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## PHOTOVOLTAIC MODULE TECHNOLOGY



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### COVER PAGE

*Quality check of a photovoltaic  
module at Module-TEC*



## NEW APPROACHES FOR EFFICIENT, COST-COMPETITIVE AND RELIABLE PV MODULES

Fraunhofer ISE offers a comprehensive range of services for product development and material qualification in the field of module technology. With many years of experience, excellently trained staff and well-equipped laboratories, we turn innovative ideas into new approaches for reliable, efficient and competitive PV modules. We assist our clients in improving the quality and efficiency of existing module and interconnection concepts. At all times we make use of the vast research network available along the entire PV value chain at Fraunhofer ISE.

The reduction of PV-generated electricity cost (LCOE) is the main challenge to be competitive in the photovoltaic market. Our ambition is to support our customers in developing LCOE-competitive PV modules with

- lower module production costs
- increased module efficiency and power and
- improved long-term reliability.

### PV Module Technology Center – Module-TEC

Our technology center Module-TEC at Fraunhofer ISE is equipped with a unique spectrum of process and analysis platforms. For cell interconnection, our equipment enables contact, infrared, induction and laser soldering as well as conductive adhesive glueing. Industrial laminators are available for producing modules with up to 72 solar cells. Partially and fully automated equipment enables product development from first proof of concept down to full size modules in sufficient quantities for testing, demonstration and certification.

R&D in our Module-TEC is complemented by the PV Technology Evaluation Center (PV-TEC) for solar cells and our accredited

laboratories TestLab PV Modules and CalLab PV Modules at Fraunhofer ISE. The combination of expert knowledge and excellent facilities along the complete PV value chain forms an ideal basis for supporting industrial partners from the development of silicon raw material to complete PV systems.

### R&D on Cell Interconnection

Cell connection is a key process in module production. We offer our customers process qualification to achieve efficient and reliable products as well as high yields and stable processes in production. Our areas of work include development on:

- 4BB/5BB-interconnection, full and half cells
- qualification of new cell metallizations
- direct contacting of Al
- electrically conductive adhesives (ECA)
- multi-wire interconnection
- shingled interconnection
- back contact interconnection
- high efficiency cells (HJT, IBC)

### Qualification of Encapsulation Material

The encapsulation film protects the solar cells and secures its performance and reliability. It ensures optical transmissivity, electrical insulation and environmental protection. We offer the following R&D services:

- foil evaluation
- lamination recipes
- edge-sealed TPedge module
- electroluminescence
- gel content analysis and adhesion
- curing kinetics
- optical material characterization
- thermomechanical material testing

### Customizing PV Modules

For applications with special requirements we offer to design, prototype and qualify customized products.

Our expertise and projects cover

- colored and patterned PV modules for building integration
- optimized solutions for device integration
- low-concentrating PV receivers
- light-weight modules
- 3D curved modules for solar car roofs
- customized modules for integration into trucks.

At Fraunhofer ISE we have developed a color-coating technology based on the morpho-butterfly effect for applications in highly-efficient BiPV modules. The adjustable, homogeneous and saturated colors offer unique design freedom in the building sector.

### Optimal Module Efficiency with SmartCalc.CTM

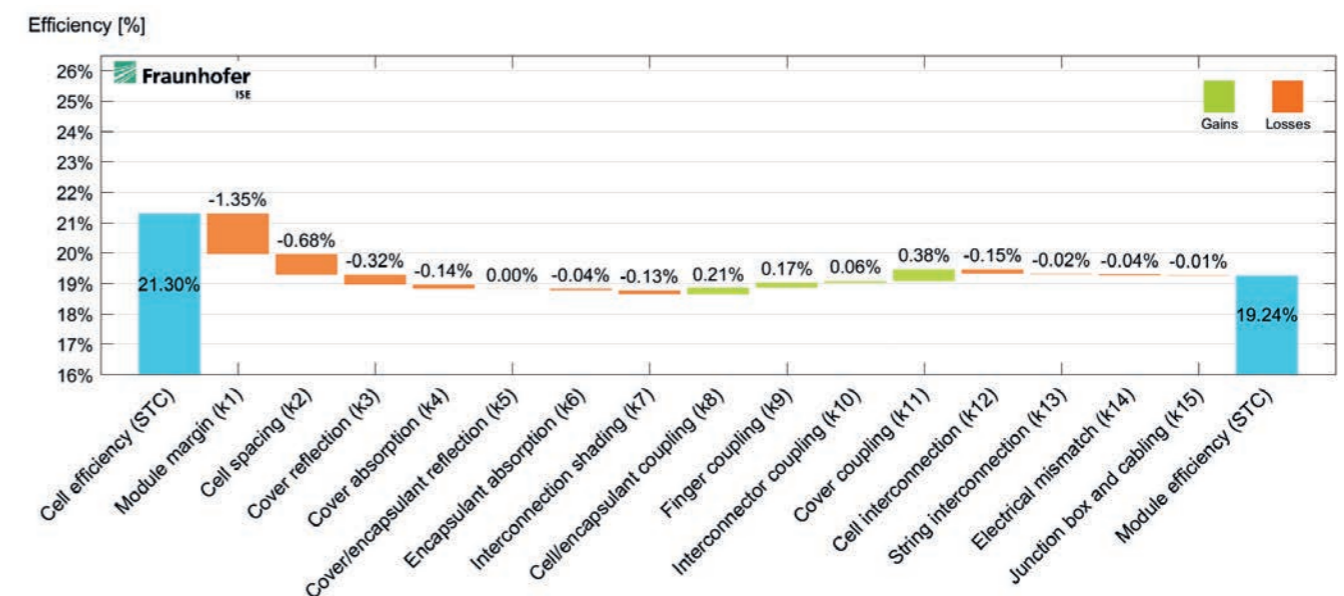
Matched cell and module design is required to maximize efficiency and electric yield of the final product. Based

- 1 *Engineer operating industrial string equipment.*
- 2 *Multi wire interconnection of solar cells for increased module efficiency.*
- 3 *Cell placement in a module stringer.*
- 4 *Customizable coloured modules for building integration.*

on our modeling experience we developed the software SmartCalc.CTM which determines the cell-to-module effects, which occur when solar cells are integrated into a module. The software tool assists in analyzing the potential for optimizing the module design, thus enabling PV manufacturers to determine how new materials or concepts would affect module efficiency and power. Depending on the needs of our customers, we offer different license packages of SmartCalc.CTM at [www.cell-to-module.com](http://www.cell-to-module.com).

### Research and Development for Your Needs

Contact us for specific support or R&D partnership intentions. We look forward to developing solutions for you and supporting your development.



5 Screenshot of SmartCalc.CTM with waterfall-chart, displaying the efficiency gains and losses for a half-cell PV module.