Welcome to the fourth newsletter of CABRISS project!

The second year of the project is coming to an end, with an important project milestone being achieved. For the first time, an Al-BSF solar cell with the efficiency of above 17% (best efficiency 18.1%) has been produced based on entirely recycled silicon material, thus achieving the project objective.

Another important result is the upscaling of a new approach for high-value PV waste recycling, which allows to retrieve glass panels undamaged and to separate the iron-free, high-value, front glass from the back glass. In this way, resource and energy efficiency of the process are significantly improved while simultaneously increasing the added value. The pilot line currently processes thin-film modules, a similar approach for silicon based PV modules is under development.

The following CABRISS project achievements will be presented:

- First results on cells production from recycled silicon by CEA and SOLITEK
- Production of conductive pastes/inks using silver coated copper particles – INKRON & RHP
- LOSER’s new opening technology including recovery of undamaged glass – Upscaling of the process
- Standardization: representative of CABRISS project as full member of CENELEC’s CLC/TC 111X group

CABRISS - Implementation of a CircuAr economy Based on Recycled, reused and recovered Indium, Silicon and Silver materials for photovoltaic and other applications
H2020-WASTE-2014

Starting date: June 1st, 2015
Project duration: 36 months
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Impact

**PV cells and modules from recycled feedstock – CEA & SOLITEK**

Second life silicon solar cells based on 100% recycled silicon have been produced recently at CEA-INES in the frame of CABRISS Project. A best efficiency of 18.1 % has been reached with Al-BSF solar cells, based on Mono-like silicon material.

During this first period, several silicon ingots were produced using different conventional methods: Multi-Si standard casting methods (CEA, SINTEF), Standard Cz-Si method (SINTEF, CEA) and also on state-of-art mono-Si casting methods (Mono-like technology (CEA).

To show the potential for cell manufacturing from recycled materials, we have developed an overall material qualification protocol to evaluate the effect of the material quality on the different processing steps of the solar cell process chain and vice versa, the effect of each processing steps on the new material. In this study, we have shown that all solar cells performances are in good agreement with the protocol, especially with bulk lifetime for each solar cell step.

This study brings new insights into the compatibility between novel Re-Si feedstocks and the fabrications of standard solar cells. This is definitely an important step to improve the determination of future Re-Si feedstock specifications and to facilitate the development of efficient recycling processes.

Further activities are running in the frame of the CABRISS project to test recycled silicon at an industrial scale. The primary objective is to demonstrate the possibility to use the recycled silicon in standard industrial cells production lines. p-type mc-Si wafer material was processed to solar cells by Solitek by substitution of reference silicon with recycled silicon. The following process sequence was used and an average cell efficiency of 16.76% (17.53% best efficiency) was achieved.
Silver-coated copper particles

As a possibly lower-cost alternative to silver flakes, INKRON have tested silver-coated copper particles in their conductive paste matrix which had been produced by RHP using silver chloride that was recovered from PV waste by LOSER. The results were surprisingly good: although conductivity of the paste is about 50% less than that of the best full silver paste, this can most likely to a very large extent be contributed to the morphology of the particles and not to the fact that part of the silver has been replaced with copper. Several pastes made from unblended silver flakes have performed worse than these hybrid particles. Moreover, the compatibility of the Ag-Cu particles with the silver nanoparticles is excellent. It is therefore expected that optimisation of the particle shape will minimize the performance difference between the Ag and Ag-Cu particles.

A novel approach for high-value recycling of PV wastes

The CABRISS approach to a circular economy for PV targets several pathways for recovery and reuse of valuable materials that are rare or have a high embedded energy value. To achieve a true high-value recycling, it is crucial that the primary treatment of PV wastes is based on recovery processes which are economic on an industrial scale, while at the same time ensuring the highest possible quality of reusable materials. In this context, one material is often neglected in spite of having the highest mass percentage: glass. With a novel, industrialised approach to high-value preservation of glass and a wide range of other materials, the CABRISS partner LOSER Chemie GmbH is currently revolutionising the way PV wastes are recycled.

Today, treatment of end-of-life and broken modules is mostly based on removing the aluminium frame, junction box and copper cables, and shredding the glass with attached organic encapsulants and absorber layers. LOSER are the first recycling facility to recover undamaged glass panels, a process which significantly reduces the mass of complex materials that have to be further separated. This approach of retrieving reusable glass panels has a unique and twofold significance: it does improve resource and energy efficiency and it simultaneously increases the added value of the process. This added value in turn allows to carry out the cost-intensive recovery of all valuable materials from the remaining mix of organic materials, absorbers, conductive materials and interconnects. As a consequence, the overall efficiency of the circular economy – in terms of recovering valuable materials and recycling them into reusable products – is being immensely increased. The innovation therefore secures economic viability while aiming at the best possible environmental results.
While LOSER have worked in CABRISS on testing the opening technology for thin film modules on an industrial level (see pilot line above), a new solution is currently being developed and will be upscaled to achieve the same results for silicon PV modules. The recovered materials (indium, silver, silicon) are applied and tested in the CABRISS value chain for reuse in PV production. First results show that in some cases, recovered compounds (instead of fully refined materials) can be used in adapted production technologies which further increases the overall efficiency. In this way, the CABRISS approach strives to implement a circular economy in photovoltaics which is optimized to the last detail.

