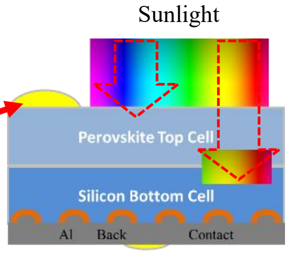
東洋アルミニウム技報
Toyal Technical Report

Low temperature curing silver paste for perovskite tandem solar cells



Silver paste for perovskite solar cells (TPA series) (left)
Example of perovskite tandem cell structure (right)

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Solar
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【1. Introduction】

Perovskite solar cells have been developed in recent years, and at the research level they have achieved conversion efficiencies close to those of current mainstream crystalline silicon solar cells. Perovskite solar cells are attracting attention as thin-film, high conversion efficiency solar cells with low cost and easy manufacturing. Furthermore, it is expected that solar cells with a conversion efficiency of 30% or higher, which is difficult to achieve using only crystalline silicon solar cells, can be realized by using a tandem structure in which they are stacked with crystalline silicon solar cells. If solar cells with a conversion efficiency of 30% or higher and low cost can be realized, they can be used in small areas such as on-vehicles, and further spread of clean energy is expected.

Although perovskite solar cells have been improving in efficiency at the research level, the challenges for practical use are increasing the area size and improving long-term reliability. One of the challenges in increasing the area of perovskite solar cells is the formation of electrodes. At the research level, electrodes are formed by metal evaporation or other processes, and it is necessary to consider a simple and fast process suitable for mass production. We are developing electrode paste for perovskite solar cells for electrode formation by screen printing method suitable for mass production.

【2. 】Conductive paste for perovskite

The front side of a perovskite solar cell consists of a transparent conducting oxide (TCO) film and a grid metal electrode. Grid electrodes must have narrow lines so as not to block light, low line resistance and low contact resistance with TCO film to reduce electrical loss. Furthermore, the conductive paste must be cured at temperatures below 150°C to prevent degradation of perovskite solar cell layers. We have been developing low-temperature curing conductive paste for silicon heterojunction (SHJ) solar cells that cures at around 200°C and has low contact resistance to transparent conductive films and low narrow line resistance. Based on this technology, we have been developing pastes applicable to perovskite solar cells by changing the materials and ratios of thermal curing resins, additives, and conductive fillers. As a result, we have developed pastes for fine line printing and cured at low temperatures between 120°C and 150°C to achieve low contact resistance and line resistance.

【3. Perovskite tandem solar cells】

The low-temperature curing silver (Ag) paste developed for perovskite solar cells was evaluated for application in a mass production process at Helmholz-Zentrum Berin (HZB), a research institute with the world's highest efficiency record in perovskite tandem solar cell research (presented at SiliconPV 2022[1]).

The structure of the tandem cell is a SHJ solar cell as the bottom cell and a perovskite solar cell on top of it (Figure 1). The perovskite layer and TCO film were formed by a process suitable for mass production and the electrodes were formed by screen-printing and cured at 150°C - 20 min. It was confirmed that the crystalline quality of TCO differs depending on the oxygen/hydrogen gas flow ratio during TCO formation, resulting in changes in the contact resistance with the Ag paste (Figure 2). Tandem cell fabrication was then performed using TCO films suitable for Ag paste.

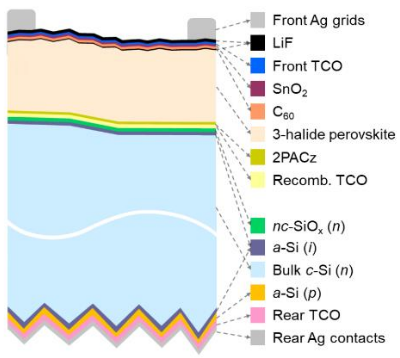

Figure 1: Perovskite tandem solar cell structure [1].
(Front Ag is our low-temperature curing Ag paste)

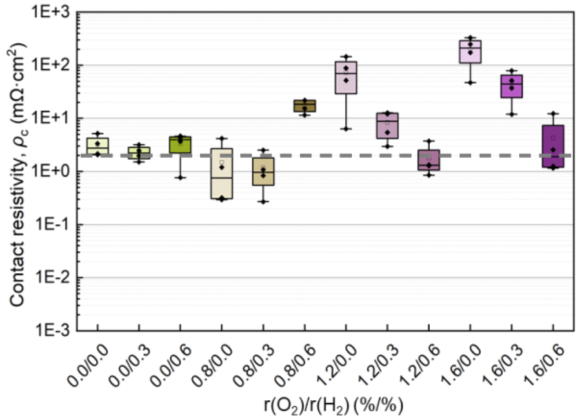

Figure 2: TCO formation conditions and contact resistance with Ag electrode [1].

The conversion efficiency of 24.1% was confirmed for a prototype perovskite tandem solar cell fabricated using a manufacturing process suitable for mass production (Figure 3). Current matching between the perovskite and silicon layers was also confirmed (Figure 4), indicating the possibility of tandem solar cells with a conversion efficiency of over 26% in a mass production process through further optimization.

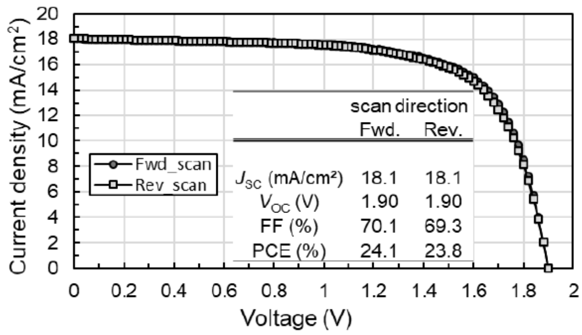

Figure 3. J-V characteristics of tandem cells [1].

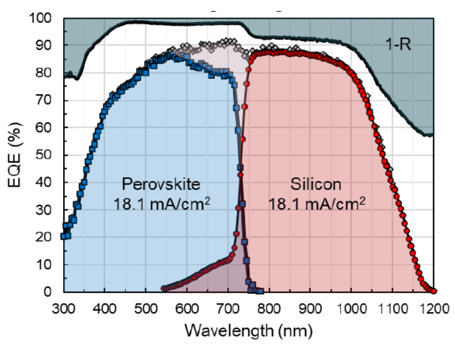

Figure 4: EQE and reflectance measurements of tandem cells [1].

【4. Conclusion】

We have developed a low-temperature curing Ag paste for perovskite solar cells. We used Ag-coated Cu as metal-coated conductive filler (Toyaltech Filler® TFM series) to further lower the cost for sustainable PV era. We will continue to develop electrode materials suitable for industrial processes toward the practical use of perovskite solar cells.

Reference

[1] Zih-Wei Peng, et al.,“Upscaling of Perovskite / c-Si Tandem Solar Cells by Using Industrial Adaptable Processes”, presented at SiliconPV 2022.