Fraunhofer
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FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE


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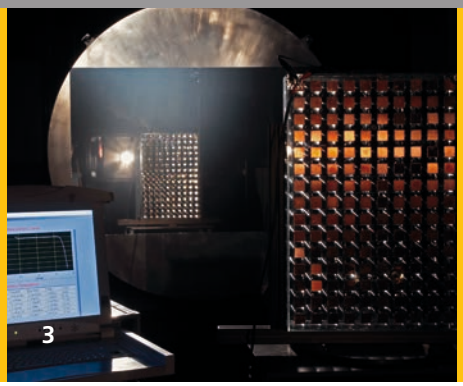
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1 *The ambient conditions required for performance analysis at CSOC are recorded with isotype sensor, pyrheliometer, skyradiometer, CSR sensor, sky picture cam and tracking accuracy sensor.*
2 *Sun tracking unit and CPV outdoor measurement facility at Fraunhofer ISE.*
3 *Indoor sun simulator for CPV module rating and characterization.*

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CHARACTERIZATION, RATING AND EVALUATION OF CPV MODULES

Based on many years of experience in characterization and evaluation of CPV modules, the Fraunhofer Institute for Solar Energy Systems ISE offers support in the development, investigation and analysis of CPV module / system design and performance. We follow a comprehensive and holistic approach in order to provide the best benefit for our customers.

We offer our customers a complete range of services spanning from bare III-V solar cells, through components and CPV modules, right up to entire CPV systems. Our broad expertise includes the characterization and power rating of CPV modules and the evaluation of CPV systems according to IEC standards. Detailed loss analyses as well as studies on design improvement using prototyping or electrical and thermal modeling are part of our offer.

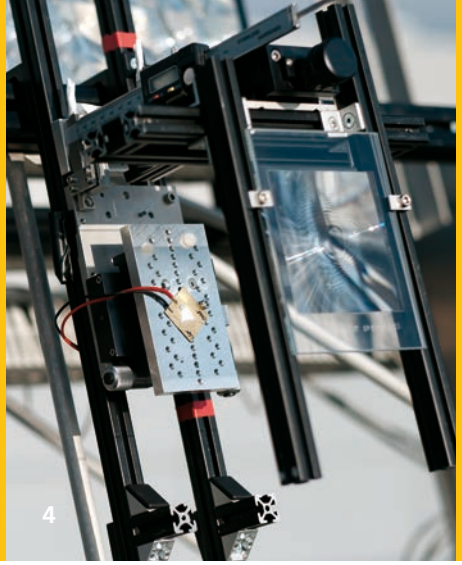
Our Services

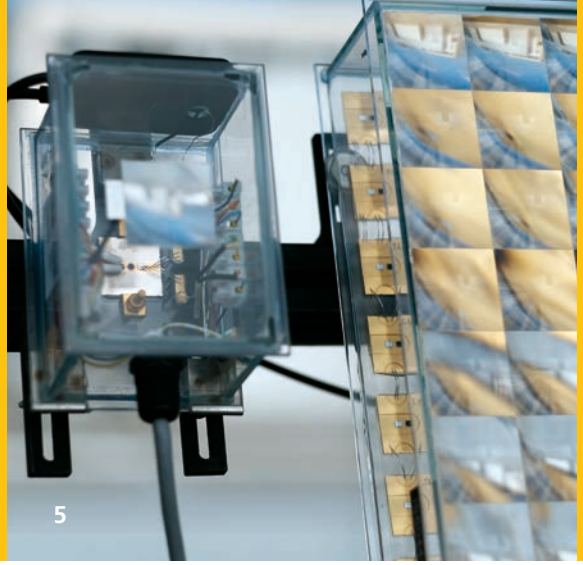
- CSOC and CSTC rating of CPV modules and systems (IEC 62670)
- evaluation and modeling of CPV modules and systems
- electrical and thermal characterization of CPV modules
- investigation on potential design improvements for CPV modules
- characterization of III-V cells and optical elements
- combination of solar cell and module characterization

Our Expertise

- several years of experience in precise measurement of CPV cells, modules and systems
- deep physical understanding of module characteristics and behaviors
- CPV module development by sensor controlled prototyping and / or by electrical and thermal modeling

March 2015





Rating of CPV Modules

- power rating at CSTC and CSOC according to IEC 62670-3
- module power rating using a sun tracking unit: ambient conditions near CSOC are typical for Freiburg (900 W/m², 20 °C ambient temperature, AM1.5d spectrum)
- module power rating using a sun simulator
- determination of module temperature coefficients

Evaluation and Modeling of CPV Modules and Systems

- data evaluation of custom specific CPV system
- analysis of cell and module performance
- modeling of the electrical characteristic of any multi-junction solar cell using a SPICE based network model
- modeling of any optical element with ray tracing and finite element method
- computer based analysis and design improvements of CPV modules using a combined ray tracing and network model of customers CPV module
- prototyping, i. e. manufacturing CPV modules with optics and / or solar cells of clients
- single lens and cell measurements with variable lens-to-cell distance

Electrical and Thermal Characterization of CPV Modules

- I-V measurements of modules outdoor or with a sun simulator
- monitoring the ambient conditions: DNI, GNI, wind, AOD, PW, CSR, spectral conditions, module and ambient temperature
- long term monitoring of modules
- monitoring and modeling the thermal and electrical behavior of CPV modules
- measuring the optical efficiency of optical elements
- characterization of III-V solar cells at various temperatures (EQE, IV, EL)

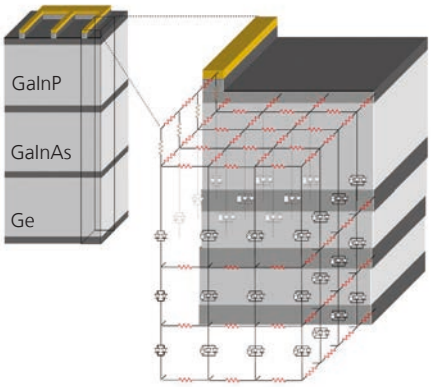
Scientific References

An overview of our latest scientific publications:
www.ise.fraunhofer.de/en/publications/20
Most relevant:

- analysis of temperature coefficients for III–V multi-junction concentrator cells
- FLATCON® CPV module with 36.7 % efficiency equipped with four-junction solar cells
- investigations on the temperature dependence of CPV modules equipped with triple-junction solar cells
- »YieldOpt«, a model to predict the power output and energy yield for concentrating photovoltaic modules

4 *Mono-lens and single cell measurement with variable cell-to-lens distance on a sun tracking unit or using a sun simulator: Characterization of solar cells using different lenses or characterization of optical elements using different target solar cells. Determination of the optimal module height at CSOC or at prevailing ambient conditions. Evaluation of the cell and lens performance.*

5 *Prototype CPV modules with a large variety of sensors: testing of customers cells in a CPV module, testing of optical elements in combination with high efficiency solar cells, testing of CPV module components in sensor monitored modules.*



6 *Network simulation of a multi-junction solar cell in combination with ray tracing and finite element method of optical elements: computer based analysis and design improvements of CPV modules or single components.*