**Equations**

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- H. Maeckel and K. Varner, Prog. Photovolt. Res. Appl. 21, 850–866 (2013).

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The total effective lifetime in a piece of Silicon is given by:

Obtaining the effective surface recombination velocity when considering the overall response of carrier diffusion towards the surface requires solving (Luke and Cheng):

For sufficiently low SRV, tan(x) ~x, and the SRV can be approximated to:

The bulk SRH recombination, when using a full SRH term, is calculated as:

We can get SRV with:

But J0s is now more heavily used, so we remember the relationship between J0s and Seff is:

Such that:

Or when assuming that SRV is low and Luke and Chengs approximation is valid:

From here, we can see that:

In both of these cases, it is possible to see that:

So one can simply do a gradient of the measured quantity:

And use it to get J0s (This has been known for a very long time as the Kane and Swanson method).

But this gradient will vary as a function of delta\_n, which most work suggests should not be the case. So we need to find an average J0s, that does not have delta\_n dependence. In Kane and Swanson you simply chose a high Delta\_n range where to fit a line to the quantity.

Alternative, you calculate the gradient, and select a flat region of the versus curve. (Kimmerle’s proposal).

Another problem that can creep up is that the gradient sometimes is all negative and thus a J0s cannot be found. In such case it is easier to get J0s directly from t\_surf:

Now, my naming of the differently obtained J0’s are:

J0s6\_Maeckel: , assuming that there is no SRH recombination in bulk.

J0s\_2\_Kimmerle\_1: either obtained as or , but with a finite SRH bulk. In case one, I am allowing SRH to be full term, with , and of any values, for the best fit.

J0s\_2\_Kimmerle\_2: same as above, but the finite bulk SRH lifetime is a constant value rather than an SRH term.

J0s\_from Seff: Seff is calculated assuming infinite SRH bulk (Seff\_1) and

J0s\_ave1: The best fit of the lifetime curve, when a single value of J0s is chosen from the average in the high carrier concentrations from J0s\_2\_Kimmerle\_1, full SRH term

J0s\_ave2: The best fit of the lifetime curve, when a single value of J0s is chosen from the average in the high carrier concentrations from J0s\_2\_Kimmerle\_2, single SRH constant lifetime

J0s\_fVoc: explained next.

**How to find J0s from iVoc**

Remember iVoc is:

In steady-state conditions it is possible to assume that:

So it is possible to combine these with the lifetime equations above, and find a Deltan that satisfies the following equation, for a generation of 1 sun:

And later plug that value of Delta N into the iVoc equation to find the dependence.

Alternatively, if we know the Delta N that corresponds to 1 Sun from the Sinton Sheet, we can estimate the J0s:

The Sinton kit has a calibrated cell, that equates the illumination on the sample to the number of Suns equivalent. Sinton sheet assumes 38 mA/cm2 (manual), so to convert short-circuit current density (Jsc ​) into the number of carriers generated per unit time per unit volume (cm³) uniformly inside a solar cell: Jsc=q×G×W

Where: q is the elementary charge (1.6e−19 C), G is the generation rate (number of carriers generated per unit time per unit volume, in cm−3, W is the thickness of the solar cell (in cm).

To find G: G=Jsc/(q×W) .

For example for the sample thickness of W=180 µm =0.018 cm: G=38×10−3 A/cm / (1.6×10−19 C × 0.018 cm), G≈1.32e19 cm−3 s−1.

Here it may serve to remember that the sheet has an optical constant value too. So the generation is in fact G\*OpticalConst.