Infrared Lock-in Carrierography (Photocarrier Radiometric Imaging) of Semiconductors and Si Solar Cells

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Abstract

Modulated photocarrier radiometric (PCR) imaging ("lock-in carrierography") of multicrystalline (mc) Si solar cells is introduced as a dynamic NDT imaging methodology for the characterization of optoelectronic defects in industrial polycrystalline silicon solar cells. Lock-in carrierography maps the charge carrier-wave density field across the device and will be presented as the evolution of optoelectronic semiconductor substrate Si PCR imaging. It can be implemented using a NIR InGaAs camera and a spread superbandgap laser beam as a photocarrier source at low modulation frequencies (< 10 Hz) or using point-by-point scanning PCR imaging with a focused laser beam at high (kHz) frequencies. Carrierographic images can be supplemented by quantitative PCR frequency scans [1]. The ac photovoltage and the PCR signals were measured simultaneously as functions of modulation frequency, excitation intensity, external dc illumination and load resistance. The interrelation and interpretation of PCR signal, ac photovoltage and static (dc) electrical parameters of solar cells will be discussed. The influence of base recombination lifetime and junction capacitance on the PCR and ac photovoltage signals will also be discussed. Solar cell lock-in carrierography will be compared to NIR optical reflectance, modulated electroluminescence (MEL) and modulated photovoltage (MPV) imaging. Non-contact carrierographic imaging is controlled by the photo-excited carrier diffusion wave and exhibits very similar features to contacting MEL and MPV images. Among these methods carrierography exhibits the highest contrast and sensitivity to mechanical and crystalline defects in the substrate at lock-in image frequencies in the range of the inverse recombination lifetime in the quasi-neutral region (bulk).

[1] A. Mandelis, J. Batista and D. Shaughnessy, Phys. Rev. B **67**, 205208 (May 2003).

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