HIGH PERFORMANCE SILVER POLYMER PASTES FOR SHJ CELLS

S. Körner[a], A. Waltinger[b], U. Partsch[a], M. Eberstein[a]

[a]Fraunhofer IKTS, Winterbergstraße 28, 01277 Dresden
[b]Meyer Burger (Germany) AG, An der Baumschule 6-8, 09337 Hohenstein-Ernstthal

OUTLINE

- IKTS: Paste Research Service (PRS) and Paste Vendor for Niche Markets (PVN)
- SHJ: Low Temperature Pastes
- Silver polymer paste
  - Experimental
  - Results and discussion
- Summary

OUTLINE

- IKTS: Paste Research Service (PRS) and Paste Vendor for Niche Markets (PVN)
- SHJ: Low Temperature Pastes
- Silver polymer paste
  - Experimental
  - Results and discussion
- Summary

IKTS Group Thick Film Technology, Photovoltaics: Paste Research Service PRS

Paste Development, Manufacturing and Characterization

Functional Requirements

- Functional phase
- Glass
- Additives
- Organics (Binder, solvents…)

Composition

Paste Characterization

- Rheometry
- Shrinkage
- Thermal Analysis
- Particle Sizes

- Screen/ stencil
- Micro dispensing
- Gravure
- Aerosol

Deposition

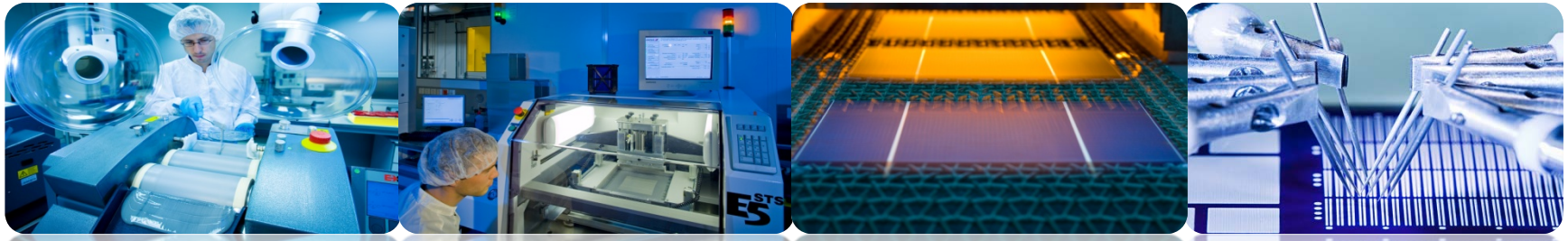
Firing

- Thick Film (min … h)
- Solar contact (sec)

„Ready for Production“

- Electrical
- Topography
- Micro structure, phase content

Film Characterization



Pastemeleons by Fraunhofer IKTS
customized functional films

Fraunhofer IKTS

Paste Vendor for Niche Markets PVN: example AlN substrates

Paste	Metal	R/ mOhm/sq	Application
FK 1205	AgPd	< 25	R termination
FK 1220	AgPd	< 25	Acid stable
FK 1164	AgPd	< 25	Via paste
FK 1071	AgPt	< 6	Low resistance
FK 1282	AgPt	< 35	Dealloy stable

Paste	Cond. Phase	R/ Ohm/sq	TCR/ ppm/K
FK 9821m	AgPd	0.1	± 100
FK 9831m	AgPd	1	± 100
FK9611	RuO_2	10	± 100
FK9615	RuO_2	50	± 100
FK9621	RuO_2	100	± 100
FK9631	RuO_2	1000	± 100

Pastemeleons customized functional films

Fraunhofer IKTS

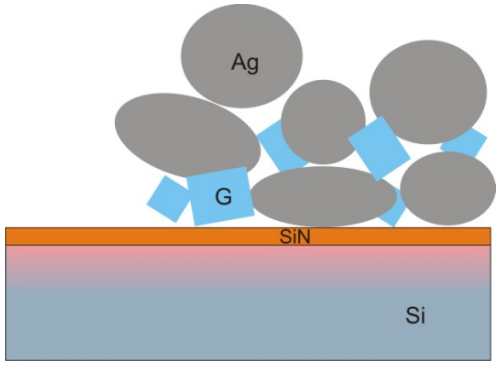
Future of crystalline silicon solar cell

- ITRPV roadmap 2015 predicts efficiencies for SHJ up to 25 % and market share of 10 % in the year 2025

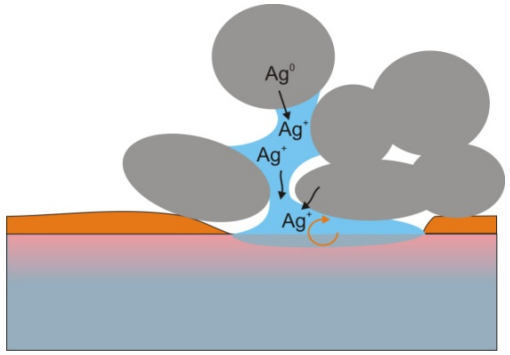
OUTLINE

- IKTS: Paste Research Service (PRS) and Paste Vendor for Niche Markets (PVN)
- SHJ: Low Temperature Pastes
- Silver polymer paste
  - Experimental
  - Results and discussion
- Summary

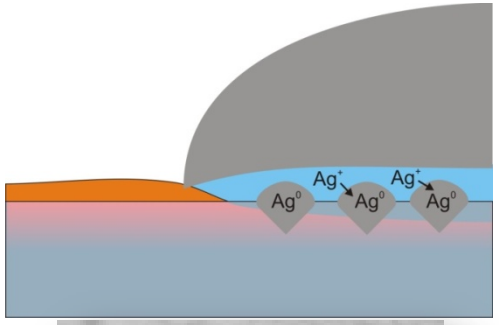
Conventional pastes for front side metallization

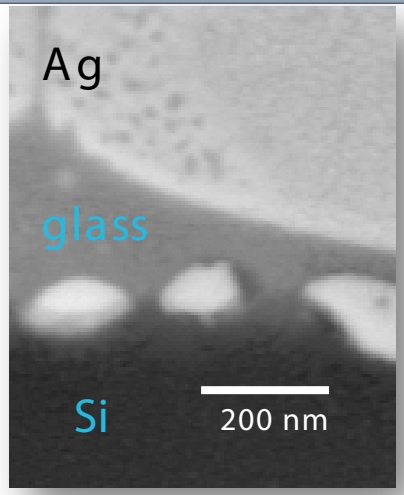


800 °C, some seconds



Cool down





e.g.

