Detection of Microplasma in Solar Cell

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Abstract - **This sheet deals with detection of generation and behavior of microplasma in solar cell. The generation of microplasma is influenced by several factors. The first of them is defected silicon crystal-grid causing non-homogeneity of parameters that, in turn, creates visible defect. The second is dislocation of PN junction. At places where PN junction is thinner or mechanically damaged, the microplasma discharge and emission of light is present.**

Keywords – **solar cell, microplasma, noise, diagnostic**

I. INTRODUCTION

One of the negative factors the technical civilization is never ending increase of power consumption. Due this factor is required highly usage of alternative electric power sources. One of the “green energy” sources is photovoltaic system which could cover high level of demand of consumption. The flagrant necessity for massive use of the solar system in praxis is increasing the solar cell efficiency. For the efficiency increasing is a selective process needed. One of the parts this process is observation and analyzing microplasma in the solar cell.

II. MICROPLASMA TIME BEHAVIOR

Let us count that a diode having a single microplasma region in the PN junction. When the reverse voltage is low, it is a stable state and there are no avalanche breakdowns. So the current on the diode is constant. If reverse voltage is increased, very-low-frequency short-time current impulses will start appearing. Next voltage increase results in increasing both the impulse frequency and width (Fig. 1). After a definite voltage is passed over, the plasma will be ionized solidly and the stable state will be obtained again. If there are a few of microplasma regions in the diode, the above process may occur several times if the voltage is further increased.

This theoretically describe of microplasma time behavior in the PN junction is applicable on large-area Si PN junction. If is named PN junction as large-area it is area much bigger than tenth of square millimeters. In this application is observed area of PN junction approximately 100 square centimeters.

Microplasma can originate in whole solar cell. The origination of microplasma can be cause by several factors. The first of factor is dislocation in crystal grid. In this case is microplasma observable with the increasing reversed biased voltage. In time scale microplasma is more evident with increasing reversed biased voltage.

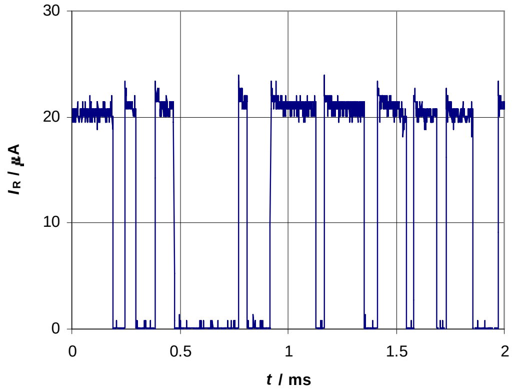

Figure 1: Example of a two-level noise vs. time plot.

Second factor of microplasma origin is mechanical damage such as damaged pyramid in PN junction, which can be caused by bad manipulation during production. Other possible sign of mechanical damage is bad treatment of solar cell edges. Passivated edges of solar cell are often damaged. Scratches originated during produce are other possible damage. Defects caused by mechanical damage are stable in time and reversed biased voltage and their quantity is still almost the same. They can be seen already with low reversed voltage. Mechanical defect can be categorized as process defects and can be minimalized by increase of produce quality.

Microplasma that originated at mechanically damaged places is critical, because the defects are usually bigger. By that ability to recombination at PN junction is decreased significantly, and total efficiency is also decreased.

If more contacts are damaged then influence of total efficiency is more significant. Influence of local defects in crystal grid that is more significant with increasing reversed biased voltage, does not decrease total efficiency solar cell. They influence on is in summary only few of percent of total solar cell area.

III. EXPERIMENTAL

Considering that microplasma emitted light in visible spectrum it is possible observed the process with a special CCD camera in a dark cryogenic box. The apparatus for the method (fig. 2) contains highly sensitive low-noise CCD camera G2-3200 with CCD chip by Kodak KAF – 3200ME. It can be cooled up to -20° C. Camera contains set of light filters, special objectives and equipment for

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contacting solar cells. Solar cell is connected to reverse bias DC power source. Signal form CCD camera is analyzed by PC computer. The contact area is placed on dish with LN2. The temperature of underside area is -21°C. Due to the cooling is possible to observe the smallest defects in solar cell.

