
5th Workshop on Metallization for Crystalline Silicon Solar Cells

The Future of Metallization – Forecast of the experts of the 5th Metallization Workshop

Gunnar Schubert^{a*}, Guy Beaucarne^b, Jaap Hoonstra^c

^aBaden Wuerttemberg Cooperative State University Ravensburg, Fallenbrunnen 2, 88045 Friedrichshafen, Germany

^bDow Corning, Parc Industriel, Zone C, Rue Jules Bordet, 7180 Seneffe, Belgium

^cECN, POBox 1, 1755 ZG Petten, The Netherlands

Abstract

For the fifth time the experts in metallization, participating at the 5th Metallization Workshop, were asked to forecast the development of metallization and interconnection technology for crystalline silicon solar cells in the next years. Like at the previous four workshops in Utrecht (2008), Constance (2010), Charleroi (2011) and Constance (2013) around 70% of the participants responded to the questionnaires. These experts represent institutes and universities (51%) and industry (49%) with material, equipment and cell manufactures. The results are presented in this paper and compared to the results of the previous years.

© 2015 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under the responsibility of Gunnar Schubert, Guy Beaucarne and Jaap Hoonstra

Keywords: Metallization; Solar Cells; Future of Metallization

1. Introduction

130 participants from 18 countries from all over the world took part at the 5th Workshop on Metallization of Crystalline Silicon Solar Cells, the majority from European countries. At the end of the workshop around 70% shared their view on future metallization techniques, materials and interconnection technology by answering a

* Corresponding author. Tel.: +49 7541 2077 231; fax: +49 7541 2077 198

E-mail address: schubert@dhbw-ravensburg.de

questionnaire. 51% of these experts represent universities and institutes (denoted as "institutes" in the following), 49% represent material, equipment and cell manufacturers. The number of representatives from cell manufactures decreased sharply compared to the previous workshops due to the solar cell industry situation in Europe, thus the industry group consists mainly of representatives of material and equipment manufacturers. In the following the results of the questionnaire are presented as a whole and differentiated between the two groups as well as comparisons with previous surveys at the last four workshops. If not otherwise mentioned, the results represent the answers of both groups.

2. Metallization techniques

2.1. Results survey 2014

The participants were asked to forecast the share of metallization techniques such as screen printing, plating, hybrid, ink-jet and new concepts in solar cell production in the next three, five and ten years (Fig. 1).

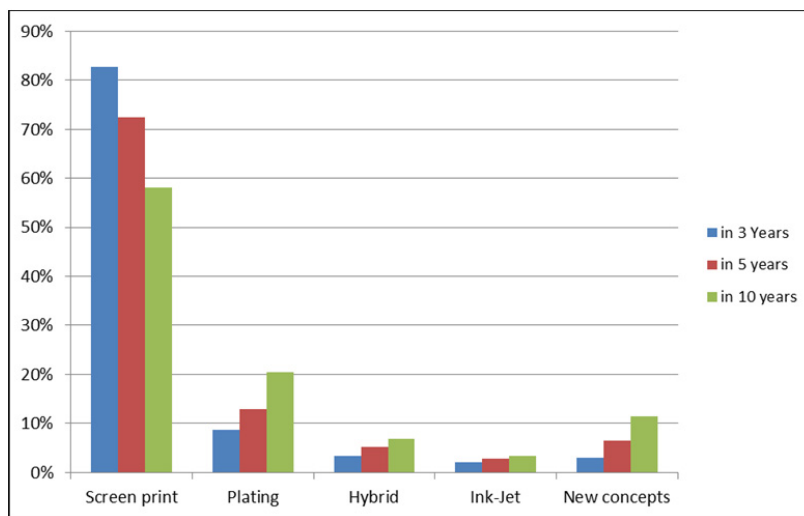


Fig. 1 Result 2014: what kind of metallization will be used in 3, 5, and 10 years from now

The share of screen printing technology will only slowly decrease in the next 3 and 5 years. Even in 10 years the experts see still screen printing dominating with a share of nearly 60%. The share of plating technology will increase to about 20% in 10 years from 2014. Hybrid and ink-jet technologies are not expected to gain a big share. The share of new concepts, some of them were presented in session VII of the workshop, will increase to around 12% in 10 years.