K.-K. Hong, S.-B. Cho, J.S. You, J.-W. Jeong, S.-M. Bea, J.-Y. Huh; Mechanism for the formation of Ag crystallites in the Ag thick-film contacts of crystalline Si solar cells, Solar Energy Materials & Solar Cells 93 (2009) 898–90

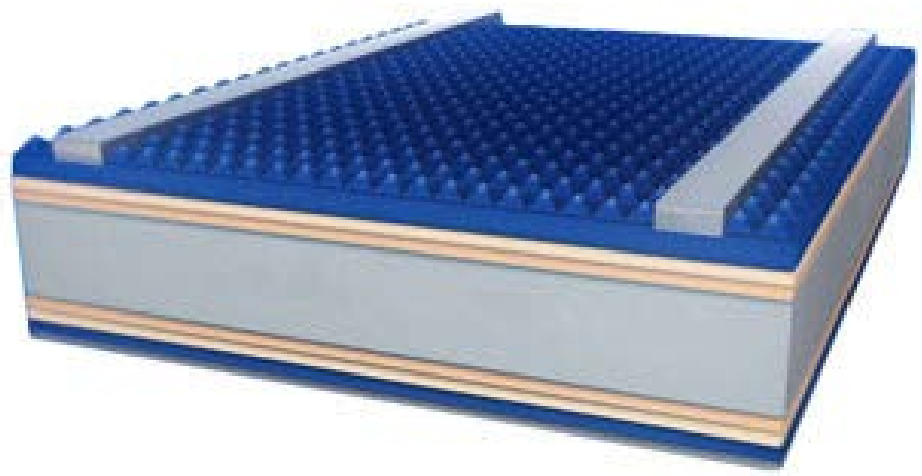
Li et al., J. Appl. Physics 110, 074304 (2011)

Kulushich, G., B. Bazer-Bachi, et al. (2012 April 03-05). Contact formation on 100 Ω/sq emitter by screen printed silver paste. SiliconPV, Leuven, Belgium.

Pastemeleons by Fraunhofer IKTS customized functional films

Fraunhofer IKTS

SHJ cell concept



silver

ITO

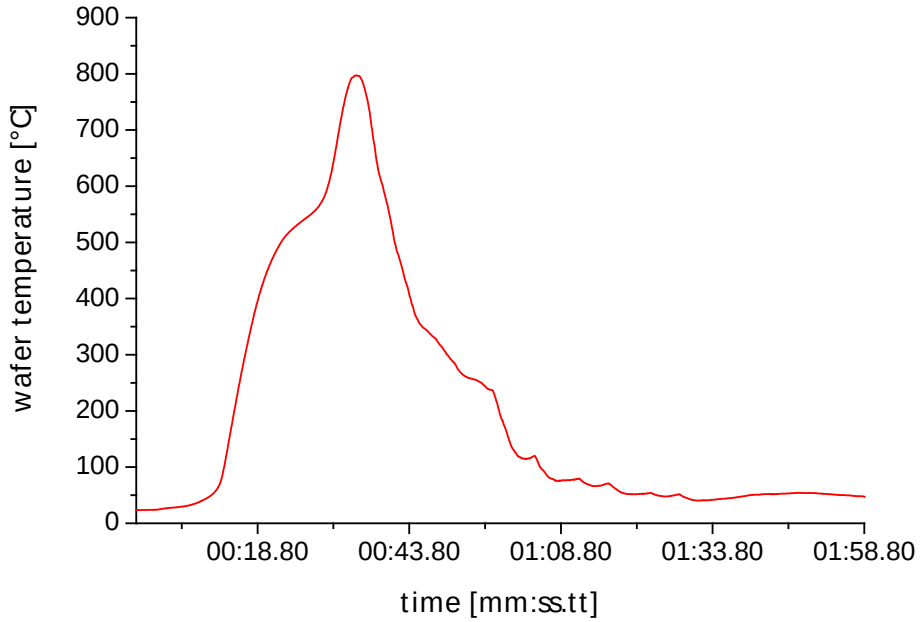
emitter: a-Si (p)

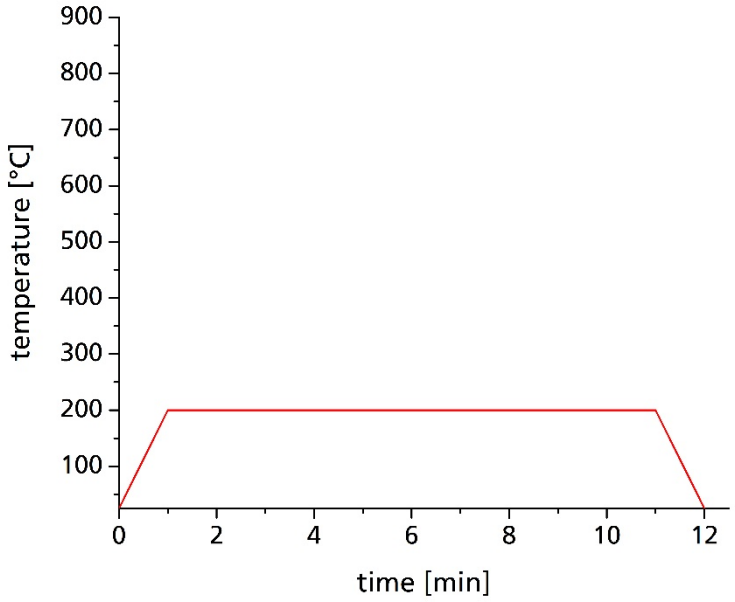
passivation: a-Si (i)

base: c-Si (n)

