NONDESTRUCTIVE NOISE DIAGNOSTICS OF SOLAR CELLS

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ABSTRACT

Several basic methods can be used to nondestructive noise diagnostics of solar cells. We used the method of RMS value of narrow-band noise current vs reverse voltage. Detection of local defects and volume degradation in PN junctions of solar cells is possible with this method. We can determine the solar cells which have A or B type of noise using these measurement results.

1. INTRODUCTION

In a semiconductor PN junction there are localized regions featuring increased concentration of donor or acceptor impurities, other element admixtures or other defects which cause the PN junction reverse breakdown voltage to be reduced and affect the total minority charge carrier lifetime. These regions may give rise to local fluctuations of the PN junction potential barrier thus reducing the solar radiation energy to electric energy conversion efficiency. If a certain part of the cell operating in a solar panel happens to be in a local shade, this particular cell will get into reverse-bias condition. Due to the existence of reduced breakdown voltage local defects, local breakdowns may occur in the neighbourhood of the defects, which in turn may lead to heavy current densities in the low-cross-section regions. This phenomenon can give rise to a heavy local temperature increase and, consequently, local diffusion or thermal breakdown, which may result in the cell destruction.

There are several basic methods designed to detect the mentioned defects: Reverse current versus reverse voltage plots, reverse *U-I* curve measurements, narrow-band noise current RMS value measurements, reverse current noise power spectral density measurements, local defect region emitted radiation measurements, and local irradiation induced electrical response measurements. Supplementary information can be gained from both near-field optical microscope and electron microscope measurements.

Noise diagnostics of solar cells in this case was carried out by effective value of narrowband noise current with PN junction polarized in reverse bias. Reverse voltage U_R may not be higher than avalanche voltage of whole no defect area of the junction. The analysis of microplasma noises determination its sources are very difficult because of large solar cell surface and uncountable number of local regions. Because of these reasons we measure not the whole solar cells but their separate fragments. The experiments show that it is possible to observe two types of noise using our method. The A type of noise [1] (microplasma noise) is shown in Fig. 1. This noise is in a shape of two or more pulse levels of current with constant amplitude, random time of appearance and random time of pulse duration.

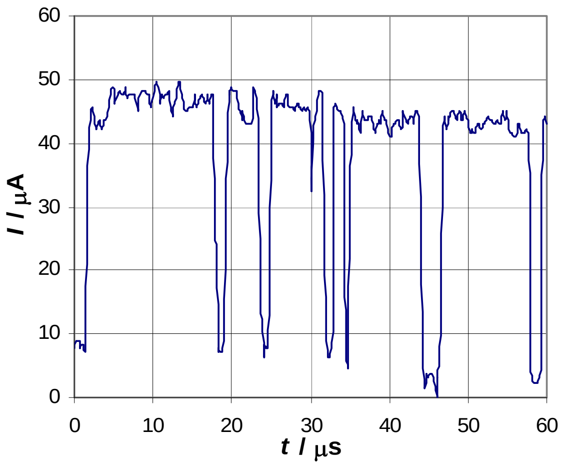

Figure 1: Microplasma noise (A-type)

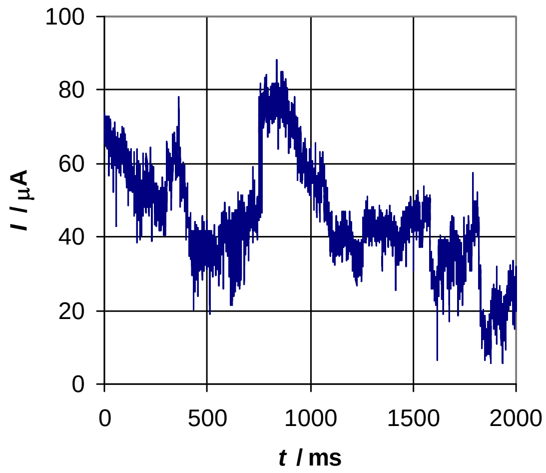

Figure 2: Heavily non-stationary B-type

Another type of noise is B-type (Fig. 2) is no stationary and this noise can occur as a result of thermal breakdowns of PN junction [2].

2. ANALYSIS

2.1. MEASUREMENT DEVICE

From the viewpoint of noise diagnostics, suitable features are RMS values of narrow-band noise current I_N versus reverse voltage U_R or reverse current I_R plots, because each local extreme of these plots corresponds to an active local defect region.

A noise voltage $u_N(t)$ appears across the load resistance $R_L = 5.17\ \Omega$ through which the noise current $i_N(t)$ is flowing (Fig. 3). Being amplified by a pre-amplifier PA (3S Sedlak PA 31) and amplifier CNRL (3S Sedlak). The noise voltage is converted into a voltage, whose time average is proportional to the RMS value U_N of $u_N(t)$ in the given frequency band by a noise detector ND (selective nanovoltmeter Unipan 237, the center frequency 420 Hz, the effective bandwidth 49 Hz). The voltage U_N is measured by a digital voltmeter DV.

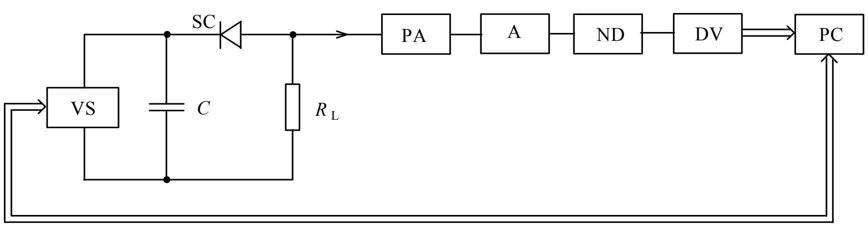

Figure 3: Apparatus to measure noise current

The set-point values of the PN junction reverse current being adjusted by means of a PC-controlled voltage supply VS (Agilent E3649A) the diagram $I_N = f(U_R)$ shows an I_N versus U_R plot.

