Student's Card 1 Recycling of silicon-based PV modules

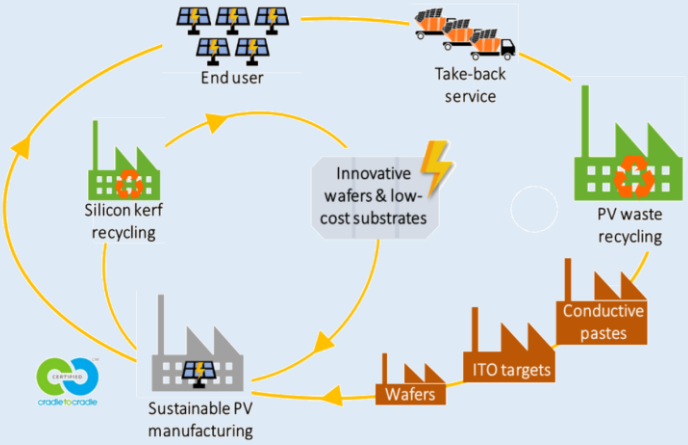
Module 1

Objective: Recycling of silicon-based PV modules

Introduction

In the last decades, the fast increase of the global energy demand and the progressive run-up in the world oil price, along with the growing global pollution and climate changes, pointed out the strong need of a cheap and sustainable clean energy supply. One of the most promising renewable energies is solar photovoltaics (PV): in 2018 not only roughly 2.8% of the worldwide electricity came from solar PV, but electricity generated from solar PV plants had become more economical than power from fossil fuel in many countries. One of the reasons behind the great development of solar PV is that CO_2 emission related to PV installations is more than 10 times lower with respect to electricity generated from fossil fuel.

In the next years, the number of solar panels reaching their end-of-life stage will increase steadily, with an estimated peak of cumulative PV waste around 900'000 tons/year by 2042. A proper recycling of PV wastes (which recently in Europe became WEEE) has been demonstrated to provide important advantages: not only it can ensure a long term sustainability of the supply chain but also a shortening of both the energy and the greenhouse-gas payback times related to the PV manufacture. Last but not least, the use of recycled materials in the PV production may improve economics by providing a less expensive feedstock supply.



At present, aluminium, glasses and silicon are mainly recycled through thermal, mechanical and chemical methods. Eliminating the encapsulant from the laminated structure is the most difficult process and the most important target of R&D recycling technology. In order to eliminate the encapsulant, thermal, mechanical and chemical methods can be used. The thermal approach is a combustion process at temperatures up to 450°C, which, however, will consume more energy compared to a mechanical process. Finally, despite metals are presently recovered by chemical methods, new technologies are being developed to get greater sustainability.

List of materials/tools

- Protection glasses and disposable gloves
- 1 domestic iron (with flat surface)
- 1 wooden cutting board or 1 ceramic tile to be used as heat resistant support

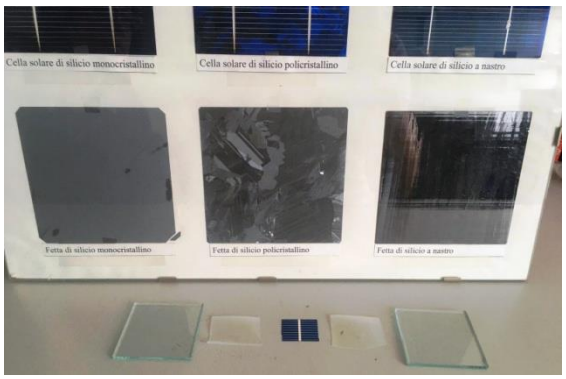
Student's Card 1 Recycling of silicon-based PV modules