It remains to be seen, if such improved solutions will be taken up for the definition recycling targets by further revisions of the WEEE directive and the accompanying standardization efforts (supplementary standard for PV panel collection and treatment – European Committee for Electrotechnical Standardization CLC/TC 111X, 2015).
Standardization

To closely link the following CABRISS’ tasks

a) collection of end-of-life modules, cells and PV waste, and
b) dismantling, extraction and recovery,

with standardization on European level, Mr Werner Brenner (TU Wien) by March 18th, 2017 became member of CEN-CLC TC10 “Energy-related products - Material Efficiency Aspects for Ecodesign”.

This European Technical Committee aims at the development of European Standards in the field of Ecodesign requirements in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council (M/543).

Tasks of CEN-CLC TC10 are the following:

1. Definitions related to material efficiency
2. Guide on how to use generic material efficiency standards when writing energy related product specific standardization deliverables
3. General method for the assessment of the durability of energy related products
4. General method for the assessment of the ability to repair reuse and upgrade energy related products
5. General method for the assessment of the ability to remanufacture energy related products
6. General methods for assessing the recyclability and recoverability of energy related products
7. General method for assessing the proportion of re-used components in an energy related product
8. General method for assessing the proportion of recycled material content in energy related products
9. General method to declare the use of critical raw materials in energy related products.
10. Methods for providing information relating to material efficiency aspects of energy related products
11. Study on existing definitions and concepts for material efficiency (in the framework of circular economy)
12. Specific metrics, methods and parameters for assessment of material and resource efficiency aspects of ICT network infrastructure goods in the context of circular economy

Cooperation with CEN/CENELEC will be fostered on the following levels

• By participation in strategic platforms and events organized by CEN-CENELEC Management Centre in Brussels. CABRISS consortium members benefit from getting links to presentations and recognized experts. Transferring such information to partners helps to raise their awareness of the main opportunities of standardization.
• Information on ongoing standardization tasks and results forwarded to CABRISS partners
• Bundling of comments of CABRISS partners concerning drafts of CEN-CLC TC10’s standardization documents
• Collecting of proposals for additional standardization tasks of CEN-CLC TC10
NEWS – Last events

- **ECO-PV**: opportunities & effects for the PV industry “Technical and economical aspects of ECODESIGN”, May 29th, 2017 – Lyon Saint-Exupéry Airport, France

- **INTERSOLAR Europe**, Munich, Germany, May 30th – June 2nd 2017
  LOSER Chemie (A3.340), ECM Greentech (A2.120), SOLITEK (A1.220), IMEC (A1.576), CEA (A2.120), Fraunhofer-ISE (A1.540) have participated.

NEWS – Upcoming events

- **Upcoming: CABRISS Open Workshop**
  CABRISS consortium announces the first CABRISS Open Workshop, which will be held on 8th June 2017, Freiberg (Germany) during the Freiberg Silicon Days. CABRISS and Eco-Solar are organising this joint-workshop to present recent results on the topic of “Recycling, reuse and resource efficiency: New solutions for a PV circular economy”.
  The agenda of the workshop is presented at the end of this newsletter. More information about the event, registration and full program is available on: [http://tu-freiberg.de/en/bht/forschung/zentrale-veranstaltungen/bht-freiberger-universitaetsforum/program#fk7](http://tu-freiberg.de/en/bht/forschung/zentrale-veranstaltungen/bht-freiberger-universitaetsforum/program#fk7).

- **33rd European Photovoltaic Solar Energy Conference and Exhibition (EU PVSEC)**, Amsterdam, The Netherlands, 25-29 September 2017 ([https://www.photovoltaic-conference.com](https://www.photovoltaic-conference.com)). Several CABRISS partners will presented project’s results (technical results on recycling but also market analysis).
## Agenda of CABRISS Open Workshop

**Thursday, June 8, 2017**

**Recycling, reuse and resource efficiency: New solutions for a PV circular economy - Results from the projects CABRISS and ECOSOLAR (3 sessions)**

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<th>Time</th>
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<td>09:15</td>
<td>Session 1</td>
<td>10:45</td>
<td><strong>Lecture Hall WIN-1005</strong></td>
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<td>09:15</td>
<td>PV Life Cycle Analysis</td>
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<td>Latest development of QCells PV Technology</td>
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<td>K. Wambach (BIFA, Augsburg, Germany)</td>
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<td>J. Müller (Hanwha Q-Cells GmbH, Germany)</td>
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<td>09:45</td>
<td>Latest development of QCells PV Technology</td>
<td>11:00</td>
<td>How to separate the components of end-of-life PV modules for further use</td>
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<td>J. Müller (Hanwha Q-Cells GmbH, Germany)</td>
<td>11:10</td>
<td>W. Palitzsch (Loser Chemie, Zwickau, Germany)</td>
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<td>11:30</td>
<td>Low-cost Si substrates from Si scraps and Si kerf: EU project Cabriss</td>
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<td>11:35</td>
<td>A. Ulyashin (SINTEF, Oslo, Norway)</td>
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<td>11:40</td>
<td>A second life: PV cells and modules from recycled feedstock</td>
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<td>11:50</td>
<td>A. Derbouz Draoua (CEA – INES, Chambery, France)</td>
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<td>12:00</td>
<td>Multicrystalline silicon ingot crystallisation from reusable crucibles</td>
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<td>12:10</td>
<td>M. Bellmann (SINTEF, Trondheim, Norway)</td>
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