Proposal Summer Project 2024

Correlating Hydrogen-Related Defects with Degradation in Silicon Solar Cells

Energy systems, materials and models

Sustainable energy production and energy efficiency

Supervisors

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Background of Candidate

The candidate preferentially has an interest in material properties, solid state physics/chemistry, and some laboratory experience. Experience in data evaluation of spectroscopical data and a curiosity for defects in solid state materials are desirable.

Number of Projects and Project Period

One Project, 6 weeks, starting in July 2024, ending mid-August 2024.

Project description

The predominant material used in the construction of most solar cells today is silicon. The longer the lifetime of the charge carriers, the greater the electricity output, thus, the more efficient the solar cell is. However, silicon solar cells suffer from degradation processes over time when exposed to environmental conditions, which is displayed by a reduction in the effective lifetime of the charge carriers.

One severe degradation process is light and elevated temperature induced degradation, short *LeTID.* It causes a reduction of the solar cell's efficiency by up to 10 %, exhibiting a significant impact even after a short time. The downward trend is illustrated in Figure 1, whereas exposures corresponding to 1 year, 10 years, and 30 years are highlighted.

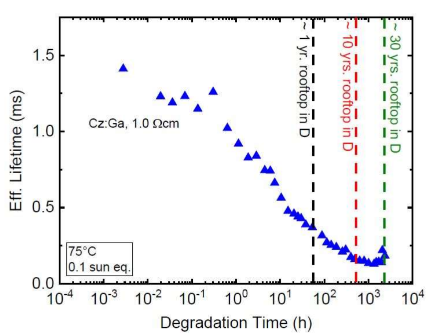

Figure 1: Effective Lifetime degradation over time of a silicon wafer during light (0.1 sun equivalent) and temperature (75 °C) exposure. [1]

Understanding this LeTID process is the goal of many research groups and will mark the initial stride towards boosting the efficiency of solar cells. What has become evident thus far is the significant role played by hydrogen in this process.

An effective method for capturing information about molecules, their structure, and their environment within a material is Fourier Transform-Infrared (FT-IR) spectroscopy. The fundamental principle of this technique involves measuring the absorption, transmission, or reflection of infrared light by a specific group in a sample at specific energies, providing a detailed molecular fingerprint, as exemplary depicted in Figure 2. This method has found application in fields such as chemistry, biology, and material science. Specifically, in our research context, FT-IR becomes an essential tool for measuring the hydrogen content in silicon crystals.

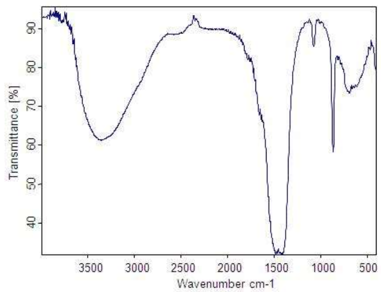

Figure 2: FT-IR transmittance spectrum of a sample for varying IR-light energy (in wavenumbers). [2]

In collaboration with Fraunhofer ISE in Germany, we aim in this project to track the evolution of hydrogen at its different stages in the LeTID process. Our objective is to validate existing hypotheses and provide clarity to aspects that have, until now, largely remained speculative. Fraunhofer ISE will be responsible for processing different samples and measuring their corresponding lifetimes at distinct degradation states. The University of Oslo's role in this project is to detect and quantify the correlated hydrogen species in the samples with cryogenic FT-IR spectroscopy.

The Student's Tasks

- Measure the concentrations of the hydrogen-acceptor complex, oxygen-hydrogen complex, and hydrogen molecule within the samples.
- Establish correlations between the FT-IR findings and the various degradation stages.
- Conduct a comparative analysis of these results against potential degradation mechanisms outlined in the existing literature.

Outcome and Deliverables

The student will gain insights into semiconductor materials and acquire in-depth knowledge about the theory of FT-IR spectroscopy. On the practical side, the student will learn how to operate the instrument and acquire skills in data evaluation.

At the end of the project, a presentation of the results followed by a discussion and interpretation with our collaboration partner Fraunhofer ISE will take place.

[1] W. Kwapil et al. Sol. RRL, 5, 2100147 (2021); https://doi.org/10.1002/solr.202100147

[2] How an FTIR Spectrometer Operates (accessed 21.12.2023) is shared under a CC BY 4.0 license and was authored, remixed, and/or curated by Nancy Birkner & Qian Wang.