Debate Market Place Wrap – Up

• During the innovative discussion forum "Debate Marketplace", in 10 small groups, and under guidance of a discussion leader, the relevance of 5 specific metallization topics were discussed in the form of a Statement and Counter Statement. A reporter summarized the output of the 30 minutes discussions for a later summary.

• The topics were relevant and sometimes provocative, but always pinpointing the message of the workshop: status, trends and new directions of Metallization for Crystalline Silicon Solar Cells; and referring to the discussion details of Screen printed Thick Film Metallization versus Plated Contacts.

• At the end of day 1 the summaries were presented by Stefan Glunz in the form of sharing an Aye or No, like in the British Parliament. Of course this led to maximum participation of the audience.

• Below are the summaries as shared by the group reporters.

Statement 1

New Ag pastes and multi-busbar designs have made Cu plating irrelevant

Counter - Statement

More than ever, Cu plating is the solution to replace costly and low performance Ag screenprinting

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Wrap – Up

- Cu, yes for sure! But: Reliability, Costs?

- New designs will potentially allow plating, but current cell structures makes it difficult because of constant Ag reduction

- Reduction of Ag weight foreseen with existing soldered cell until 60-70mg, further reduction possible with implications on module making ex. Multi busbar at 20-30mg)

Statement 1b

New Ag pastes and multi-busbar designs have made Cu plating irrelevant

Counter - Statement

More than ever, Cu plating is the solution to replace costly and low performance Ag screenprinting

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Wrap – Up

- Need for bigger differentiator, not for current available, industrial cells. Ag screenprinting is moving target and difficult to catch-up with. Worth it for advanced, high efficiency cells, lower surface concentration, heterojunction cells, IBC.

- Complexity: Ag is multi-functional but all these functions need different layers in case of using Cu. Too much different equipment is needed to start-up, expensive. Difficult to get market share and on-the-field learning for the moment due to crisis. On the other hand: time to think about new technologies = now, there is no need for fast installing of more capacity...

- No shortage of Ag expected, even for increased amount of installed power by PV energy; but investment metal, unstable price in time (fluctuating up but also down).

Statement 2

Busbars and solder pads will become irrelevant

Counter - Statement

No busbars or pads, no reliability

Wrap – Up

- There is a great opportunity for cells without busbars.
- Front BB replacement is more important.
- Front side: reliability is a concern, though Day4 solved it. Aesthetics are much better.

Statement 3

State-of-the-art metallization reduce shading so much that back-contact structures are no longer needed

Counter - Statement

Ultimate solar cell performance can only be reached by IBC structure

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Wrap – Up

- Statement 1: more critical aspects than metallisation alone (yield, up-time, cost per Wp etc)

- Statement 2: ultimate efficiency for IBC designs (optimisation of passivation and optical properties etc.)

- Statement 3: both parties (SunPower vs. the rest of the world) are conservative, no need to change?

Statement 3b

State-of-the-art metallization reduce shading so much that back-contact structures are no longer needed

Counter - Statement

Ultimate solar cell performance can only be reached by IBC structure

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Wrap – Up

• For aesthetical reasons IBC are favorable, although also multibusbar and fine lines together with black frames may be sufficient.

• Heterojunctions with metallization on both sides are already very close from Si limit, so there is no need for IBC.

• IBC and also Heterojunction-IBC may be the ultimate for highest efficiency, but they are not yet simple and cheap enough in fabrication.

• One outlayer thinks that thin film will win, so this discussion is obsolete in the long term.

Statement 4

Advanced printing will push performance further

Counter - Statement

Dual printing, double printing - double trouble

Wrap – Up

- Finer screen meshes & fine line stencils will give screen/stencil printing a few more years.

- Yield losses with extra processes?

- Double print can correct 1st print defects. (No double trouble!). Dual print can substantially reduce silver use, offsetting any extra trouble, though not everyone is happy to adopt.

Statement 4b

Advanced printing will push performance further

Counter - Statement

Dual printing, double printing - double trouble

Wrap – Up

- Statement 1 Dual printing could be cost effective (is already used in mass production), double printing not at the moment
- Statement 2 Stencil printing is a very interesting approach for high efficiencies, especially if dual printing is used
- Statement 3 Printing technology follows paste development not vice versa

Statement 5

Contacting emitters with P-concentrations of about $10^{19}cm^{-3}$ will be possible with silver screen printing

Counter - Statement

Silver screen printing has reached is limits.

Wrap – Up

- To $1x10^{20}$ cm^{-3} is already shown.
  Lower doping → experiments are missing
- Cell manufactures WANT to contact 10^{19} cm^{-3}
- Screen printing is far away from its limits

Statement 5b

Contacting emitters with P-concentrations of about $1x10^{19}cm^{-3}$ will be possible with silver screen printing

Counter - Statement

Silver screen printing has reached is limits.

Wrap – Up

- Statement 1 We should not go down to $1x10^{19}$ because J_0 increases too much by metallization (too many holes at contact)

- Statement 2 If we are silly enough to lower it down to $1x10^{19}$, we should understand the current-conduction mechanism first, i.e., we should apply knowledge-based, not witchcraft-based development.

- Statement 3 Paste chemistry is very important, changing the ARC may also help.