Maximum process temperature ≤ 200°C

Low temperature thick film pastes for solar cell metallization





Conductive phase Ag

glass ➔ crucial for adhesion, reactive contact formation, and interface/finger conductivty

Conductive phase Ag or LMPA

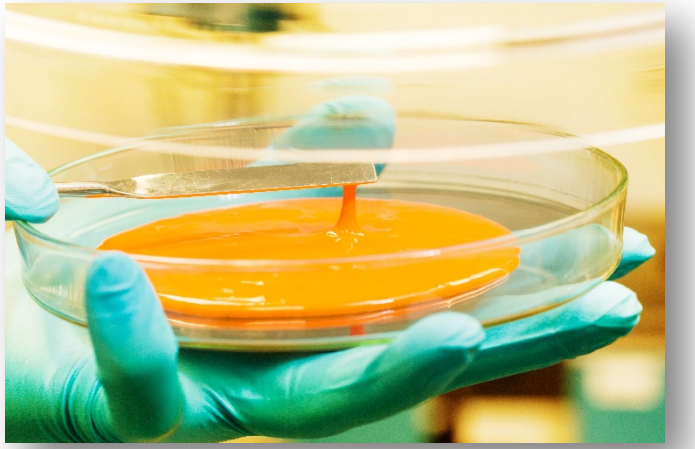
polymer → crucial for adhesion and interface/finger conductivity

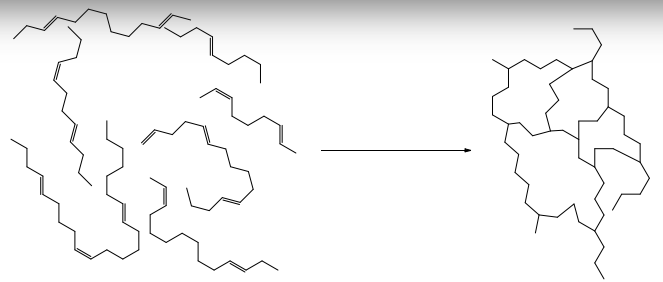
OUTLINE

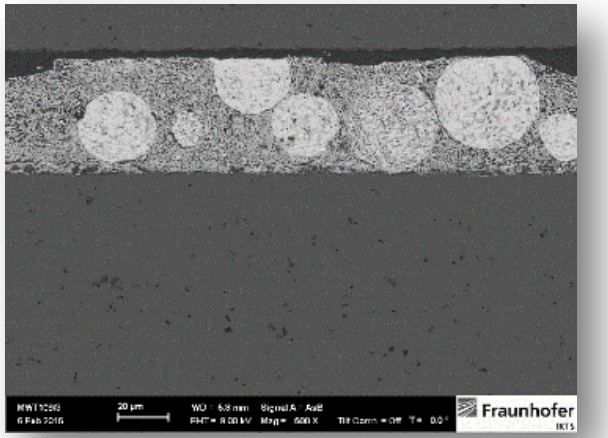
- IKTS: Paste Research Service (PRS) and Paste Vendor for Niche Markets (PVN)
- SHJ: Low Temperature Pastes
- Silver polymer paste
  - Experimental
  - Results and discussion
- Summary

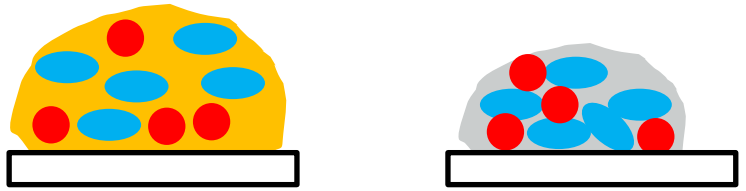
Processing of low temperature pastes

Thermal (IR or convection; air or nitrogen, 2400 wafers / h, manufactured 2015 by REHM, Germany)





