# ACCESS-CIGS
# Atmospheric Cost Competitive Elemental Sulpho-Selenisation for CIGS

*Project duration: from 03.2016 to 02.2019*
*Final report submitted: 05.2019*

## Summary

Thin film Cu(In,Ga)(Se,S)$_2$ (CIGSSe) solar cells exhibit conversion efficiencies that are at the same level as those based on multi-crystalline silicon wafers. Therefore, the CIGSSe technology has potential to significantly contribute on a larger scale to the production of photovoltaic energy. However, several of the fabrication steps leading to CIGSSe solar modules rely on relatively slow vacuum processes and/or involve material inefficient toxic gases. This increases considerably the costs of module fabrication reducing the competitiveness of this technology. The introduction of vacuum-free, high through-put in-line processes can lead to a significant cost reduction. Provided that the respective power conversion efficiencies can be maintained or increased, the cost of PV-generated electricity produced with this technology can be significantly reduced.

The objectives of this project were the combined reduction of CIGSSe processing cost and the improvement of the conversion efficiency. Since the CIGSSe absorber layer has the highest cost and the highest efficiency impact on the finished CIGSSe module, this project focused on improving sequential CIGSSe absorber formation, one of the commercially and industrially most attractive processes for the fabrication of CIGSSe absorbers. In this sequential process, stacks of Cu-In-Ga metallic films are transformed into the active absorber CIGSSe layer in a vacuum-free, high-throughput, in-line reactive thermal process by gaseous S and Se compounds. To reduce the costs involved in handling and safety measures related to toxic $H_2Se$ gas, elemental selenium (Se) vapour was used for the reaction. For the subsequent sulfur incorporation (SAS, sulfurization after selenisation) two approaches, namely sulphur vapour and $H_2S$ were compared. Since the thermal process occurs at atmospheric pressures the cost of vacuum equipment is eliminated. Within the project, two measures were tested with respect to their influence on the chalcogen consumption as well as the quality of the absorber layer: First, the recirculation of excess selenium that is not incorporated into the deposited CIGSSe. Second, cracking selenium in the vapour into smaller Se molecules before it is provided for the thermally activated reaction.

## Project consortium

Coordinator and contact details:



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|---|---|
| Full name of organisation: | Helmholtz-Zentrum Berlin für Materialien und Energie |
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Participating countries and financing:

| Country | Number of organisations involved | Project costs in EUR | Public funding in EUR |
|---|---|---|---|
| Germany | 2 | 979’094 | 874’452 |
| The Netherlands | 2 | 826’768 | 649’773 |
| *Total* | *4* | *1’805’862* | *1’524’225* |

## Funding agencies involved and contracts

| Funding Agency | Contract N° and Title |
|---|---|
| Projektträger Jülich (PTJ) | 0325903A |
| Rijksdienst voor Ondernemend Nederland (RvO) | TEZ0214016 |
| Projektträger Jülich (PTJ) | 0325903B |
| Rijksdienst voor Ondernemend Nederland (RvO) | TEZ0214016 |