Thermomechanical-Stress-Free Interconnection for Future Solar Modules with Thin Silicon Wafers

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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

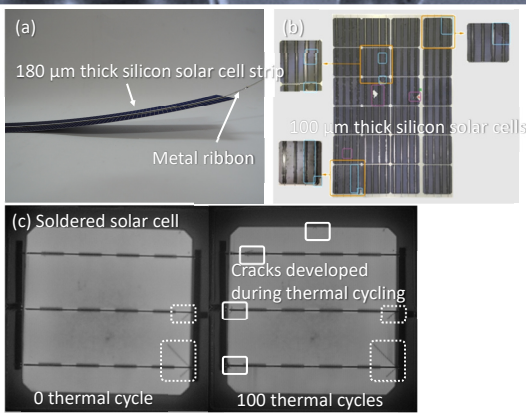


Fig. 1. Drawbacks of conventional soldering, (a) bending due to mismatched coefficients of thermal expansion between a metal ribbon and a silicon wafer, (b) breakage due to thermal shock, and (c) post-development of cracks during thermal cycling [2].

Experiments

- As an electrically conductive material which can interconnect at room temperature, a liquid metal (Ga-In-Sn) was chosen
  - Melting point: −19~6°C
  - Viscosity: 2.4 mPa·s @20°C
  - Electrical resistivity: 28.9 μΩ·cm @20 °C
  - Surface tension: 535 mN/m @20 °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

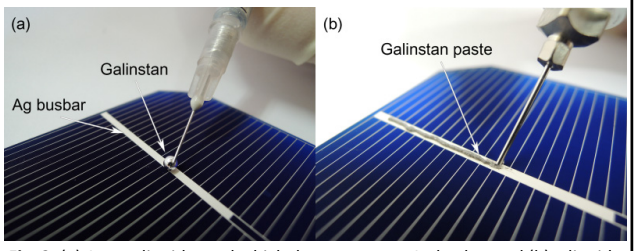


Fig. 2. (a) A pure liquid metal which does not wet a Ag busbar and (b) a liquid metal paste which can easily wet a Ag busbar [2].

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]
  - Ag (1.6 μΩ·cm) + Ga-In-Sn (28.9 μΩ·cm) → Ga (27 μΩ·cm) + Ag-In-Sn (~ 18 μΩ·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

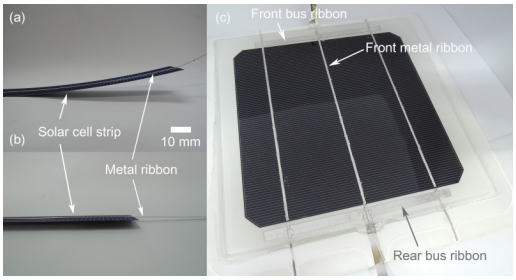
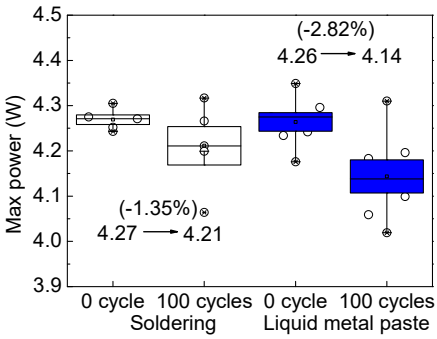


Fig. 3. (a) Bending of a soldered solar cell strip, (b) no bending of a liquid metal interconnected solar cell strip, and (c) a unit module interconnected using a liquid metal [2].



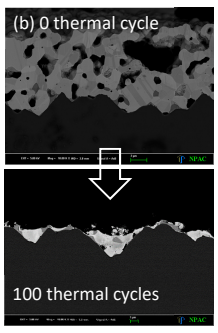


Fig. 4. (a) Degraded power performance after 100 thermal cycles and (b) a SEM image of a corroded Ag busbar by a liquid metal [2].

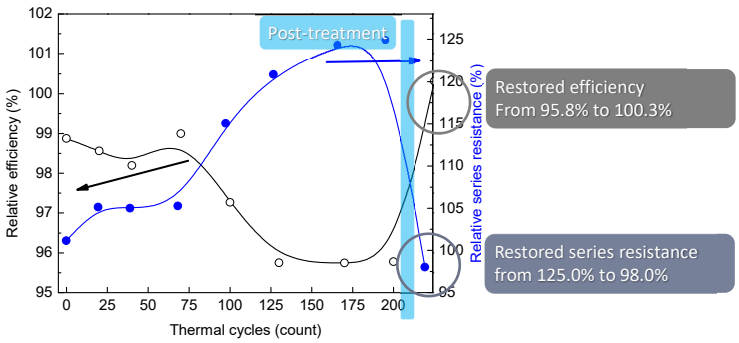


Fig. 5. Restored performance of solar modules interconnected using a liquid metal after post-treatment.

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

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[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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