There are only little differences in the eyes of university or industry representatives (see Fig. 2). The researchers from institutes and universities expect a little sharper decrease of the share of screen printing technology (80% in 3 years to 54% in ten years vs. 85% in three years to 61% in ten years) and a little higher share of plating technology (23% in ten years vs. 18% in ten years) and new concepts (13% in ten years vs. 10% in ten years).

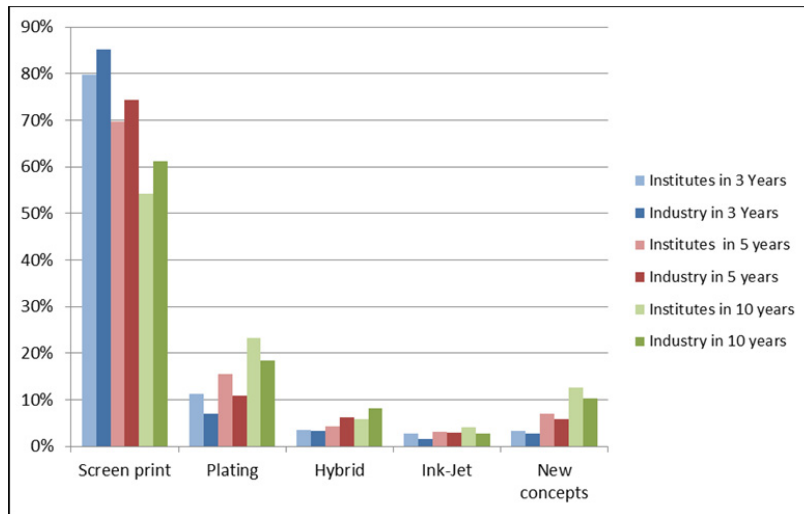
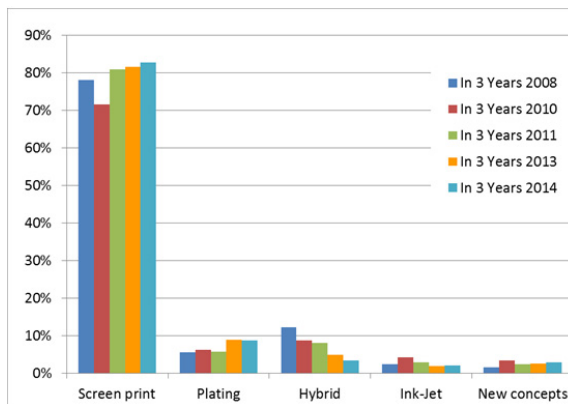


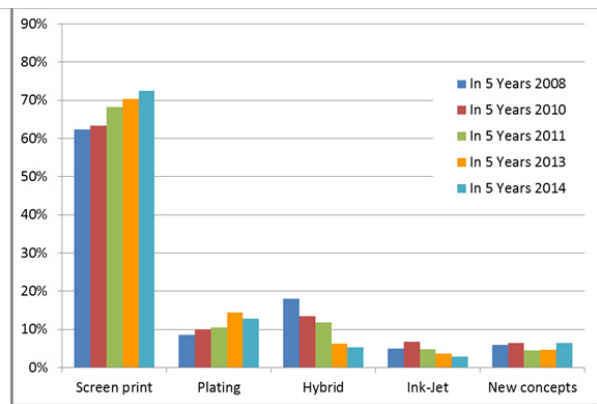
Fig. 2 Future metallization technology in the view of institute and industry representatives.