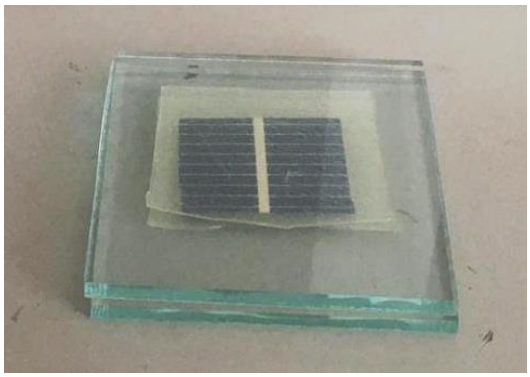
- 2 heat resistant gloves for temperatures up to 250°C (for example: https://www.amazon.co.uk/Inkbird-Resistant-Grilling-Sillicone-Microwave/dp/B08GR1B2V1/ref=sr_1_1_sspa?dchild=1&keywords=heat+resistance+gloves&qid=1621443808&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzUk83MExKS09LQk80JmVuY3J5cHRlZElkPUEwMTgxNzAzM0UzNURXNzBXVFpSMSZlbmNyeXB0ZWRBZElkPUEwMDE2MjMwMUFHUDRTUVpDSUdGQiZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU=)
- 2 glass slices, 2 EVA sheets and 1 silicon solar cells for each mini-module (these items of course are not available on the market, so please ask by email the RM ambassadors responsible for this toolkit and they'll send them to your school as soon as possible)

Procedure

- Wear protection glasses and disposable gloves.
- Turn on the domestic flatiron and set a temperature compatible with wool, silk or synthetic textile, which usually is around 150°C. **PLEASE, PAY ATTENTION TO THE HOTPLATE because 150°C is a severe temperature for both your skin and for any furniture**.

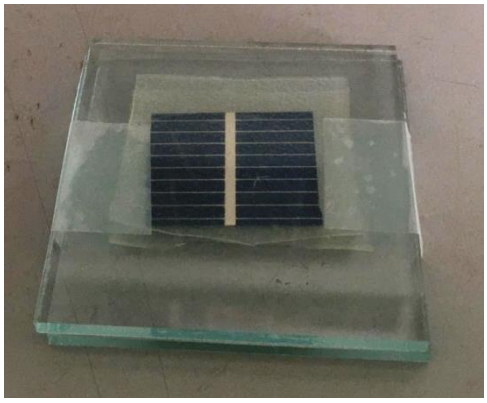
- Stack the mini-module as follows. From the bottom to the top: 1 glass slice, 1 EVA sheet, 1 silicon solar cell, 1 EVA sheet, 1 glass slice (see the pictures below).





Student's Card 1 Recycling of silicon-based PV modules

- Put a small strip of adhesive tape as reported in the pictures, in order to make the stack more compact:



WHOLE STACK

—— ADHESIVE TAPE

- Put the stack onto the heat resistant support, then carefully put the iron hotplate onto the mini-module stack (see the picture below). The iron must be kept in this way for about 20 minutes.

- Remove the iron, then wait at least 20 minutes to allow the mini-module to cool down to room temperature. **PLEASE, PAY ATTENTION TO THE HOT SURFACES!**
- Now the mini-module is assembled.

Student's Card 1 Recycling of silicon-based PV modules

- When you want to start disassembling the mini-module, set the maximum iron temperature, which usually is around 250°C.

- Put once again the mini-module onto the heat resistant support, then put carefully the iron hotplate on it (see the picture below). The iron must be kept in this way for about 20 minutes.

- After 20 minutes the iron can be removed. For few moments after iron removal, the EVA softening induced by the just applied heat allows for a manual separation of the mini-module constituting parts (see picture below). **<u>However, this step can be performed only wearing good heat resistant gloves (see "List of Materials" section), the mini-module temperature being around 250°C.</u>**

Student's Card 1 Recycling of silicon-based PV modules

Additional Safety Notes

In this experience, high temperatures of 150°C and 250°C are used. Therefore, PLEASE, PAY ATTENTION TO THE HOTPLATE and IRON because 150°C and 250°C are severe temperatures for both your skin and any furniture. When handling with high temperature, always use good heat-resistant gloves.

Questions/Quiz

Hereafter some questions are proposed to students to evaluate the comprehension of the topic.

1. **How can a photovoltaic panel produce electric current?**
2. **CO_2 emissions related to PV installations are higher or lower with respect to electricity generation from fossil fuel? How much?**
3. **Are PV panels WEEE? Are PV panels WEEE? What does it mean?**
4. **What are the advantages of a proper recycling of PV wastes?**
5. **Are high temperature steps involved in the industrial processes for assembling and disassembling of PV panels?**
6. **Is the economic potential value of the recycling panel high or low? What are the most precious elements in the recycling of silicon PV panel?**