Luminescence Imaging of Solar Cells

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Modern, low noise silicon CCD-cameras are ideal devices to observe the luminescence radiation emitted by a solar cell under various operating conditions. A high-resolution image of the distribution of the luminescence intensity contains information about essential properties of a solar cell:

1. The distribution of the voltage over the surface, from which the distribution of series resistances and shorts may be derived indicating shortcomings of the production process.

2. The distribution of the diffusion length of the minority carriers indicating the quality of the solar cell material.

3. The distribution of the back surface recombination indicating the quality of the surface passivation.

The analysis of the luminescence image starts with the determination of the diffusion length distribution. Two images are taken in different spectral ranges. By dividing these images pixel by pixel, all factors affecting the intensities in both spectral ranges in the same way, e.g. geometrical effects and the distribution of the voltage are thereby eliminated. From a theoretical analysis it follows that the result of this division is a function of the diffusion length. It allows determining the distribution of the diffusion length in absolute units without the need for calibration.
As an example, a poly-crystalline silicon solar cell is investigated by electro-luminescence. The images below show the distribution of the electron diffusion length (in µm) as determined from luminescence on the left and as determined from LBIC (Light Beam Induced Current) by a scanning technique, on the right. Essentially the same information is obtained by luminescence in a few minutes, whereas the LBIC-technique requires several hours.

This technique is not limited to electro-luminescence and silicon solar cells. It may applied to photo-luminescence allowing the investigation of wafers as well as cells. This technique may be applied to other solar cell materials since its requirement that the diffusion length is in the order of magnitude of the penetration depth of the light is a property of most good solar cells.