², and Gi-Hwn Kang²

¹Dept. Graphic Arts Information Engineering, Pukyong National University, Busan, Republic of Korea

²Photovoltaic Laboratory, Korea Institute of Energy Research, Daejeon, Republic of Korea

Contact : dongyoun.shin@gmail.com

Introduction

- Silicon wafers get thinner from 170 μm in the year 2018 to 130 μm in the year 2028 [1]
 - Saving the materials cost of silicon solar cells
 - More flexible and lighter solar modules with high efficiency are required for the application of solar modules on conformal surfaces
- However, conventional interconnection does not fit for flexible thin silicon solar cells, as shown in Fig. 1 [2]
 - Breakage due to thermal shock
 - Bending due to mismatched coefficients of thermal expansion between metal ribbon and silicon
 - Breakage due to interfacial stress developed while bent
- Herein, thermomechanical-stress-free interconnection at room temperature using a liquid metal is explored as an alternative to conventional soldering

Experiments

- As an electrically conductive material which can interconnect at room temperature, a liquid metal (Ga-In-Sn) was chosen
 - Melting point: $-19\sim 6^\circ\text{C}$
 - Viscosity: 2.4 mPa·s @20 $^\circ\text{C}$
 - Electrical resistivity: 28.9 $\mu\Omega\cdot\text{cm}$ @20 $^\circ\text{C}$
 - Surface tension: 535 mN/m @20 $^\circ\text{C}$
- For an easy application, it was dispersed in a carrier vehicle, formulated as a liquid metal paste, and applied on Ag busbars using a syringe, as shown in Fig. 2

Results and Discussion

- As can be seen in Fig. 3, solar modules interconnected using a liquid metal at room temperature do not suffer from thermomechanical stress
- However, their power performance was quickly degraded due to the corroded Ag busbars by a corrosive liquid metal, as shown in Fig. 4
 - The series resistance increase of solar modules was conjectured to be the cause of power degradation [2]
 - $\text{Ag} (1.6 \mu\Omega\cdot\text{cm}) + \text{Ga-In-Sn} (28.9 \mu\Omega\cdot\text{cm}) \rightarrow \text{Ga} (27 \mu\Omega\cdot\text{cm}) + \text{Ag-In-Sn} (\sim 18 \mu\Omega\cdot\text{cm})$
- However, their efficiency and series resistance were recently found to be restored by an appropriate post-treatment, as shown in Fig. 5
 - The prevention of power degradation without a post-treatment is working on

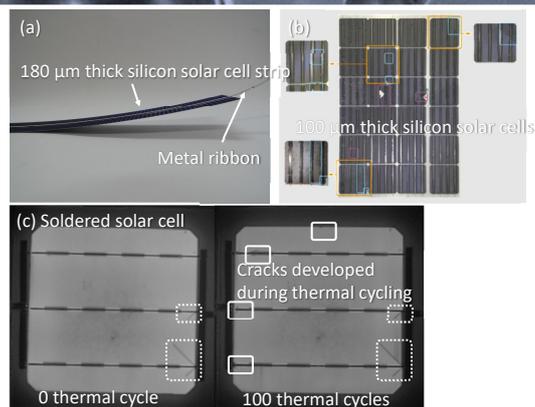


Fig. 1. Drawbacks of conventional soldering, (a) bending due to mismatched coefficients of thermal expansion between a metal ribbon and a silicon wafer, (b) breakage due to thermal shock, and (c) post-development of cracks during thermal cycling [2].

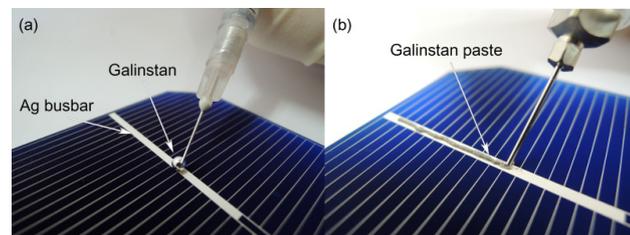


Fig. 2. (a) A pure liquid metal which does not wet an Ag busbar and (b) a liquid metal paste which can easily wet an Ag busbar [2].

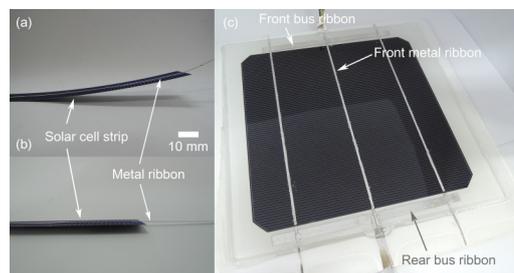


Fig. 3. (a) Bending of a soldered solar cell strip, (b) no bending of a liquid metal interconnected solar cell strip, and (c) a unit module interconnected using a liquid metal [2].

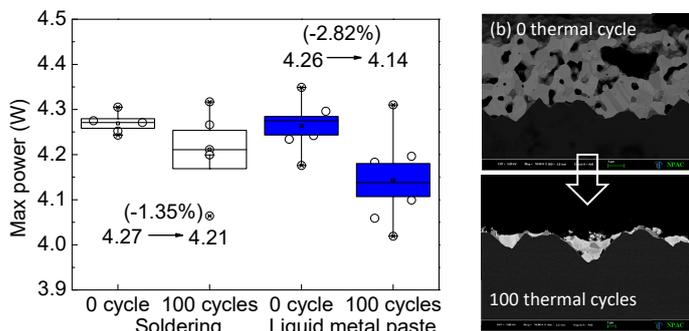


Fig. 4. (a) Degraded power performance after 100 thermal cycles and (b) a SEM image of a corroded Ag busbar by a liquid metal [2].

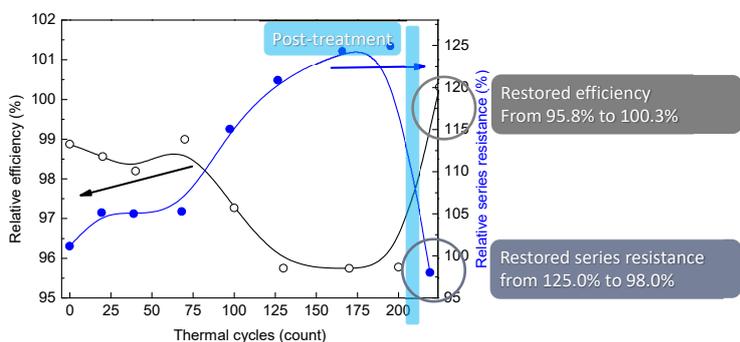


Fig. 5. Restored performance of solar modules interconnected using a liquid metal after post-treatment.

Conclusion

- Herein, a facile means to interconnect solar cells and metal ribbons at room temperature with no development of thermomechanical stress is presented
- Severe corrosion of Ag busbars by a liquid metal was conjectured to be the cause of power degradation
- However, the recent investigation found efficiency and series resistance could be restored by an appropriate post-treatment
- The prevention of power degradation without a post-treatment is working on

References

[1] SEMI PV Group, International Technology Roadmap for Photovoltaic (ITRPV.net), Results 2018.
 [2] D.-Y. Shin, H. W. Chung, H. J. Song, J. I. Lee, K. H. Kim, and G. H. Kang, "Thermomechanical-stress-free interconnection of solar cells using a liquid metal," *Solar Energy Materials and Solar Cells* 180, 10 – 18 (2018).

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