# METALLIZATION CONTRIBUTIONS, REQUIREMENTS, AND EFFECTS RELATED TO PATTERN TRANSFER PRINTING (PTP™) ON CRYSTALLINE SILICON SOLAR CELLS

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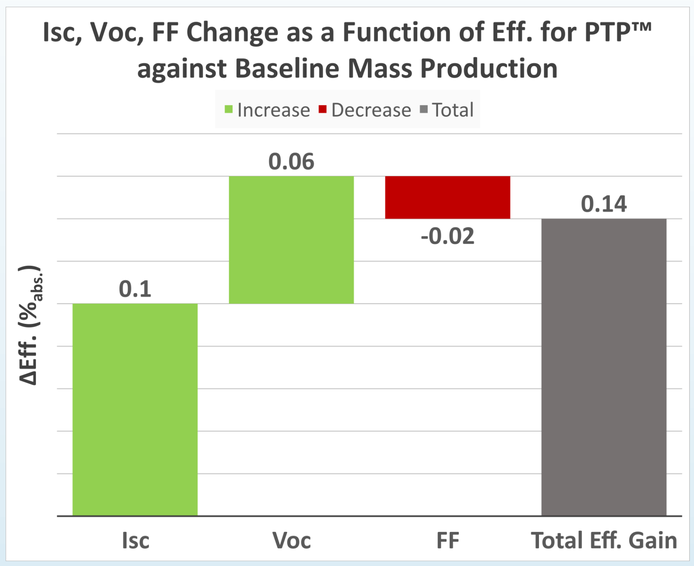
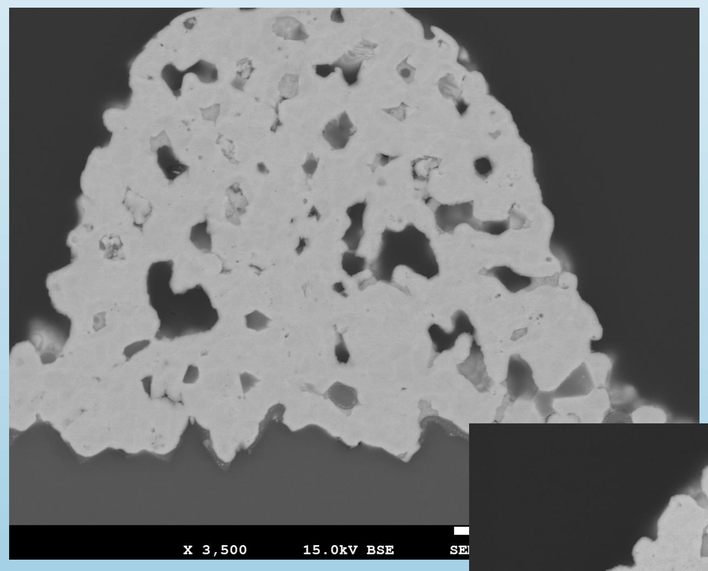
**Pattern Transfer Printing (PTP™) is a printing method developed and commercialized by Utilight. It is an alternative printing process that shows very promising results via consistent ultra fine lines down to 20um after firing and is mass production proven. However, using any standard, commercially available silver paste gives poor results due to substantial increases in series resistance and printability issues. The general process and results of silver paste developed by Hereaus for PTP™ are shown here.**

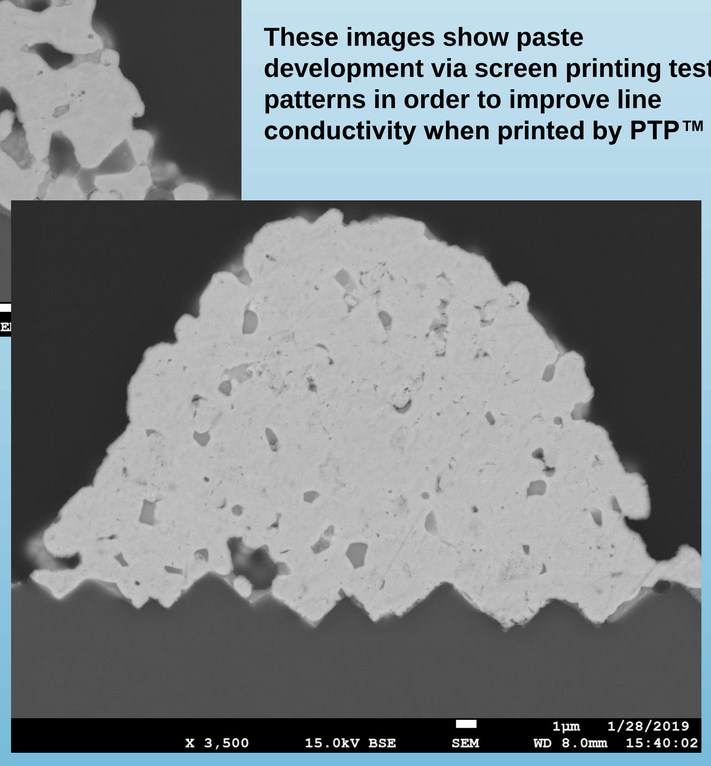
| | Fired Line Width (µm) | Fired Line Height (µm) | Metallization coverage (%) (finger lines only) | Eff. (%) | Isc (mA) | Voc (mV) | FF ($\%_{abs}$) | $R_{series}$ (Ω) | $R_{shunt}$ (Ω) |
|---|---|---|---|---|---|---|---|---|---|
| **Screen Print Reference (mass production)** | 37 | 15 | 2.6 | - | - | - | - | - | - |
| **20µm PTP™ Tape – Heraeus R&D Paste** | 20 | 10 | 1.4 | +0.14 | +48 | +1.9 | -0.12 | +.03 | +440 |

