Revolutionising PV recycling for a sustainable future

PES joins Dr. Wolfram Palitzsch of LuxChemtech, Dr. Charly Lemoine from CEA, and Dr. Ana Maria Martinez of SINTEF for a discussion about the latest groundbreaking advancements in solar panel recycling, and how the PHOTORAMA project is pioneering robust technological solutions to recover and recycle valuable materials from end-of-life PV panels.

PES: We are looking forward to catching up with you all today. In our last interview we spoke about the PHOTORAMA project and its purpose. Would you mind just recapping on the story so far with this, for readers who may have missed it?

Ana Maria Martinez (SINTEF): PHOTORAMA project is developing robust technological solutions for recovering and recycling desirable materials and components from end-of-life PV panels and scrap. Our main target is to demonstrate the potential of those technologies, providing new business perspectives.

PHOTORAMA is setting up a full management-Pilot Line including all needed interrelated successive steps needed for the management of end-of-life panels, i.e., disassembly, smart separation of the panels, and innovative recovery of metals (Si, Ag, In, Ga). In total, more than six technologies that strongly depend on each other are being brought to TRL 6-7 and implemented in a pilot line. Besides, the technologies developed to produce high-quality, high-purity secondary raw materials are also very efficient for the treatment of manufacturing waste.

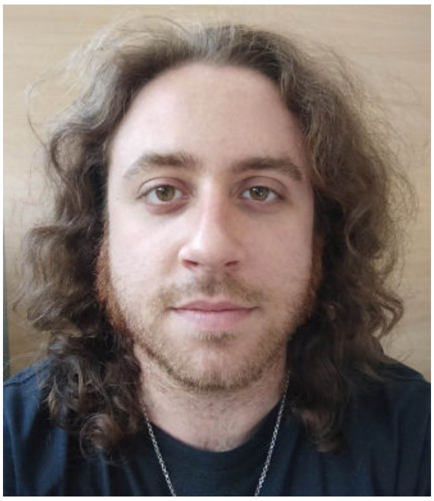
We can also mention that the project has been selected as one of the EU-Horizon's successful raw materials projects at the EU Raw Materials Week 2023, and the technology for the recovery of Si and Ag has been selected by the EU's Innovation radar as one of the cutting-edge innovations developed by Europe's leading researchers and innovators in 2023.

Leaching reactor at CEA

PES: Fast forward to today and the EU H2020 project is now on the home stretch,

Ana Maria Martinez

Wolfram Palitzsch



Charly Lemoine

with the potential to make a valuable contribution to the recycling of used PV modules. Can you tell us about your results?

Wolfram Palitzsch (LUX): Yes, of course, some machines for the mechanical disassembly of end-of-life PV panels have now been completed and are being prepared for transport as we conduct this interview. The Mondragon systems, which represent an important pre-treatment unit, deserve special mention. Besides, the pilots for mechanical and optical delamination of the PV panels are soon being installed at LuxChemTech's facilities in Tangermünde for their validation.

AMM: Furthermore, the innovative recovery process for Si, and Ag based on leaching and subsequent electrowinning, has been optimised at bench scale, and the integrated engineering design of the 2 pilot units finalised. The Pilot units are currently under construction. It is expected that the technology is ready to be validated at TRL7 right after the summer.

PES: Back to the mechanical disassembly process: removing the frames of various types of modules without damaging the glasses must be a huge challenge?

WP: The correct pre-treatment plays an enormous role in the following work steps. The innovative approach of our project is to achieve the highest possible purity of the respective materials used in a module after the recycling process. This happens through a kind of controlled dismantling. This means we are easily able to obtain highly clean glass from single glass modules or front and back glass from double glass modules. By the way, a shredding company cannot sort the different qualities of front and back glasses.

PES: This treatment method sounds very exciting. Can you explain it in more detail?

WP: There are three different working techniques that are combined depending on the module type. A special wire saw can turn a double glass module into a single glass module. Individual glass modules can each be treated with a water jet to clean the glass pane and expose the cells at the same time. And light helps us treat so-called thin-film modules, another step that makes the semiconductors susceptible to chemical attack.

PES: That sounds promising. How is it possible to get to the relatively valuable materials that are encapsulated in a kind of sandwich in relatively small quantities?

WP: The biggest challenge, in addition to the targeted positive environmental effects, is making the processes affordable. Because we have easy access to the relatively small amounts of valuable cell materials after the purely physical separation of the different module types, our processing technologies have been able to conjure up very good products. Of course, we can't do without chemicals here either. However, we have some great non-classic processes for recycling semiconductors and contacts.

PES: Silver, for example, is known to dissolve in nitric acid, what is your method and what is the advantage of this?

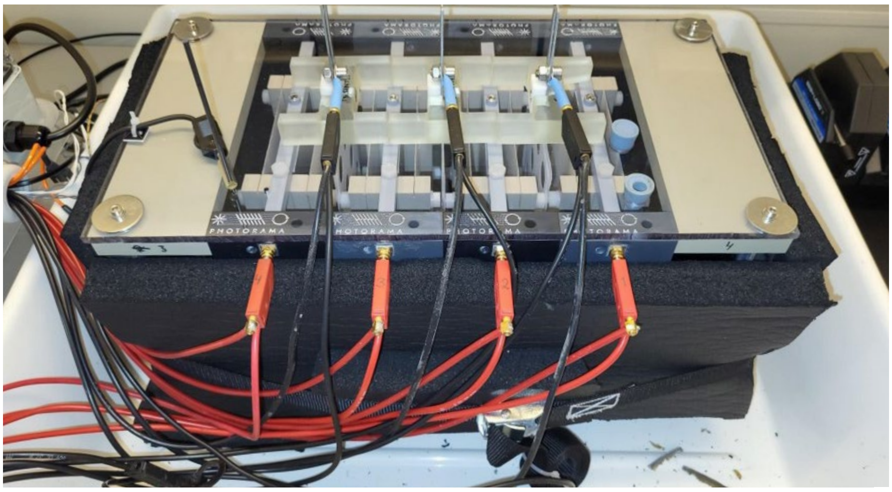
WP: Yes, exactly, that is the general status. Nitric acid, but imagine the large-scale technical application. The costs for the capture and detoxification of NOx alone. That would firstly not be environmentally friendly and secondly would be too expensive due to the gas scrubbing. We have developed a great redox system that was designed for the de-silvering of Si cell pieces.

