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Fast large area reflectivity scans of wafers and solar cells with high spatial resolution

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Abstract

A solar cell local characterization (CELLO) set-up is modified to measure reflectivity maps of any objects in a non-destructive way. Four different laser wavelengths (BLUE 403 nm, RED 630 nm, IR 830 nm and SIR 934 nm) are applicable. This paper will present the measurement principle, the reflectivity calibration to samples previously analyzed with an integrating sphere, and demonstrate the reflectivity analysis of wafers and solar cells. Compared to other measurement techniques like integrating spheres, this approach has two advantages: First, being fast on large areas (15.6 cm x 15.6 cm sample size; 1 million pixels, measurement time 10 min to 1 hour depending on the accepted noise-level) and second, resolving details in zoom scans with high local resolution (10 µm-spot size). This may allow optimizing processes, where reflectivity is a key parameter like texturization, SiN-PECVD-Antireflective coating or wafer cutting and cleaning processes. Furthermore, independently measured reflectivity maps may be helpful for CELLO photo-impedance analysis in the future.

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Keywords: CELLO; reflectivity; wafer; solar cells; bathlifetime; texturization

1. Introduction

Reflectivity is one key parameter in the characterization of solar cells. It is well-known that texturing, antireflection coating deposition of SiN, and grain orientation of multi-crystalline material have a major impact on the reflectance. Reflectivity losses are direct losses of the photocurrent of a certain wavelength. The front reflectivity R is linked with the external quantum efficiency EQE and the internal quantum efficiency IQE via the equation $IQE(\lambda)=EQE(\lambda)/(1-R(\lambda))$[1]. Standard reflectivity measurement techniques like IQE, or global reflectance measurements, or integrating spheres give just integral values averaged over an area of at least some square-

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millimeters. Additionally, there are some commercially LBIC-systems which measure the local reflectivity, too. However in this paper, we will present an adapted CELLO set-up for much faster reflectivity measurements. Another advantage of this approach is that the measurement is contactless and by this not restricted to solar cells. Any object can be simply used. This paper presents the modified CELLO set-up, explains the calibration procedure and finally, gives some first examples of the technique. Furthermore, independent measured reflectivity data will also be very helpful in the future to improve the CELLO photo-impedance analysis.

Nomenclature

BLUE	laser with 403 nm wavelength
CELLO	solar CELl LOcal characterization
IR	laser with 830 nm wavelength
RED	laser with 630 nm wavelength
SIR	laser with 934 nm wavelength

2. Measurement principle

Fig. 1 presents the modified CELLO set-up [2] for reflectance measurements. Objects, here a sample wafer, are placed on the Au coated Cu chuck. A laser beam is scanned across the sample. The reflected light is collected via a vertically arranged solar cell mini-module that is contacted via a four probe arrangement. This is the first big difference compared to the set-up for standard CELLO measurements. The laser beam is intensity modulated with a perturbation frequency *f* of around 6 kHz. The collected signal is analyzed via a lock-in routine resulting in an amplitude map of the sample. For reflectance measurements the sample holder room is covered with diffusively light reflecting material, imitating the function of an integrating sphere and increasing the signal yield of the reflected laser light, which is the second big modification of the standard CELLO set-up. A typical map has a size of 1000 x 1000 pixels, with 200 µm being the length of one pixel. The smallest possible pixel length is 50 µm. The measurement time for this typical map is 10 minutes to one hour, depending on how many periods of the lock-in measurement are used to average.

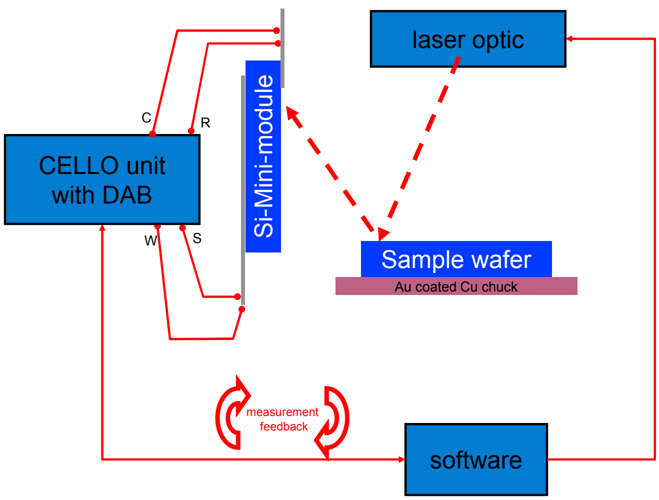

Fig. 1. Schematic of a modified CELLO set-up for reflectivity measurements. The reflected laser beam is collected via a vertical placed solar cell mini-module that is connected via a 4 probe set-up (C: counter electrode; R: reference electrode; W: working electrode; S: sense electrode) to the CELLO unit with the data acquisition board (DAB).