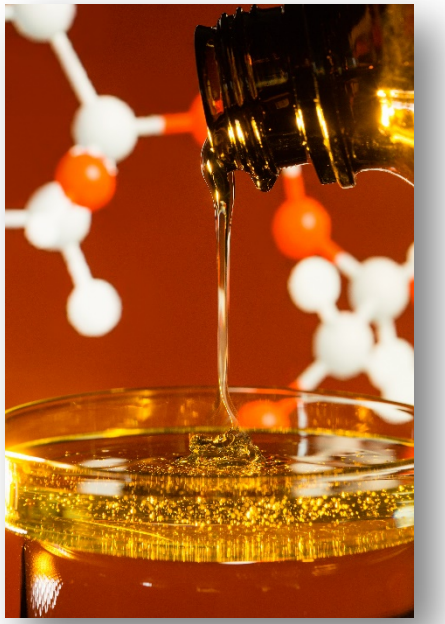


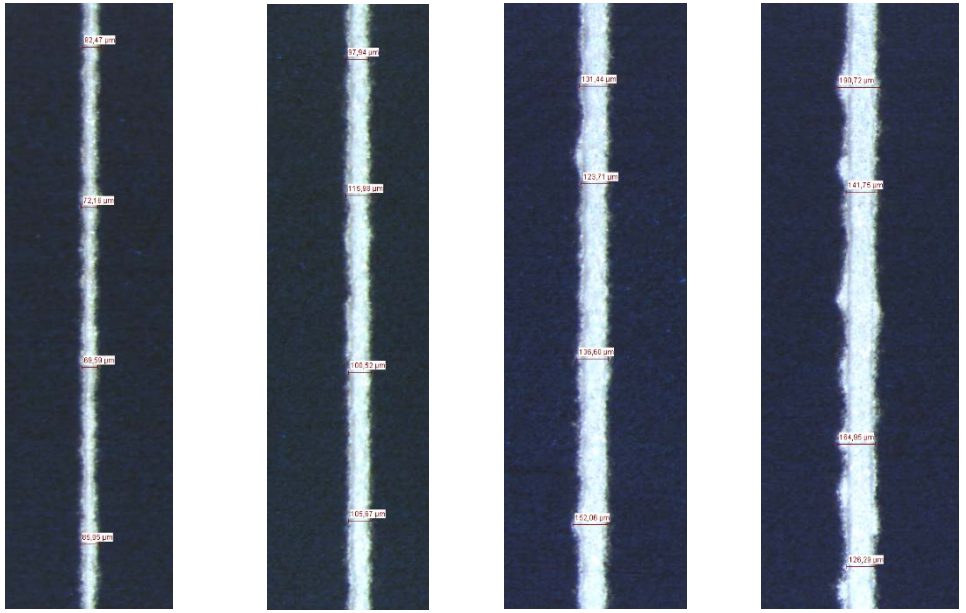


Pastemeleons customized functional films

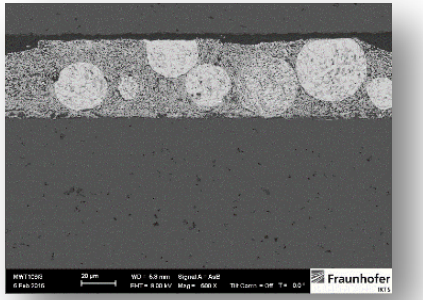
Fraunhofer IKTS

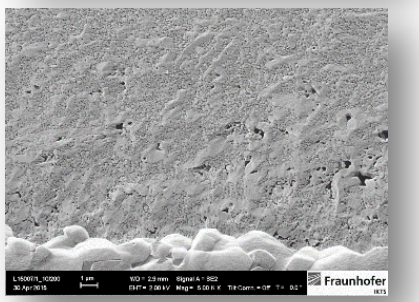
Low temperature thick film pastes for solar cell metallization





40 µm 60 µm 80µm 100 µm





- tuning of curable binder: polymer, solvent

$R_{sq} = 25\ m\Omega/sq$

- conductive phases: Ag mono/polymodal Low Melting Point Alloys (LMPA)

Pastemeleons customized functional films

Fraunhofer IKTS

Experimental

storage

IKTS paste
commercial paste

fridge 7 °C or RT
freezer -20 °C

- comparison with reference

screen printing

- 10 wafer per paste
- 74 fingers with 100 µm width

convection

infrared

- 5 wafer per kind of heat transfer
- 15 min at 200°C

characterization

- GridTouch system
- Measured at Meyer Burger (Germany) AG

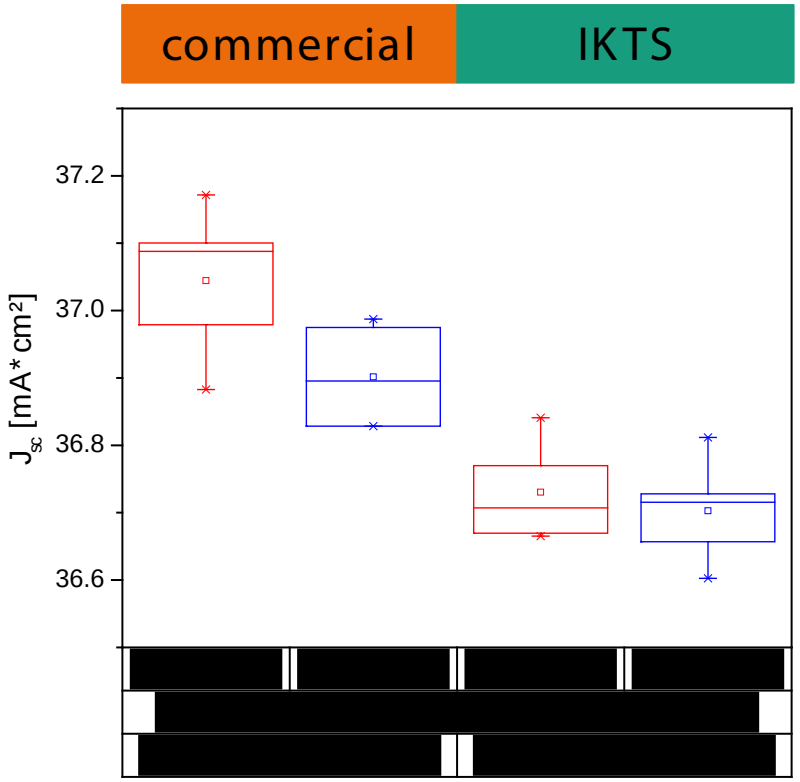
Pastemelons by Fraunhofer IKTS customized functional films

Fraunhofer IKTS

OUTLINE

- IKTS: Paste Research Service (PRS) and Paste Vendor for Niche Markets (PVN)
- SHJ: Low Temperature Pastes
- Silver polymer paste
  - Experimental
  - Results and discussion
- Summary