PES: Is it possible to do all this without the use of chemicals?

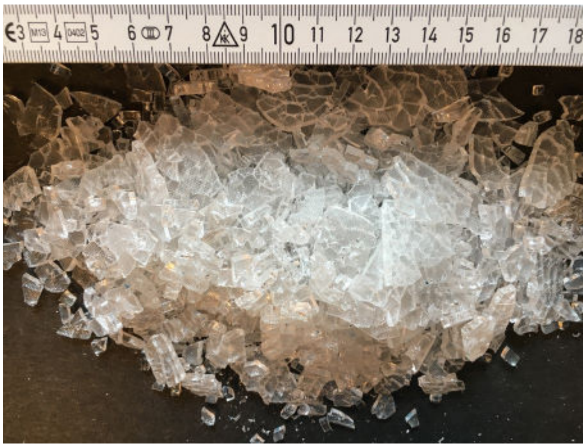
AMM: The use of chemicals cannot be circumvented to recover the critical and valuable metals from the metallic fractions extracted from end-of-life PV panels or manufacturing scrap. But one can use chemicals with no or low environmental impact, and innovative processes allowing their complete regeneration.

PES: Silver recovery processes already exist of course, so what technological breakthrough are you bringing to the table?

Charly Lemoine (CEA): We developed a new circular recycling concept based on ionometallurgy to recover silver and silicon.



Electrowinning cell for Ag production at SINTEF


Si PV front glass


Silver crystals produced at SINTEF

The general principle associates a deep eutectic solvent (DES) and a redox shuttle as oxidising agent in a leaching process that extract silver ions. In a second step, the leachate containing silver ions can be used as electrolyte in a specially developed electrowinning process to obtain silver in metallic form, while the redox shuttle is regenerated and can be reused in the leaching process.

AMM: The specially developed innovative electrowinning process is tuned to be adapted to the essentials of the leaching process, as well as to the nature of the input material, weather this is metallic fraction stemming from end-of-life PV panels, or manufacturing scrap.

PES: What are the beneficial impacts of your work on the environment compared to other recycling methods?

CL: The concept includes principles of a novel and more sustainable approach promoting the regeneration of reagents, close solvent loops, prevent waste, use benign chemicals and reduction of chemical diversity.

PES: Aluminum is also present as a back contact on the silicon cell in old modules isn't it? What is the process for this?

WP: That is absolutely right. The aluminum must of course be removed before the leaching step. We have an upstream process for this, in the case of HJT cells, we also have to remove the ITO, for example. Both ITO and Al are brought into solution and collected and both solutions can be further processed. If necessary, we can point out that we also dissolve the semiconductor layers of thin-film modules using biodegradable chemistry and process them further later.

PES: It seems that you have thought of everything. Presumably the quality of the recycled materials makes them suitable for reuse?

WP: The main amount of waste and secondary raw material produced is glass. A high-quality material, only the antimony content of the same determines its further use in Europe. It is important to know that high levels of antimony in solar glass come from China and that we still have to find the appropriate recycling channels here in Europe. In contrast, there are silver and indium in particular, the recovery and utilisation of which moves us very much.

PES: What can you do with them? Do you have any example applications?

WP: Thanks to our technology, silver can be used either as a metal (granules or powder) or as a compound (silver chloride). Our project partner RHP characterises these products and uses them as secondary raw materials for our own processes.

PES: In conclusion, considering the innovative advancements and environmental benefits your project offers, could you outline your vision for the widespread implementation of PHOTORAMA's recycling solutions, and how it might transform the sustainability landscape of the solar industry moving forward?

AMM: By combining several innovative technologies, the PHOTORAMA concept demonstrates an efficient PV waste management and opens the perspectives of PV recycling to move forward to upcycling. Besides, it also demonstrates the strong potential to develop a new market for secondary raw materials in Europe.

PHOTORAMA's commercial exploitation is designed to generate market-ready equipment as an isolated unit or combined/full-line, involving collective business ownership and operations from the consortium. All in all, the project will draw up a profitable and sustainable circular value chain that will lead to a carbon neutral PV industry in Europe.

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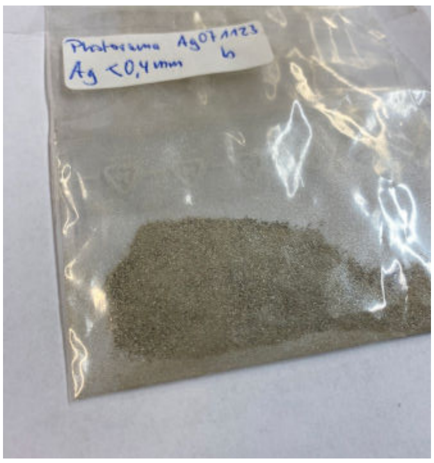
PHOTORAMA has been selected among the three finalists for the Innovation Awards by the European Commission (EUSEW 2024) and will be present at the E-waste world on June 27 in Frankfurt and EU PVSEC on 23-27 September in Vienna.


Silver powder produced from scrap


Silver grains produced from scrap