The local recombination current density $j_{0,loc}$ is an important parameter to quantify local recombination of charge carriers in solar cells e.g. due to metallization. Different methods to quantify $j_{0,loc}$ have been proposed in literature by e.g. Fellmeth EnerProc8 2011; Wong IEEE JPV5 2015. In our contribution we propose and compare three photoluminescence imaging (PLI) based methods (area fraction variation, constant signal approach, two-diode fit) to quantify $j_{0,loc}$. We carefully review all assumptions needed for the methods and analyze the impact of deviations from the assumptions on the final result using error propagation. We exemplarily present experimental results on a set of samples, on which the methods are applied. We focus on the area fraction variation method only in this abstract.

**Method:** Analogously to the method proposed by Fellmeth et.al., samples with different area fraction of locally increased recombination $F$ are needed. A derivation yields the following equation:

$$\frac{1}{\varphi} = \frac{1}{j_\gamma q(1-R)C} (j_{0,b} + j_{0,e}) + \frac{1}{j_\gamma q(1-R)C} (j_{0,loc} - j_{0,e}) * F$$

with $\varphi$ being the PL-signal of the sample, $C$ being the conversion factor from PL-signal to quasi fermi level split $\Delta \eta$ due to $\varphi = C * \exp(\Delta \eta/kT)$, $j_{0,b}$ and $j_{0,e}$ being the base and emitter dark saturation current densities, $j_\gamma$ being the incident photon flux on the sample during the PL measurement and $R$ being the sample’s reflectance at the PL excitation wavelength. Equation (1) can be interpreted as a linear equation with slope $m$ and y-intercept $b$, and $j_{0,loc}$ follows via:

$$j_{0,loc} = m_{j_\gamma} q(1-R)C + j_{0,e}.$$  

**Assumptions and error propagation:** Four major assumptions need to be pointed out clearly and reviewed carefully for the above method. 1.) There is only one well-defined value of $j_{0,loc}$. 2.) The sample behaves like an ideal diode. $j_{rec} = j_{0,e} \Delta \eta/kT$ is assumed. 3.) The quasi fermi level split $\Delta \eta$ is constant throughout the sample. In other words no contrasts should be visible in the PL images. 4.) The investigated wafers only differ in $F$. Any corruption of these assumptions will lead to an error in the slope $m$ and propagate accordingly in $j_{0,loc}$. An analytic error propagation leads to the simplified expression

$$\frac{\Delta j_{0,loc}}{j_{0,loc}} = \frac{\Delta C}{C} + \frac{\Delta m}{m},$$

for the relative error in $j_{0,loc}$. Determination of $\Delta C$ and $\Delta m$ will be part of the final contribution.

**Experiment:** A set of samples with different $F$-values has been prepared (see Fig 1a). Locally increased recombination was realized via a line-wise laser opening of the ARC layer with different line distances and a fixed line width of 16 μm. Fig 1b shows a PL-image of a sample with 1500 μm line distance. The visibility of the dark lines due to locally increased recombination indicates a deviation from assumption 3. Fig 1c shows the inverse PL signal plotted against $F$. The deviation of the three marked points from the line can be explained by a corruption of assumption 3 due to line distances larger than the diffusion length.

**Fig 1:** a) sketch of prepared samples; b) Part of a PL image (1500 μm line distance); c) plot of inverse PL signal vs. $F$

Analysis of the data with the above method yields a value of $j_{0,loc} = 2700 \pm 240 \text{ fA/cm}^2$ for the samples. We conclude that depending on the technology used, which induces locally increased recombination, the PLI-based methods are capable of a surprisingly precise quantification of $j_{0,loc}$. One main application is the determination of metal recombination current densities to quantify recombination behavior of metal pastes.