MODULE TECHNOLOGY

Fraunhofer CSP Module Technology Center (MTC)

Research activities at MTC focus on analysis, optimization and development of industrial manufacturing processes for PV modules. MTC offers full scale production equipment (max. 2.2 x 2.6 m²) for solar module producers as well as equipment and material suppliers. New module technologies as well as module technologies for new cell concepts can be investigated using production environment.

Development of PV modules for special applications

Standard modules have driven PV cost below grid parity and opened up many cost effective applications for PV modules. Adapting design and materials used in the modules to special appplications is one of the main focuses of R&D efforts at MTC. The research activities combine the knowledge of mechanics of materials and polymer technologies and processing.

Technology and material evaluation for solar module packaging

At MTC materials in soldering process are evaluated using characterization methods developed in microelectronics packaging. In details analysis of material and interaction between different materials from soldering PV modules are linked to pull tests and cross section analysis of solder joints and other connecting technologies.

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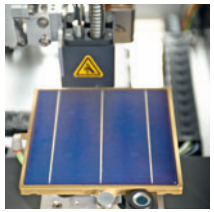
DIAGNOSTICS OF SOLAR CELLS

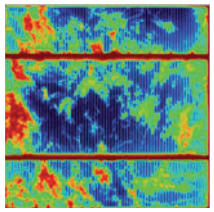
Microstructural and elemental analysis of crystalline solar cells and thin film modules

Localization and investigation of defects in solar cells is done using high resolution methods like SEM, TEM or EBIC. ICP-MS, XPS and ToF-SIMS offer the potential for quantitative analysis of trace elements in silicon and other materials with high sensitivity.



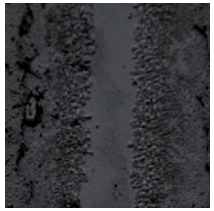
Electrical characterization of solar cells

Methods for electrical characterization are applied to ingots, wafers, solar cells or thin layers of metals, semiconductors or TCOs. This includes the measurement of I-V-curves, carrier mobility and carrier life time, photo luminescence, light-beam induced current and quantum efficiency.

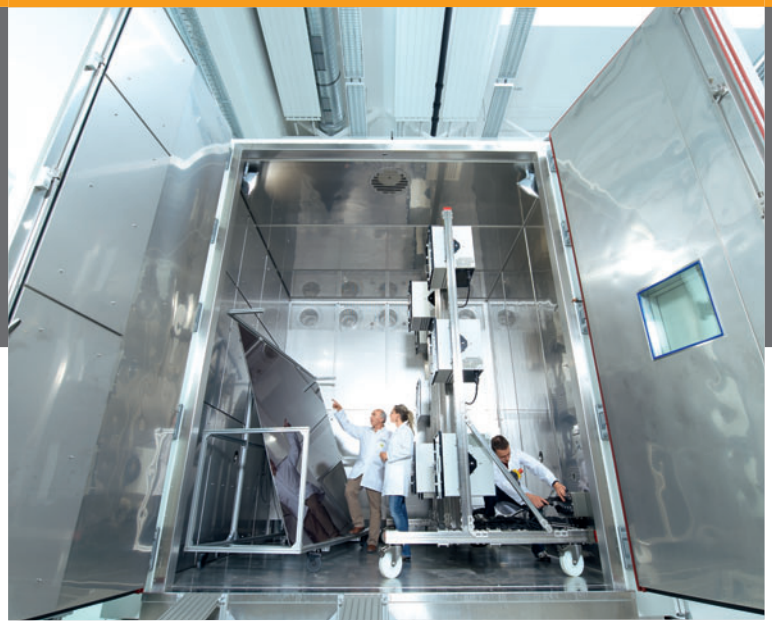


Technologies for laser structuring of solar cells

Laser structures are investigated geometrically and electrically. High resolution methods are used for investigation of scribe defects. Microprobing allows electrical characterization of scribe structures and defects on a microscopic level.



MODULE RELIABILITY

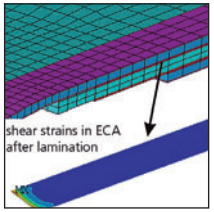


Characterization of Polymers

For optimization of photovoltaic modules it is essential to characterize the polymers in the modules e.g. encapsulants, Electrically Conductive Adhesives (ECA), edge sealants and other components in regard to thermal, optical, mechanical and electrical properties. Lamination and weathering of test structures to analyse the processing and aging behaviour.

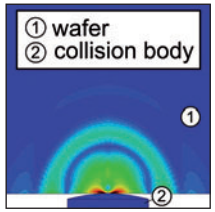
Simulation of stresses and aging behaviours

From the polymer characterisation data deformation models are derived. Finite element modelling is used to access the stress and strain states in critical regions of the modules (ECA joint) during production (lamination process) and application (mechanical load, temperature cycle). The results of the cyclic simulation are correlated with aging laws.



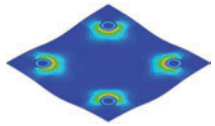
SILICON WAFERS

Damage and breakage of wafers during impact loading



Impact loading on the wafer edge occurs in different handling steps in PV manufacturing. The wafer behavior during impact can be analyzed by using drop tests of wafers. Dynamical simulation models are used to observe local deformation and stress fields of the wafers at the contact region. By correlating the results with experimental investigations it can be shown that cracks can propagate due to critical stress and deformation states in the wafer. Furthermore, the fracture probability of the wafers can be calculated using these models and probabilistic methods. The fracture probability quantifies the damage potential of different handling steps and equipment. Thus, handling can be optimized in order to reduce damage and reduce the breakage rate in the production line.

Evaluation of different gripper setups



To evaluate the stress in wafers during handling operations with different gripper setups, e.g. vacuum grippers or Bernoulli grippers, dynamic simulations can be performed. The models consider the pressure from the inside of the cups, as well as the air pressure due to the moving and the resulting transient inertia forces. In combination with a probabilistic strength criterion the fracture probability, as parameter of the damage potential, is predictable and could be used to evaluate different gripper setups.