Electrical performance

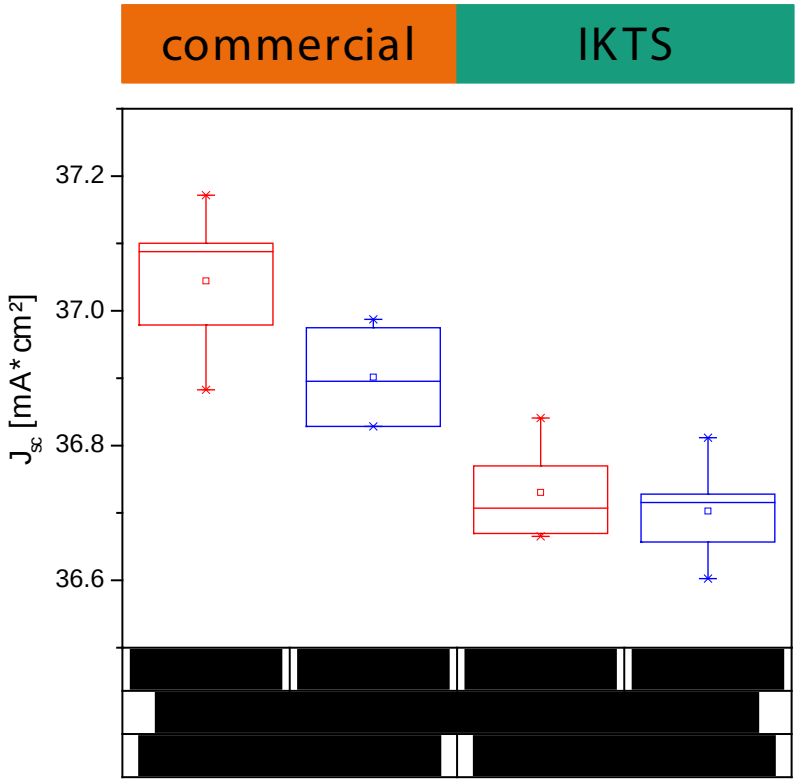


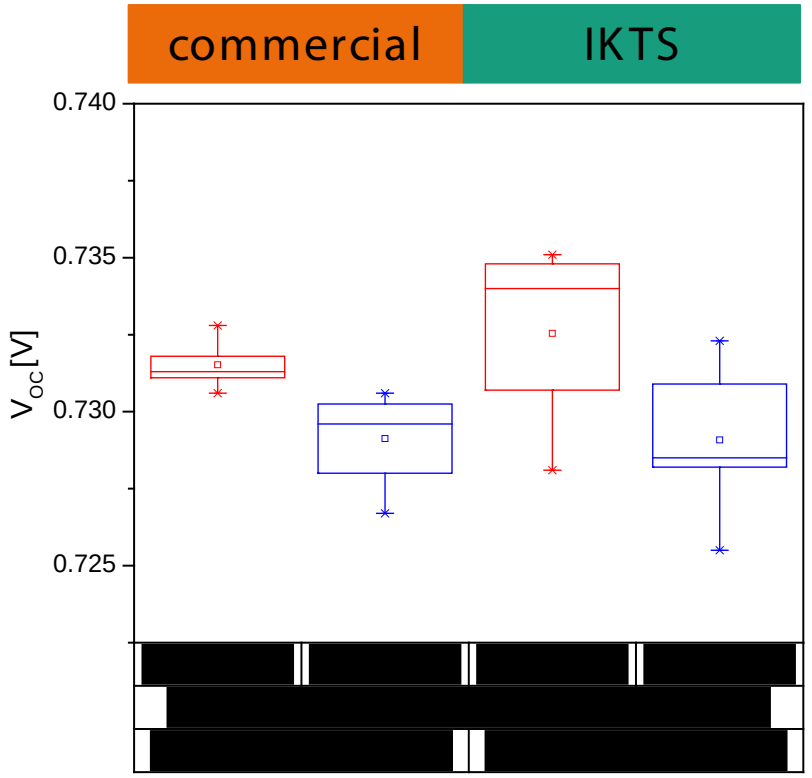
- IKTS pastes provide slightly lower J_{sc}
  - Optimizing paste rheology will increase J_{sc} due to optimized finger narrowing and decreasing shading

