The spatially resolved data ( QFLS maps) were taken using an in house-built photoluminescence measurement setup. The setup consists of an LED illumination source, an image sensor and lens (camera) to collect and measure the photoluminescence (PL), a longpass filter to prevent stray/reflected light from the excitation source from falling onto the image sensor, and a source meter to bias the sample.

A picture containing diagram

Description automatically generated

The illumination was provided by a ThorLabs M450LP1 LED collimated by a Thorlabs SM2F lens. The emission was at 450nm, well above the bandgap of the tested samples. The Intensity was controlled by controlling the power supplied to the LED. In order to determine the ‘1 sun’ illumination, the sample was shorted and the LED power tweaked till the current readout was near the short circuit current measured on a solar simulator. The biasing was done using a Keithley 2400.

The PL was measured using an ANDOR Zyla 4.2, a ‘scientific CMOS’ or sCMOS sensor. The sensor was cooled to 0C. The collection lens was a Kowa LM50XC, a 50mm lens with an aperture of f2.0. The sample was brought to the focal plane of the lens, and positioned to coincide with the center of the incident beam. The filter was a Thorlabs FGL515S longpass filter, with a cutoff of 515 nm. Exposure times were varied to obtain a good signal. In the analysis, the measured counts were linearly scaled by exposure time to correct for this.

In order to both correct for beam nonuniformity as well as calculating the PLQY for the QFLS calculation, a white reference was imaged without the filter. This was a barium sulphate plate, which has near unity reflectivity and a Lambertian reflection profile. This gave both a spatial map of the beam that could be used to correct the PL images, as well as the measured counts corresponding to the photon flux from the LED, at some known intensity and exposure time. The

on a per pixel level, where *C* is a correction factor determined to account for:

* The LED intensity difference between the sample and the ref images
* The Quantum efficiency of the detector and wavelength response of the lens and filter.