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FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE


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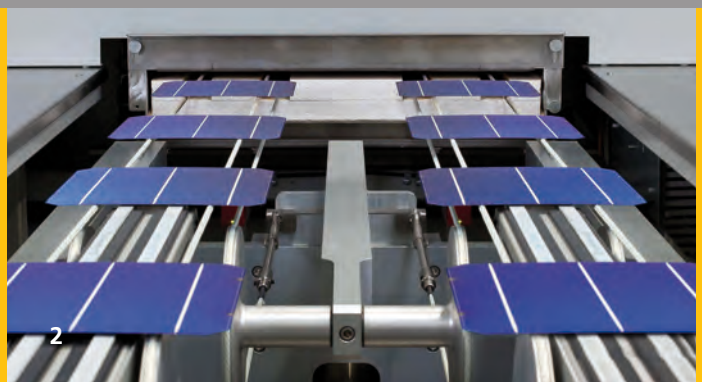
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1 *High capacity tube furnace in the Photovoltaic Technology Evaluation Center (PV-TEC).*
2 *Two track inline furnace for annealing of solar cells in forming gas.*

THERMAL PROCESSES

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High temperature processes form a vital part of solar cell fabrication. Examples of such processes are forming the pn-junction by diffusion, firing screen printed contacts, activating surface passivation layers or annealing process induced defects. In order to take full advantage of new materials, continuous optimization of high temperature processes is indispensable.

The Fraunhofer Institute for Solar Energy Systems ISE has long-standing expertise in thermal processing and characterization. We support solar cell and equipment manufacturers as well as material suppliers in the development and fabrication of industrial and next-generation silicon solar cells.

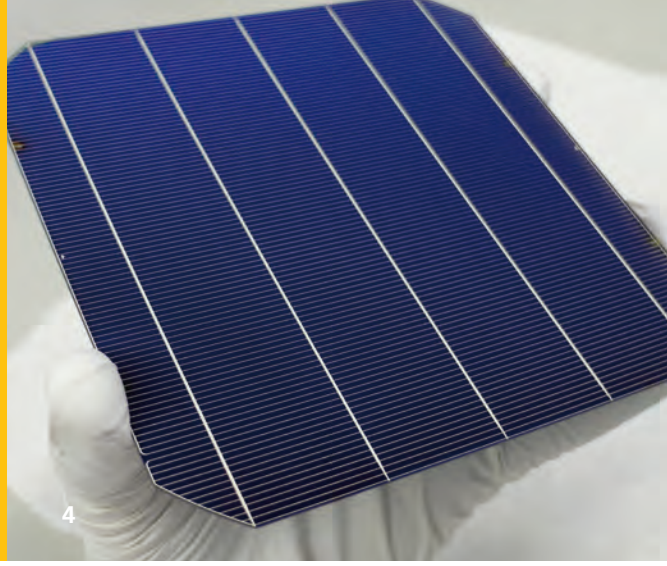
With our pilot-line processing facility, the Photovoltaic Technology Evaluation Center (PV-TEC), and our clean room facility for high-efficiency solar cells, ETALab®, we offer both an excellent infrastructure and state of the art equipment for solar cell processing on an industrial and laboratory scale.

Our expertise covers the application and characterization of a wide range of dopant sources. We also offer process development for advanced solar cell structures from prototyping to the industrial production stage.

Among other services, we tailor dopant profiles, integrate pre-deposited doping sources, supply half processed solar cells and integrate single processes or preprocessed wafers into full process sequences. We provide solar cell processing for wafer sizes from 4" round to 210 mm full square. Other formats are also acceptable.

For process control, we perform inline characterization of large numbers of wafers in PV-TEC, and in-depth analysis in our characterization laboratories.

August 2015



Infrastructure and Expertise

We have a wide range of equipment for thermal processing at our disposal, which is either fully automated for production or allows for manual loading for flexibility with respect to wafer size, thickness or special handling. In addition to batch type tube furnaces, we provide single wafer reactors with halogen lamp heating for process development in a controlled atmosphere as well as in-line tools. Our processes meet industrial requirements with respect to cycle time and high quality standards as required for high-efficiency solar cells.

Gas Phase Diffusion

- atmospheric pressure tube furnace diffusion using $POCl_3$ or BBr_3 liquids
- large variety of dopant profiles concerning surface concentration and depth
- profound knowledge on basic processes, process development and optimization as well as sophisticated co-diffusion processes using printed, CVD-deposited or implanted sources

Inline Processing

- inline diffusion from dopant sources, including co-diffusion
- inline oxidation for surface passivation or thin diffusion barriers
- inline annealing in forming gas, nitrogen or clean dry air for activation of passivation layers, contact sintering or defect annealing
- fast firing for contact formation or activation of passivation layers

Thermal Oxidation / Implant Annealing

- batch processing in tube furnace or continuous inline oxidation
- growth of thermal oxide layers in O_2 or steam ambient
- inert gas annealing and activation of ion implanted dopants

Rapid Thermal Processing

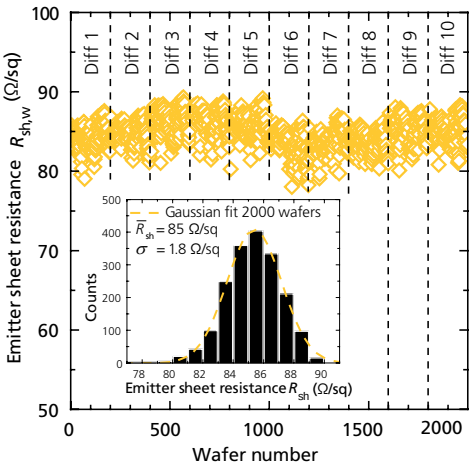
- rapid thermal processing (RTP) in N_2, O_2, clean dry air or forming gas
- separate reactors for metallized and non-metallized samples
- activation of passivation layers
- metal contact firing and sintering

Characterization

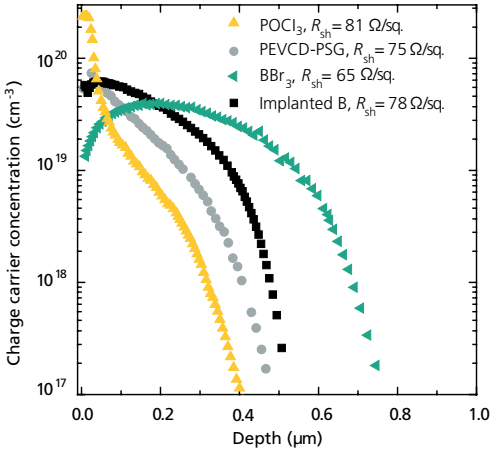
- inline characterization (wafer and layer thickness, sheet resistance, minority carrier lifetime)
- determination of saturation current density of passivated ($J_{0,pass}$) and metallized regions ($J_{0,met}$)
- defect imaging by luminescence
- sheet resistance measurements (4pp or inline inductive coupling)
- contact resistance determination
- electrochemical capacitance voltage profiling (ECV)
- layer characterization by FTIR and spectral ellipsometry
- optical, confocal and scanning electron microscopes
- corona charging and surface photovoltage for interface characterization (SPV)
- analytical modelling and numerical simulation

3 *Inline quality control after processing.*

4 *Process integration of high efficiency cells with five busbars.*



5 *Emitter sheet resistance by inline inductive coupling, and histogram over 2000 wafers from ten consecutive $POCl_3$ diffusion runs.*



6 *Charge carrier concentration profiles generated with different sources.*