2.2. Comparison with previous surveys

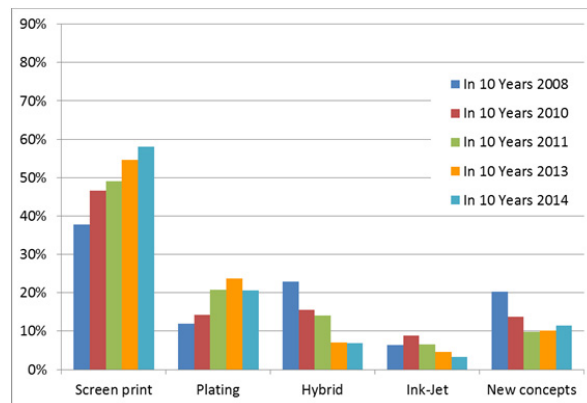
What is the share of metallization techniques in three, five, ten years in production? The results gained from the 5 surveys over the past six years show a clear trend: screen printing is predicted to play a more dominant role in future from year to year. Whereas in 2008 the experts saw only 38% share of screen printing technology in the production halls ten years from 2008 on, the results of this survey show a strong confidence in screen printing technology with 58% share in ten years from now. This can be attributed to the progress and improvements due to steady and successful development of this technology in the past years, again shown at this workshop. The confidence in new technologies decreased over the years, stabilizing by around 10% in the 10 year forecast. Hybrid technologies face a sharp decrease in expected share in the view of the metallization experts. Interestingly, the interest in full plating technology seems to decrease in the actual survey compared to the survey in 2013. However, the differences are small.



(a) 5 survey's comparison: in 3 years



(b) 5 survey's comparison: in 5 years



(c) 5 survey's comparison: in 10 years

Fig. 3 Comparison of the results of four surveys in 2008, 2010, 2011, 2013 and 2014

2.3. Comparison projections for 2017/2018 and 2019/2020 from different surveys

Comparing the results for the 10 years forecast of the survey in 2008, i.e. the share of metallization technologies in 2018 and the 3 year forecast in 2014, the share of metallization technologies projected in 2017, screen printing technology shows a sharp increase (Fig 4 (a)). The prediction of the share for the full plating technology is approximately the same whereas the interest in hybrid technology is, in the view of the experts in 2014, low compared to the expected interest from 2008. The same trend is obvious comparing the results of the 10 years forecast of the survey in 2010 and the 5 year forecast in 2014, i.e. comparing the share of metallization technology in 2019/2020 (Fig. 4 (b)).

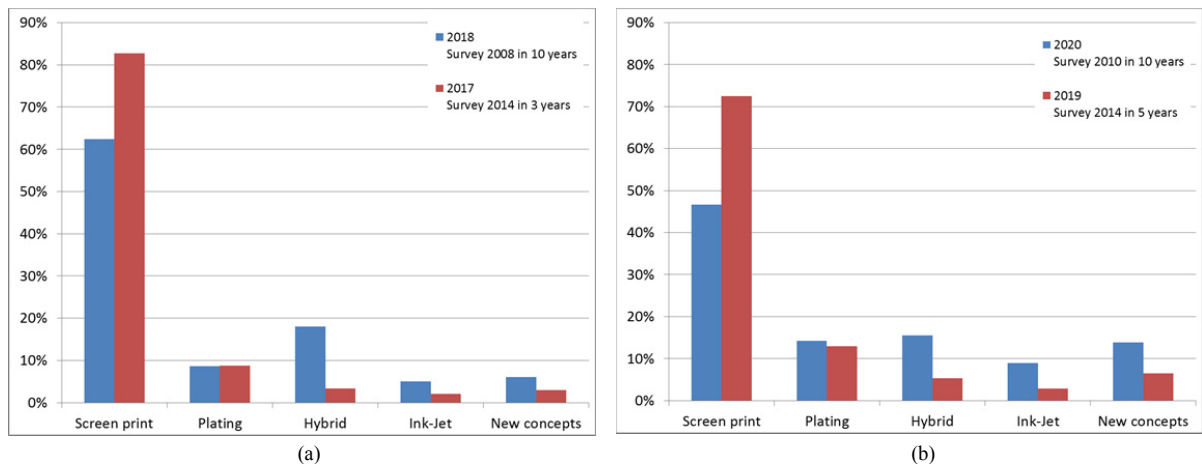


Fig. 4 (a) Comparison results for 2017/2018 of the survey in 2008 (10 years from 2008) and 2014 (3 years from 2014) (b) Comparison results for 2019/2020 of the survey in 2010 (10 years from 2010) and 2014 (5 years from 2014)