2.2. RMS VALUE OF NARROW-BAND NOISE CURRENT

Figure 4, 5 shows the noise current RMS value I_N, versus the ramp reverse voltage U_R. Each measurement was carried out for reverse current up to 3 mA.

The example of a course measured on a solar cell from indication Inf4 is in Fig. 4. The solar cell exhibits the threshold of the noise current increasing for the reverse voltage of about 1 V. This effect is probably due to strong voltage dependence of local defects activity. The measured noise current maximum value is 16 nA. We can assume that this sample of solar cell will not show microplasma noise.

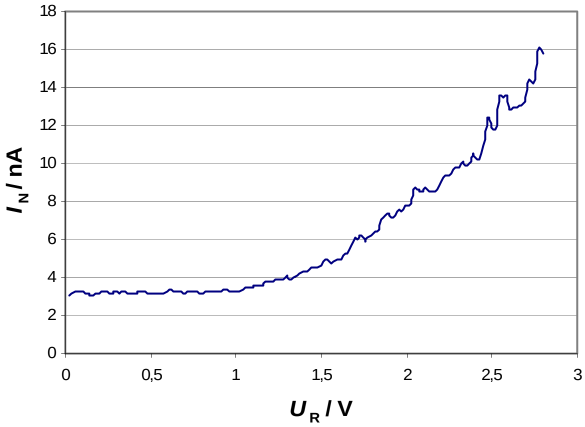

Figure 4: Narrow band RMS noise current versus reverse voltage plot, solar cell Inf4

The noise characteristics of a solar cell with the indication Inf5 is in Fig. 5. This realisation has many local extremes which correspond to local noise sources. Current noise of this sample significantly increases from 10V. Its maximum value is 29 nA. This sample was measured up to reverse voltage 33V (3mA). On the basis of the realisation we can assume that microplasma noise will occur.

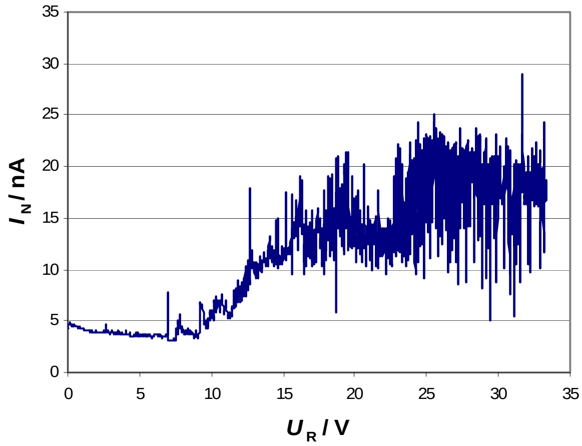

Figure 5: Narrow band RMS noise current versus reverse voltage plot, solar cell Inf5

2.3. TIME REALIZATION MEASUREMENTS ON OSCILLOSCOPE

The similar connection was used for time realization measurements as in the previous case (Fig. 6)

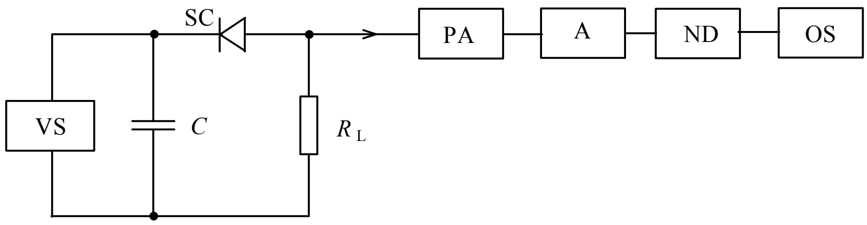

Figure 6: Equipment to measure time realization

We can determine if a particular solar cell could have microplasma noise based on measurement result of RMS value of narrow-band noise current. Solar cell Inf4 doesn't show microplasma noise. We assumed this also based on noise characteristic realization (Fig. 4). The noise characteristic of sample Inf5 showed that it is possible to observe microplasma noise of this sample (Fig. 5). Thiss assumption was also confirmed by Fig. 7.

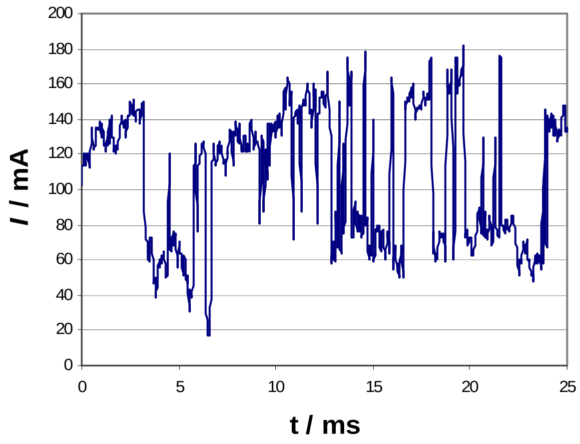

Figure 7: Microplasma noise of solar cell Inf5

3. CONCLUSION

RMS value of narrow-band noise current measuring method vs reverse voltage was used for solar cell diagnostics. This method was very efficient. It is very simple method which can be easy realized and can be used to detection of solar cells local defects in PN junction area.

This method can be used to microplasma noise detection of particular solar cells. If there are some peaks in the noise characteristic than we can assume that this sample will show microplasma noise. Otherwise microplasma noise doesn't occur.

From the realization in Fig. 7 we can see that this sample has A-type of noise (microplasma noise) and B-type noise. This effect was observed for the first time and it will be the object of following research.

ACKNOWLEDGEMENTS

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