Pastemelons by Fraunhofer IKTS customized functional films

Fraunhofer IKTS

Electrical performance



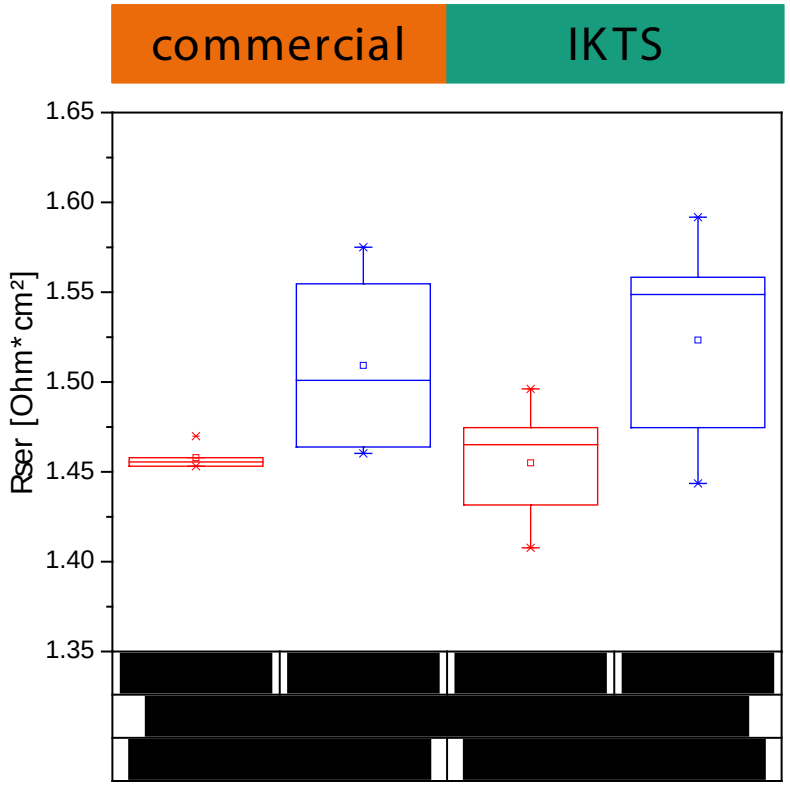


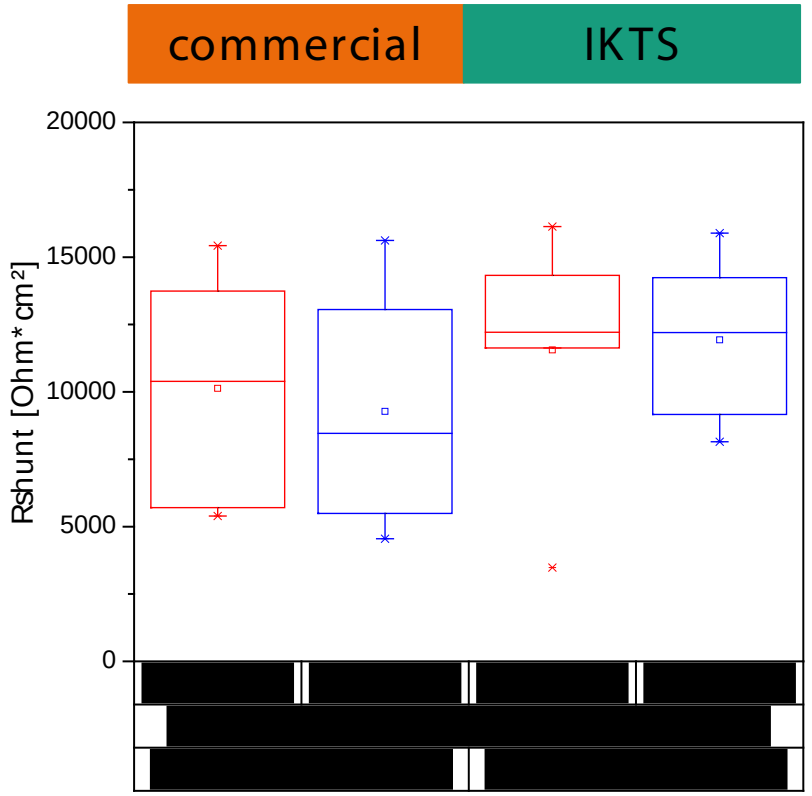
- IKTS pastes provide slightly lower J_{sc}
  - Optimizing paste rheology will increase J_{sc} due to optimized finger narrowing and decreasing shading

Pastemeleons by Fraunhofer IKTS customized functional films

Fraunhofer IKTS

Electrical performance



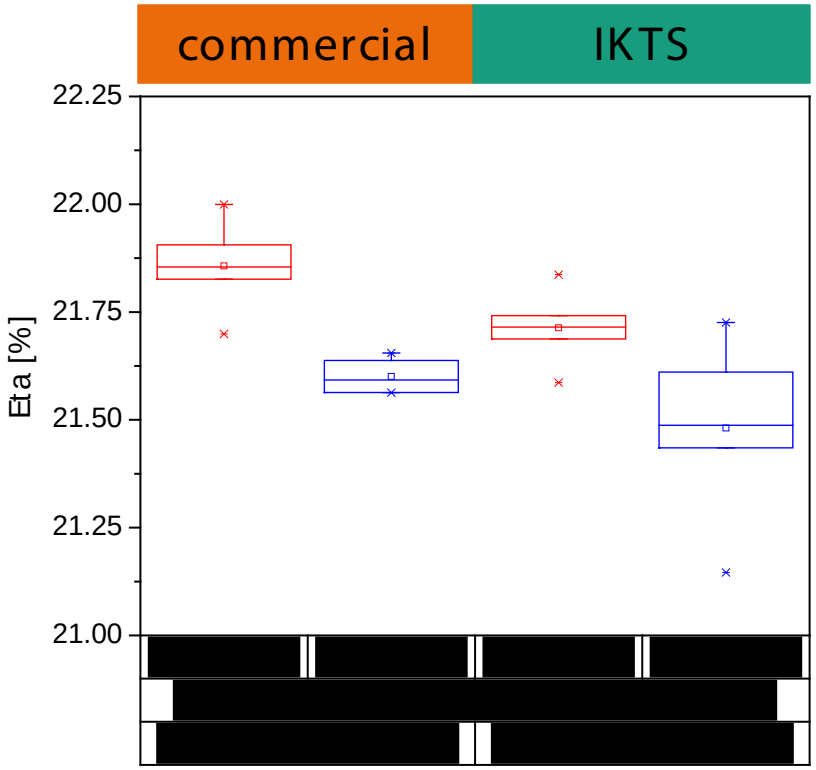


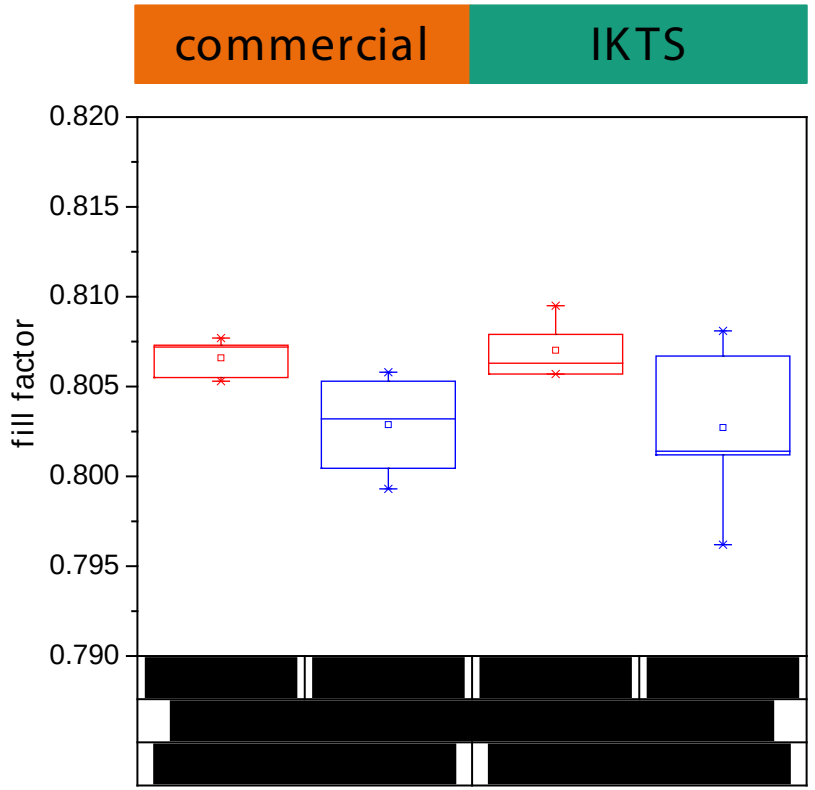
- Series resistances comparable for both pastes
  - Infrared curing provides lower series resistances as well as a lower standard deviation
    - Optimized heat transfer due to coupling of IR radiation