3. Metals used for front grid metallization

The participants of the metallization workshop were asked for the expected share in three, five and ten years of metals used for front grid metallization in solar cell production. The expected share of silver is decreasing over the years and the share of copper is expected to increase, in line with the expected share of metallization techniques

(Fig. 5). Other materials are currently not in the focus for front grid metallization. The share of copper in five and ten years is expected to be higher than the share of full plating which might be attributed to the expectation of copper based screen printing pastes or the expectation of new techniques that uses copper as contacting material.

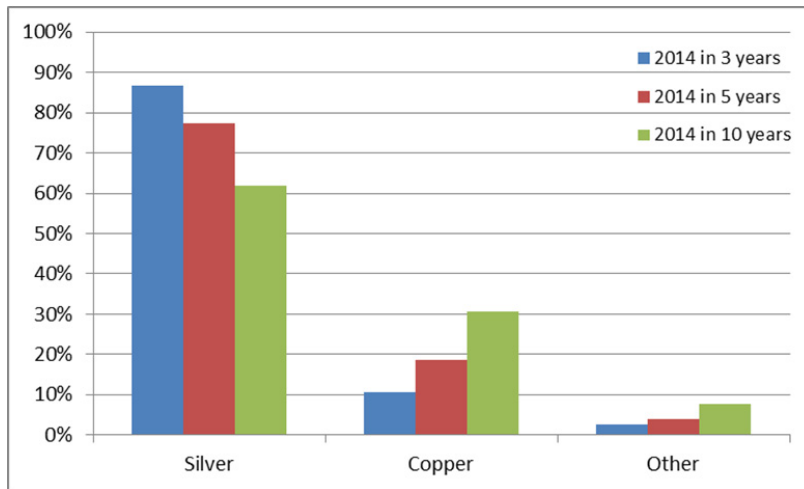


Fig. 5 Expected share of metals used for front grid metallization of silicon solar cells in production

Comparing the answers from academic and industry representatives the results are quite similar. Researcher from institutes and universities see copper to play a bigger role in the solar industry a little earlier than the industry experts (Fig. 6).

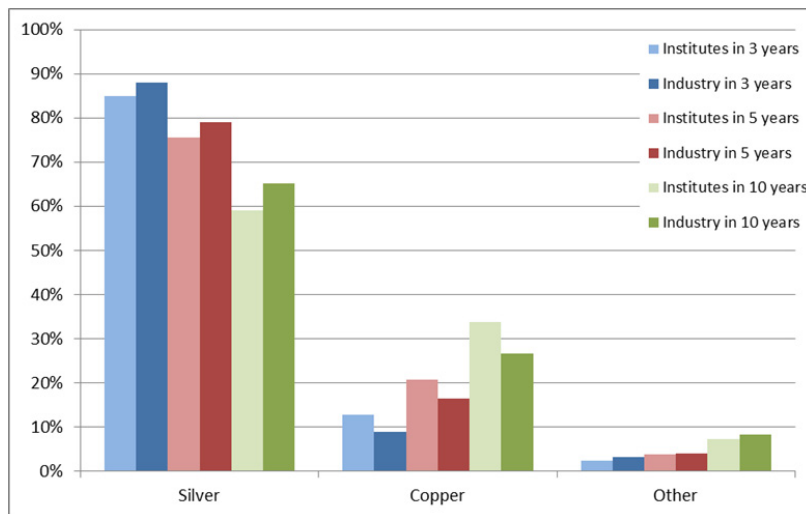


Fig. 6 Expected share of materials for front grid metallization in the view of institute and industry representatives.

