Long-term behaviour of the sensitivity of amorphous silicon photo detectors

Abstract
We study the deterioration of the photo current response of the hydrogenated amorphous silicon (a-Si:H) under illumination. The position sensitivity of a-Si:H detectors allows for the significant reduction of systematic measurement errors originating from the varying light intensity. We compare the measurement results to the kinetic model of the behaviour of metastable states under illumination by Stutzman et al.

ALMY photo detectors consist of a thin layer of hydrogenated amorphous silicon (a-Si:H) between two transparent layers of indium-tin-oxide (ITO) electrodes (6x64 gitter), deposited on a 1 mm thick glass substrate.

Detectors provide a 2D measurement of the laser beam position with a 1 micron precision in both directions, over a 20x20 mm² of sensitive area. The laser beam has a gaussian beam profile of 2-3 mm width. Its position is given by the two centroids of the photo current distribution on the bottom and the top strips.

Staebler-Wronski effect (1977):
The photo current response of a-Si:H deteriorates under illumination due to the creation of additional metastable states in the band gap of amorphous silicon which decreases the life-time of excess carriers and thus reduces the photoconductivity.

Prediction by the kinetic model of Stutzman et al.

Short time of illumination:

\[
\frac{s(t)}{s_0} = (1 + A I t)^{-1}
\]

Long time of illumination:

\[
\frac{s(t)}{s_0} = (1 + A 3 I t)^{-1/3}
\]

Local degradation of the sensitivity obtained from the scan of the sensor surface.

Fit of the theoretical model to the measured data:

Shorter illumination intervals: Good agreement with the kinematic model.

Longer illumination intervals: Qualitative agreement with the kinematic model:
- quadratic dependence on the laser intensity
- no dependence on the laser wavelength, but photo current sensitivity decreases slower than what is expected from the initial degradation rate (i.e. \(a_{long} = 3a_{short}\) expected; \(a_{long} = 0.3a_{short}\) observed).

Dependence on the laser intensity:

Dependence on the laser wavelength:

Intensities normalized to equal responses.