**General properties via each printing method as well as electrical data from a recent pilot line test against a mass production reference paste on equivalent substrates. Paste development is still on-going for further optimization with PTP™.**



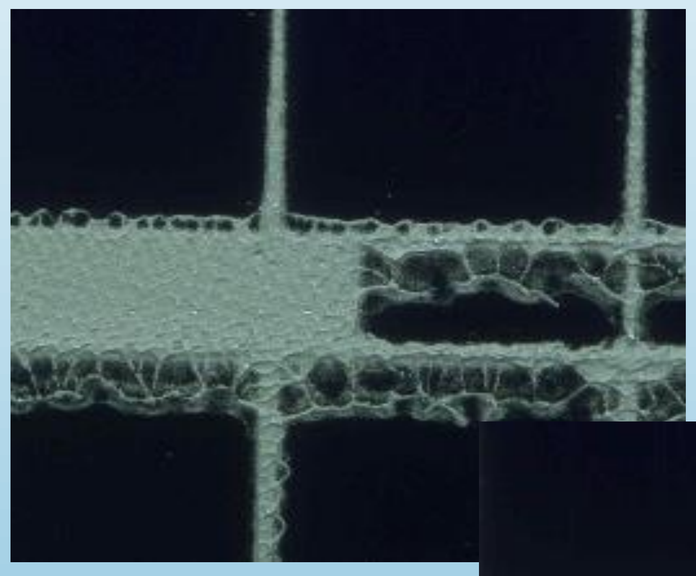

**Breakdown of each component's effect on overall efficiency from the data shown in the table**

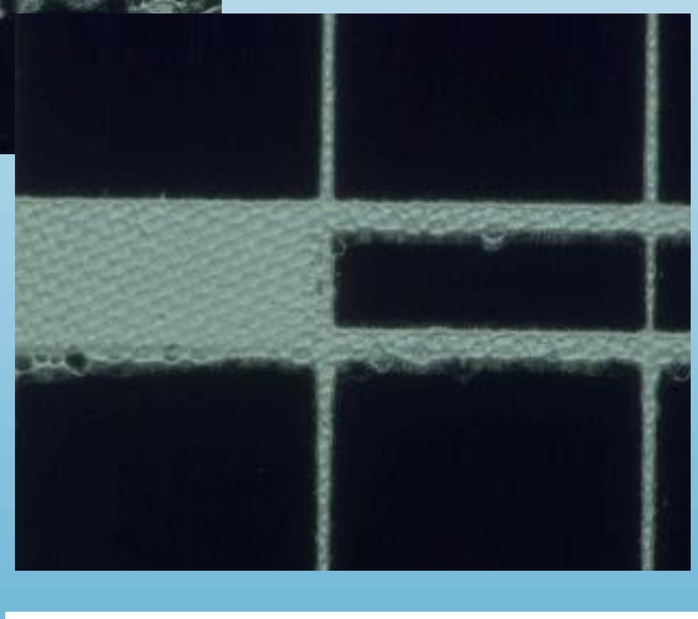



**In order to maintain sufficient line conductivity with the reduced finger line volume, the time/temperature sintering characteristics of standard pastes need to be altered significantly**

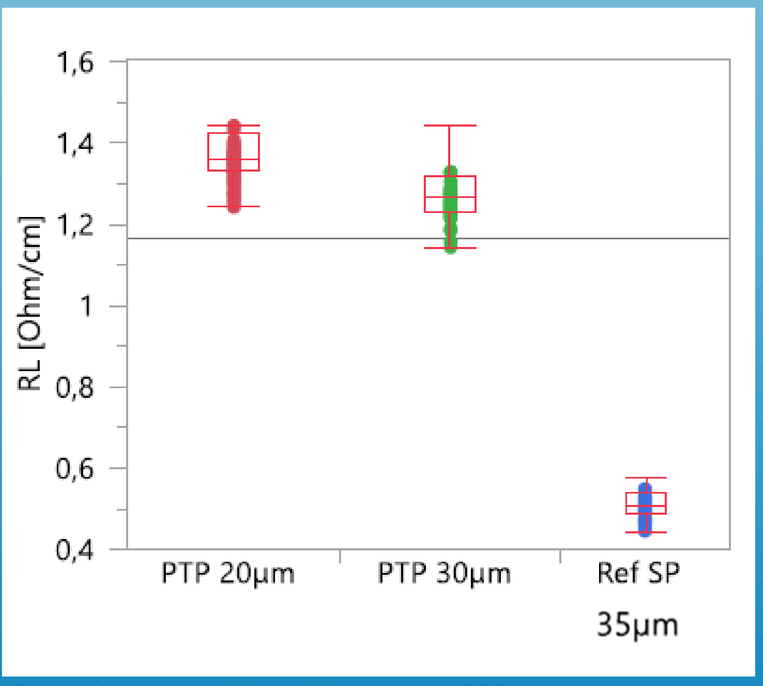
**These images show paste development via screen printing test patterns in order to improve line conductivity when printed by PTP™**



