Solar cell manufacturers are challenged to continuously investigate efficiency limitations of their products in order to detect optimization opportunities. Fraunhofer ISE offers a customized Complete Solar Cell Loss Analysis package including experimental results as well as detailed expert reports. Our unique methodology combines three different spatially resolved state-of-the-art measurement techniques: spectrally resolved light beam induced current (SR-LBIC), dark lock-in thermography (DLIT), and photoluminescence imaging (PLI). The green rectangles denote homogeneous areas. Averaging in these areas reveals the homogeneous losses of this cell.

**SR-LBIC** measures reflection and short-circuit current and is thus suited for quantitative analysis of all losses under short-circuit conditions. Our evaluation method allows the separation of optical and electrical losses in short-circuit current density and open-circuit voltage, fill factor losses due to ohmic or diode-like shunts and fill factor losses due to series resistance.

**DLIT** is used to determine the local power dissipation in cells. It is especially suited for detecting both, ohmic shunts and diode-like shunts. Thus the impact of both losses on the fill factor of the cell can be evaluated. The differentiation between ohmic and
2. *Spatially resolved analysis by a combination of spectrally resolved light beam induced current (SR-LBIC), dark lock-in thermography (DLIT) and photoluminescence imaging (PLI). The green rectangles denote homogeneous areas. Averaging in these areas reveals the homogeneous losses of this cell.*

diode-like shunts is highly beneficial for cell manufacturers when determining the root cause of a defect.

PLI has proven to be very effective in detecting the spatially resolved series resistance. The image allows an easy identification of processing issues originating from broken fingers, contact resistance or emitter diffusion.

All three evaluation methods provide quantitatively reliable results that correspond with the measured global IV characteristics of the cell. All loss images can be scaled in absolute efficiency losses that allow a direct comparison of pattern and magnitude of each loss mechanism.

**Complete Solar Cell Loss Analysis Package**
- spatially-resolved SR-LBIC measurements at six different wavelengths
- spatially-resolved DLIT measurements at different points along the IV-curve
- spatially-resolved PLI measurements at different points along the IV-curve
- analysis of optical and electrical losses of short-circuit current density
- separation of short-circuit current density losses due to front or bulk / rear side
- analysis of fill factor losses due to ohmic and diode-like shunts
- analysis of fill factor losses due to series resistance
- report of results and conclusions

3. *Selection of cell parameter images which are the basis for the analysis of spatially resolved absolute efficiency losses. From top to bottom: short-circuit current density map, open-circuit voltage image, pseudo fill factor image, series resistance image.*