

# SOLAR CELL EFFICIENCY CHARACTERIZATION THROUGH IMAGING TECHNIQUES

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## ABSTRACT

There are many material parameters that can affect the overall efficiency of a solar cell. The purpose of this poster is to highlight imaging techniques that can evaluate these parameters over an entire wafer in a short period of time. The parameters that we will focus on are minority-carrier lifetime, diffusion length, and shunt resistance.

Minority-carrier lifetime is how long an excited carrier exists in a material before it recombines and is lost. Therefore the longer the lifetime is, the more likely the carrier can be swept out of the material and generate electricity. This technique is very good at probing the raw material efficiency in the early stages of processing. The imaging techniques that we cover are photoluminescence (PL) imaging, carrier density imaging (CDI), and microwave photo-conductive decay (uPCD) mapping. PL imaging looks at the radiative-recombination rate of a material, which is proportional to the total recombination rate. CDI images a heat source through a wafer and measures the attenuation of the heat signal due to free carrier absorption. uPCD measures the change in conductivity of a sample, which is proportional to the lifetime; This is not an imaging technique, but is an industry standard for lifetime measurements and serves well as a comparison.

Diffusion length is the distance an excited carrier travels in a material before it recombines. This is also a material efficiency measurement as well and requires a finished cell to perform. While very similar to lifetime, this parameter takes mobility into account and yields an actual distance on how far a carrier can travel in the material. The imaging technique we use for this parameter is electroluminescence (EL) imaging, which is very similar to PL, however instead of optically exciting the sample it is driven electrically like an LED. This measurement is then compared with the standard Light-beam-induced-current (LBIC) mapping measurement.

Shunt resistance affects the amount of current leakage in a solar cell. Where a small resistance causes current leakage and can lead to very low cell efficiency. This defect is often introduced from processing and is not caused by the material. We image these techniques using thermography, where the sample is driven electrically like in EL imaging, but this time the heat from the device is imaged onto a camera. The hotspots that appear represent low resistance regions with current leakage with the stronger spots corresponding to greater current leakage.