POSTDOC SUBJECT

1 Context and challenges

Medium-voltage (MV) PV power plant technology is an integral part of the development of photovoltaic energy production. By using higher voltages, power plants can aim for lower installation and maintenance costs, thanks to the reduced cable lengths needed to interconnect module strings to power plant inverters, as shown in Figure 1. The aim is to design PV modules that can withstand voltages up to 9 kV.

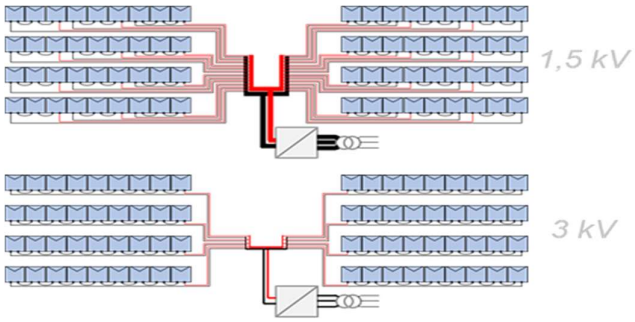

Figure 1 – Scheme of cabling in 1.5 kV and 3 kV PV plants.

2 State of the art

PID (Potential Induced Degradation) losses are one of the main causes of dramatic degradation, up to -50 % in the first year of operation [1]. There are many known PID degradation mechanisms, depending strongly on module composition: PID-shunting [2], PID-polarization [3], PID-corrosion [4]. These mechanisms are responsible for limiting module operating voltage levels. Technological solutions need to be found, based on a detailed understanding of the various physico-chemical mechanisms at work in the modules, as illustrated in the Figure 2.

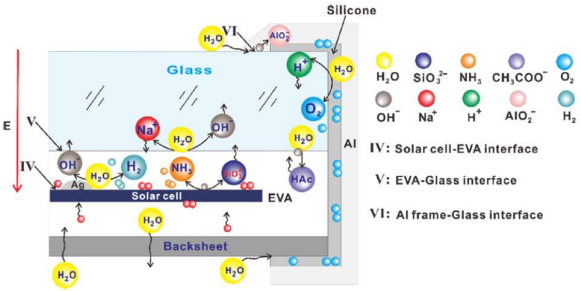

Figure 2 – Electrochemical reactions under negative voltage [5].

3 Project objectives

The first objective of the project is to understand the mechanisms of PID degradation in MV PV module. To meet this objective, it is necessary to characterize in detail the various module components: PV cells, encapsulants and glass. Among the parameters expected to have an impact on the MV sensitivity of modules are: the hydrolytic class of the glass used, the water vapor permeability of encapsulants and sealants, the insulation resistance of glass, encapsulants and sealants, and the sensitivity of encapsulants to ionic migration depending on their degree of hydration.

To obtain this data and set up test protocols, we have joined forces with G2Elab, whose expertise in the characterization of insulation resistance, conductivity and LIPP (Laser Induced Pressure Pulse) measurements is internationally recognized. Setting up protocols and synthesizing results on different types of encapsulants will be the post-doc's primary task. The role of the encapsulants is key to the behavior of the module in MV. Studying the influence of encapsulants matrix type and formulation on module sensitivity to PID in MV is an avenue that need to be explored.

Skills in materials science and modeling are strong assets for this position.

[1] Huang et al., « Investigation of PID in a 50 MWp crystalline silicon PV power plant », Int. J. Photoenergy 2018, 2018, 1.

[2] Naumann et al., « Explanation of PID of the shunting type by Na decoration of stacking faults in Si solar cells », Sol. Energy Mat. And Solar Cells, 120, 2014, 383-389.

[3] Yamaguchi et al., « Mechanistic understanding of polarization type PID in c-Si PV cell module », 2022, 2200167.

[4] Yamaguchi et al., « PID degradation in high-efficiency n-type crystallline silicon PV modules: a literature review », RRL Solar, 2021, 2100708.

[5] Bai et al., « Analysis of the electrochemical reactions and ions migration for crystalline silicon solar module under high system voltage », Solar Energy. 225 (2021) 718-725.

[6] Martinez Loran et al., «A Poisson-Nernst-Planck model of ion transport and interface segregation in MIS structures and solar cells », 2022, 259, 2100514.