Pastemelons by Fraunhofer IKTS
customized functional films

Fraunhofer IKTS

Electrical performance



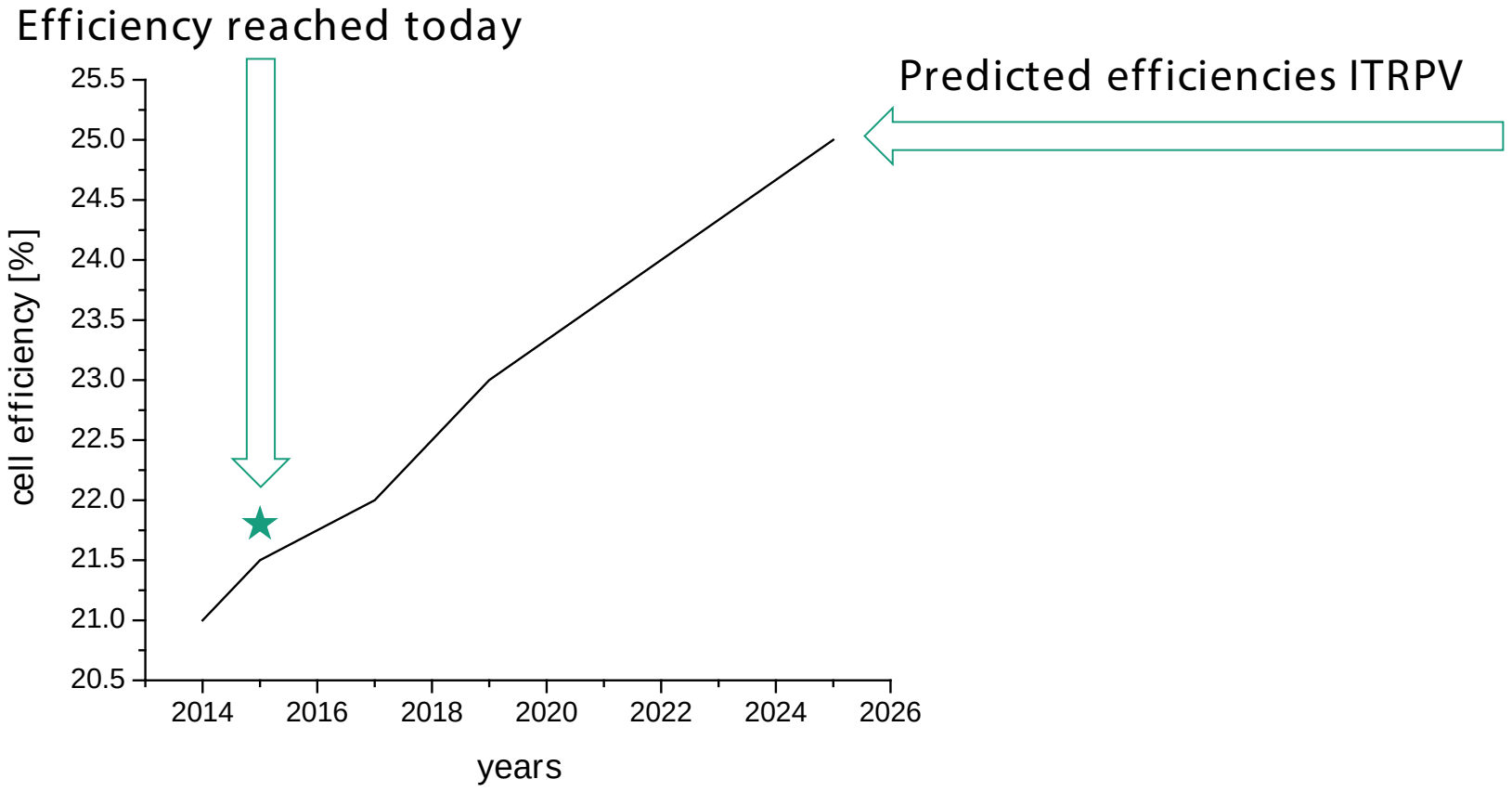


- Efficiency level higher than 21.5 %
  - CC commercial paste 22 % using IR curing → benefit against convection of 0.25 %
  - CC IKTS paste 21.8 % using IR curing → benefit against convection of 0.1 %
- Fill factor constant higher than 80 %

Pastemeleons by Fraunhofer IKTS
customized functional films

Fraunhofer IKTS

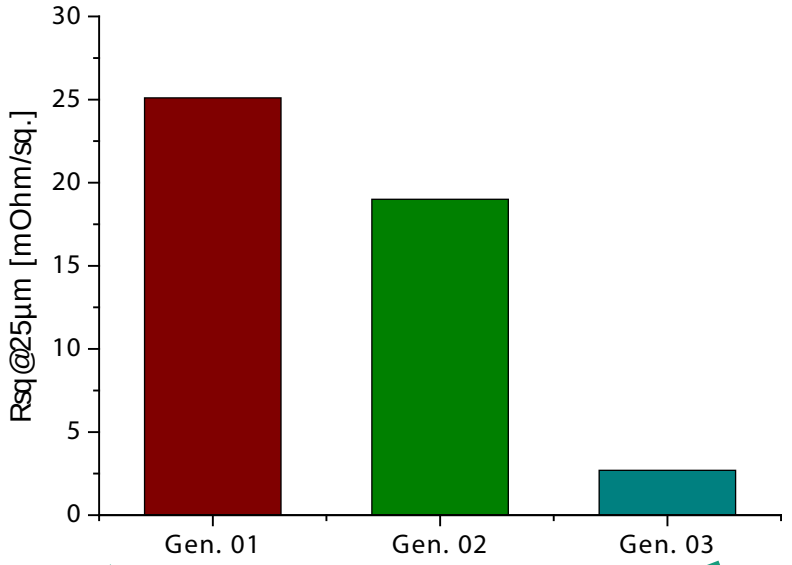
Presence and future of crystalline silicon solar cell