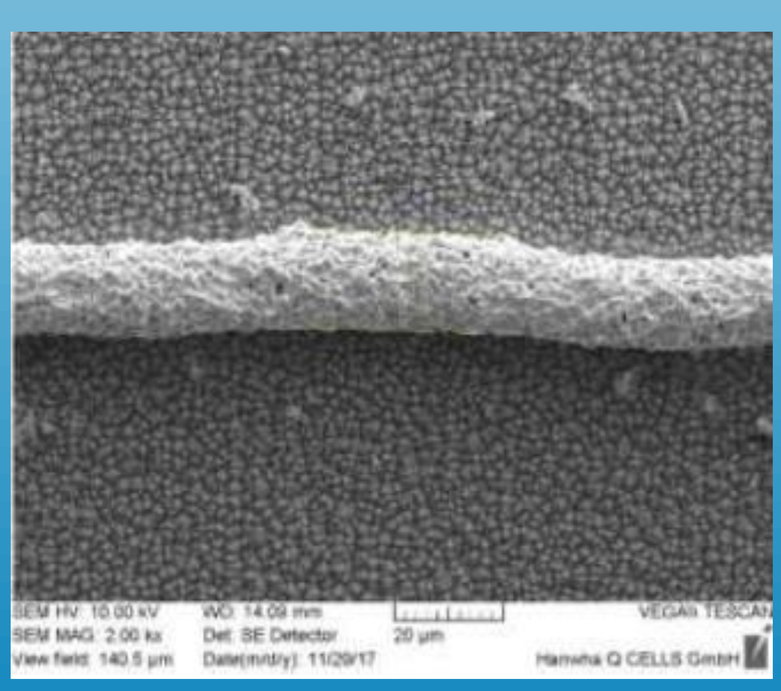


**The transition from state-of-the-art screen printing pastes to PTP™ is not a plug-and-play solution in regards to printability**

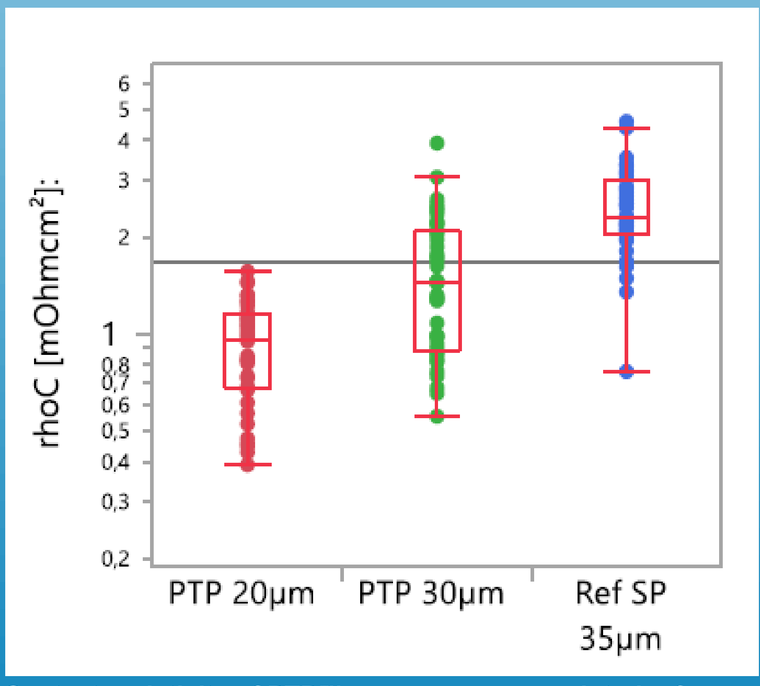
**These images show modifications to the organic on screen printed test patterns with busbars (to make the effect more clear) in order to mitigate paste splashing issues when transferred to PTP™**




**Line resistance at 20µm, 30µm tape widths versus a screen printed reference paste through a 35µm opening – the increase in line resistance is due to the decrease in paste volume**




**Finger line printed by PTP™ process using 20um tape - fired line widths are ≤20µm**




**Contact resistivity of PTP™ versus a screen printed reference – after significant paste and glass modifications, we are able to achieve even lower rhoC values than that of the reference**

**In this work, both the inorganic and organic paste components were either modified or entirely replaced in order to satisfy the demands of a new technology; Heraeus is fully committed to the development of novel paste platforms for all promising metallization and cell technologies.**

**This work was done in collaboration with Utilight, ISC Konstanz, and Hanwha Qcells.**