Microscale Localization and Detection of Defects in Crystalline Silicon Solar Cells

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Silicon remains the only material that is well-researched in both bulk and thin-film configurations. Monocrystalline silicon solar cells are the photovoltaic devices with highest efficiency, but they content a variety of tiny local defects decreasing the efficiency. So the novel method combining electric and optical measurement is presented.

1 Introduction

The Department of Physics of Brno University of Technology studied the problem of noise in electrical and electronic devices during last 25 years. Recently, the initiative of Laboratory of Optical Nanometrology took place in searching, if the noise had integral nature over whole device or if it was only localized on certain sites of the surface or in bulk of the device [1].

Hence a convergence of two different approaches is explained in the case of monocrystalline silicon solar cell.

2 Macroscopic experimental set-up

Electric mesurements generally characterize solar cells and provide an overall insight into solar cells, but do not inform us about their local properties.

To have a deeper insight into the structure, it is important to determine local electric parameters of solar cell and to characterize certain types of defects.

As solar cells are optoelectronic devices based on photoelectric effect, it is natural and desirable to also test them by tailored optical methods (Fig.1).

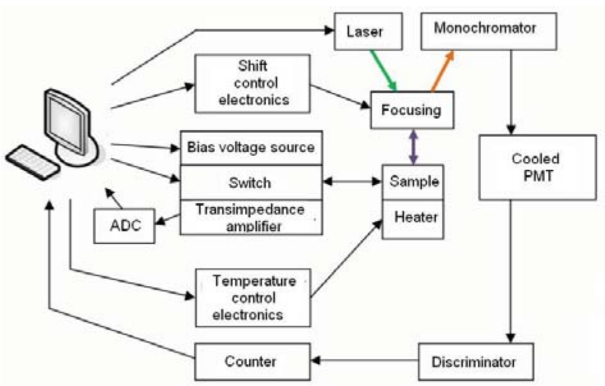

Fig. 1 *Macroscopic experimental setup.*

To correctly localize and resolve defects, which are material ones provided by imperfection or irregularities of material, or processing ones, due to the imperfection of material during processing, it is necessary to use local mesurement methods.

With this experimental set-up one can measure both electric and optical properties [2,3]. Electronic measurement of noise on Si sample allows to detect a presence of low-voltage breakdowns in defect sites of corresponding *p*-n junctions.

The figure 2 shows the noise current values for applied reverse-bias voltages [1]. The noise for certain voltages is quite important.

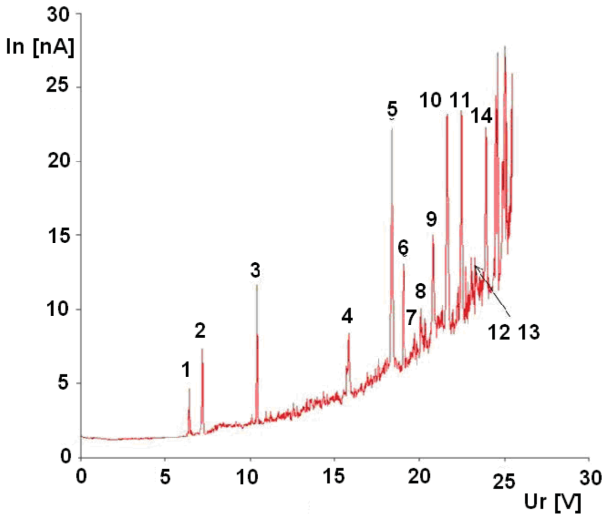

Fig. 2 *Noise-current vs. reverse-bias voltage.*

The optical part of the investigated set-up allows to localized defects on the silicon wafer, using reverse-bias light emission from defects in combination with light beam induced current (LBIC) method (Fig.3).

3 Near-field Optical Beam Induced Current (NOBIC) microscopic method

To obtain a better resolution, the NOBIC method is used [4]. Therefore this investigation represents the application of reflection-illumination-collection mode SNOM microscope to characterize structures of subwavelenght dimensions. The resolution of set-up depends strongly on the dimension of sharp probe

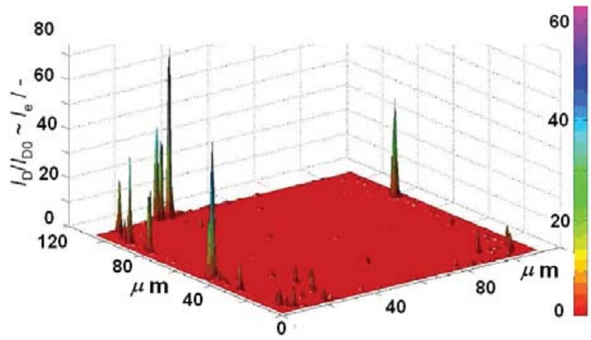

Fig. 3 *Defect localization for Ur = 7.5V.*

4 Results

As an example of the method one defect is presented – truncated pyramid (Figs. 4-7) [5]. Here the p-n junction is damaged, and produces a microplasma noise.

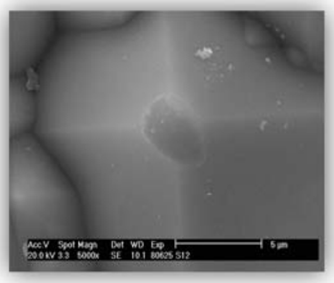

Fig 4 *SEM figure of the defect*

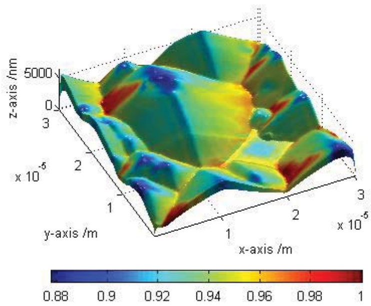

Fig 5 *Relative NOBIC map*

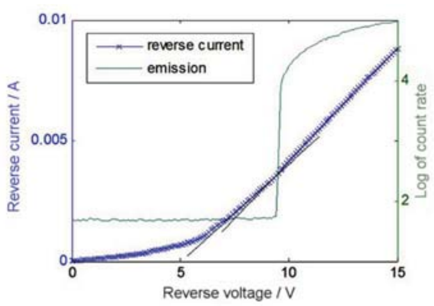

Fig 6 *Reverse-current and emission from the defect vs. reverse-voltage*

5 Conclusion

As a conclusion, novel combined set-up for apertureless SNOM topography, NOBIC measurement and reflectivity of solar cells with a lateral resolution of about 250 nm has been established.

Accuracy of this method depends on actual size of the probe tip or a light spot and on the scanning step of the piezo-driver. The accuracy of the combined reflection measurements after calibration is better than 5%.

At short circuit condition the NOBIC photocurrent of this cell is dominated by the variation of the reflectivity.

The principal advantage of the proposed method lies in the fact that it is non-contact and non-destructive.

Additional information on the surface topography is one of the major advantages of SNOM.

Acknowledments

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