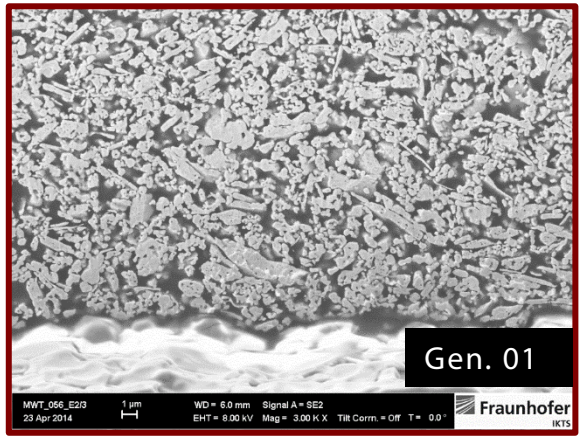


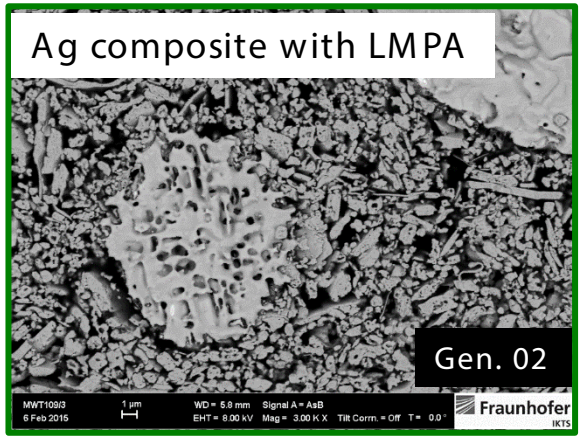
Pastemelons by Fraunhofer IKTS
customized functional films

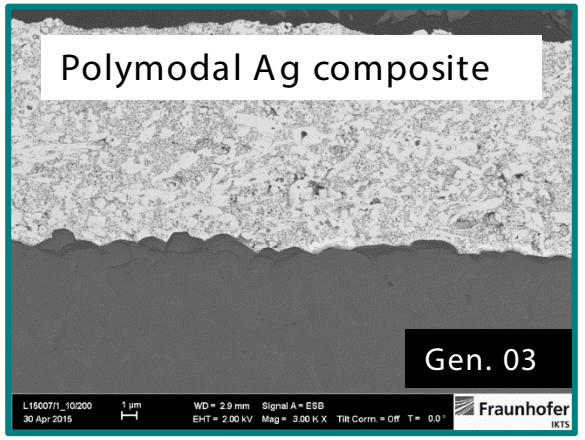
Fraunhofer IKTS

Performance forecast







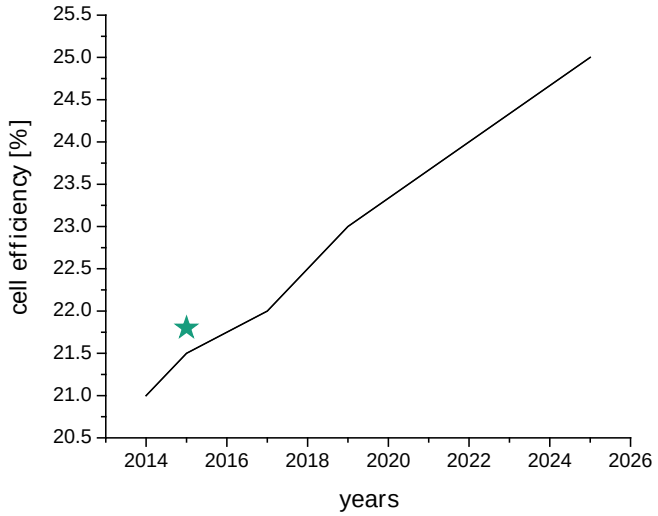


Pastemeleons customized functional films

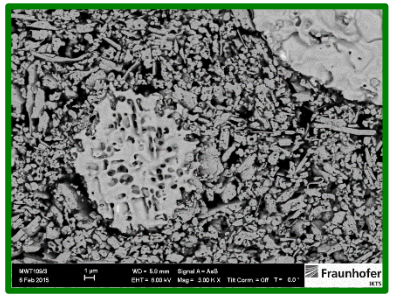
Fraunhofer IKTS

Summary

- 1st generation IKTS paste curable at 200°C for SHJ solar cells is introduced
  - IR curing leads to better electrical performance of the reference paste as well as the own development, obviously due to improved microstructure formation
  - Electrical performance on cell level is comparable to industrial standard
  - Handling, storage and therewith processing of IKTS paste is much more easier than the commercial reference



- Further improvement announced with next generations:
  - low melting point alloys with reduced silver amount
  - polymodal silver powders for minimal finger resistances



Pasteme leons
customized functional films

Fraunhofer IKTS

Thanks to the german Federal Ministry of Education and Research (MWT+ #03SF0420)...

...and you for your attention!

Further Information:

Markus Eberstein

+49-351-2553-7518

stefan.koerner@ikts.fraunhofer.de

Fraunhofer Institut Keramische

Technologien und Systeme

Winterbergstraße 28, 01277 Dresden

Pastemelons by Fraunhofer IKTS
customized functional films

Fraunhofer IKTS