4. Interconnection technology

The interconnection between solar cell and ribbon is more and more important for the performance of the solar module. Therefore, the participants were asked to share their view on the future of interconnection technology (Fig. 7).

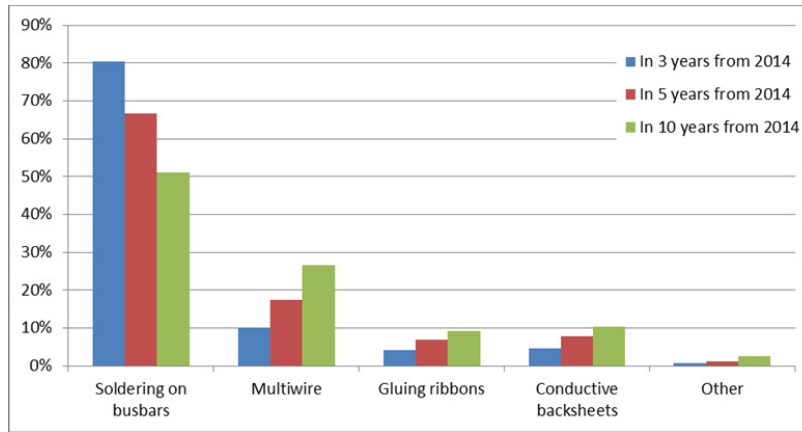


Fig. 7 Share interconnection technologies in three, five and ten years

The share of standard soldering on busbars is expected to decrease slowly showing confidence in this established technology. The importance of multiwire technologies is forecasted to increase significantly in comparison with other methods like gluing of ribbons and conductive backsheets.

Institute and industry representatives have, according to this survey, slightly different view on the interconnection methods used in future (Fig. 8). Researchers from institutes and universities expect the share of multiwire technology in the production to be around 5% to 10% higher in three, five and ten years comparing with the answers of industry representatives. The industry group sees a little higher share of gluing of ribbons in five and ten years. The share of conductive backsheets technology is rated approximately the same of both groups.

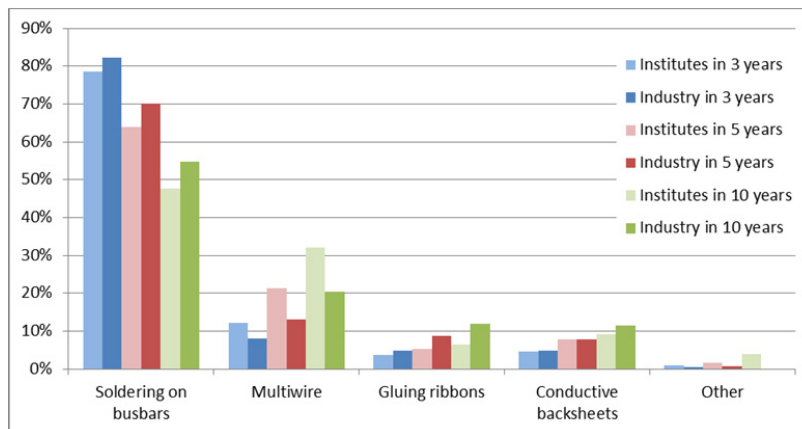


Fig. 8 Share of interconnection technology in the view of participants from institutes and industry

5. Summary

The results of the survey at the 5th Workshop on Metallization underline the trends of the previous workshops. The confidence in established technologies is still increasing in both groups, institute and industry representatives, presumably due to the continuous developments and progress in the last years. The share of screen printing technology is expected to be >60% even in ten years from now. Plating is in the eyes of the metallization experts the technology with the second largest share of about 20% in ten years. Copper is gaining market share as a contacting metal for front grids of solar cells, however, silver is seen to dominate in industry even in 10 years with a share of about 60%.

The future of interconnection technologies follows, according to the experts at this workshop, a similar trend. The well-established soldering on busbar technology is expected to dominate even in 10 years with a share of about 50%. The most promising technology to gain market share is, in the eyes of the participants, the multiwire technology with an expected market share of nearly 30% in ten years.