Fraunhofer ISE offers a comprehensive range of services for product development and material testing in the field of module technology. We provide support for turning innovative ideas into reliable, efficient and competitive PV modules, as well as for improving quality and efficiency in existing module and interconnection concepts. Our R&D is backed by a profound internal PV research network from silicon to system. Our fields of expertise include:

- integration of high-efficiency solar cells (PERC, MWT, IBC, Heterojunction)
- detailed analysis of cell-to-module (CTM) losses
- reliable soldering on screen printed and plated contacts
- contact formation on aluminum
- conductive adhesive technology
- wire interconnection technology
- module optics and mechanics
- customized module designs

Our PV Module Technology Center, Module-TEC, is equipped with a unique spectrum of process and analysis platforms. For cell interconnection, our process tools enable contact, infrared, induction and laser soldering as well as conductive adhesive gluing. Different laminators are available for producing modules with up to 72 solar cells. Partially and fully automated equipment enables us to support product development from first proof of concept down to full size modules in sufficient quantities for testing and demonstration. R&D in the Module-TEC can be completed by our PV Technology Evaluation Center for solar cells (PV-TEC) and our accredited Test Lab PV Modules.

The combination of expert knowledge and excellent facilities forms an ideal basis for supporting industrial partners from the development of silicon raw material to complete PV systems.
Integration of Novel Cells and Materials
Accelerated innovation cycles constantly require the introduction of new cell and material generations into module production. We help our customers to qualify new materials and processes for achieving efficient and reliable products as well as high yields and stable processes in production.

- novel cell metallization
- analysis and reduction of thermo-mechanical stress
- low-temperature solders
- lead-free solders
- conductive adhesives
- innovative cell connectors
- back-contact technology (MWT, BI-BC)
- qualification of encapsulation materials

Optimal Module Efficiency
Matched cell and module design is required to maximize efficiency and electric yield of the final product. We help to analyze the multitude of loss and gain effects at the cell-to-module interface down to the material level. Based on our unique measurement and simulation tools including TCO analysis, we provide guidance for cost-effective improvement of electrical and optical efficiency.

Cell Joint and Laminate Qualification
Cell connection and encapsulation are the key processes in module production. We offer comprehensive characterization along the processing steps and in support of reliability testing. For material and device analysis we use:

- tensile and shear measurement
- adhesion, gel content measurement
- dynamic mechanical analysis
- IR-spectrometer for transmission and reflection
- differential scanning calorimetry
- electroluminescence
- series resistance measurements

For the analysis of solder and glue joints on solar cells we deploy:

- X-Ray microscopy
- in-house developed metallographic preparation sequences
- SEM, EDX
- FIB preparation
- wettability and adhesion tests

Customized Module Design
For application in challenging climates or with special requirements, we help our customers to design, prototype and qualify customized products, comprising:

- adaptation to hot-arid and hot-humid climates
- combined PV / Solar Thermal (PVT)
- mechanically flexible modules
- lightweight modules
- building-integration (BIPV)
- receivers for low-concentration photovoltaics (LCPV)
- device-integrated modules (DIPV)

Optimal Module Performance
The electric yield of a module is influenced by parameters beyond Standard Testing Conditions (STC). We analyze module performance in real operating conditions by:

- flashing and steady state measurements at oblique incidence
- energy rating
- spectral analysis
- reliability and soiling evaluation

Modeling and Simulation
With our simulation tools we support efficient product development and qualification. In order to understand the optical, electrical, thermal and mechanical effects relevant for module operation and production, we use in-house developed tools as well as professional software:

- optical ray tracing
- thermomechanical Finite-Element Modeling (FEM)
- fracture mechanical analysis
- electrical circuit simulation for interconnector or conductive back sheet optimization
- annual electric yield