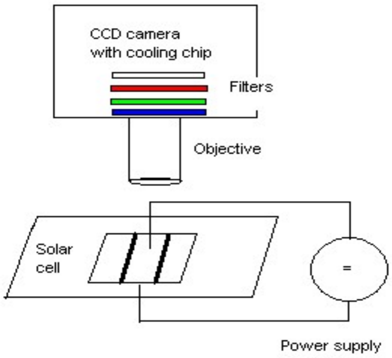

Figure 2: Microplasma method workplace

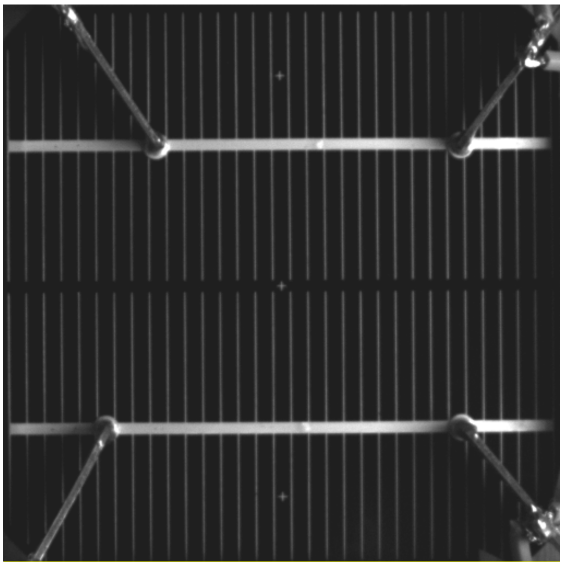

Figure 3: Tested solar cell

The number of the visible defects in solar cell depends on connected reversed biased voltage (RBV). During increasing reverse biased voltage it is possible to observe more shining points (Fig. 4 - Fig. 5.). It was measured with exposure time 20 sec, clear light filter and the CCD chip was cooled into -20° C.

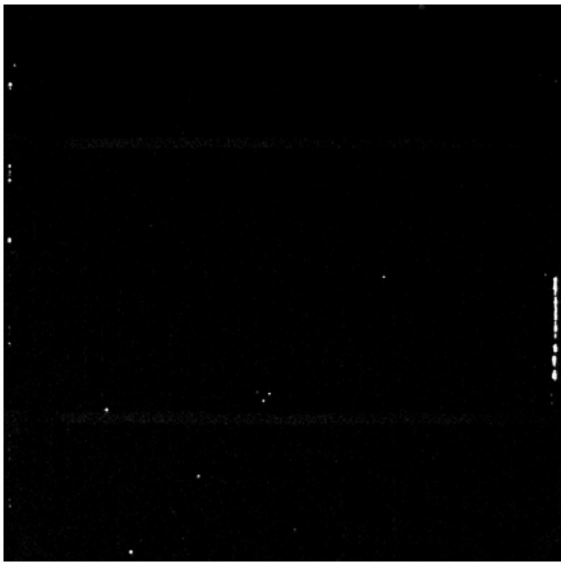

Figure 4: First bigger detection of microplasma sources - right edge and a few of local microplasma on solar cell; R_{BV} = 4 V, I = 0,13 A

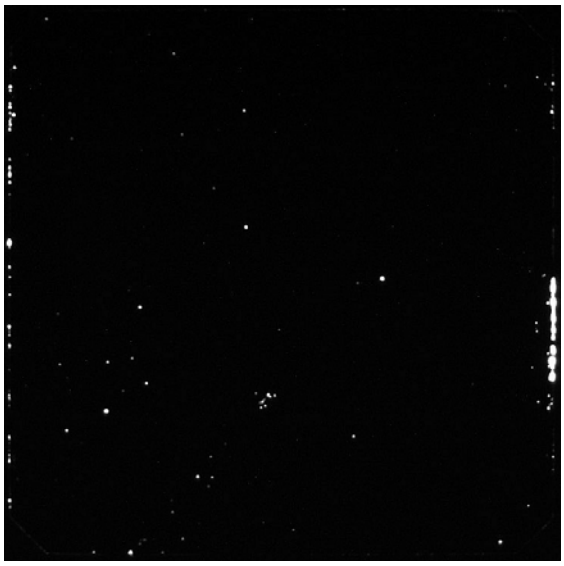

Figure 5: Fully developed areas of microplasma sources – left and right edges and much more local microplasma on solar cell; R_{BV} = 10 V, I = 0,34 A

As we can see on figures 4 and 5 during increasing reverse biased voltage it is possible to recognize more local microplasma sources. Counts of microplasma sources are highly depending on reversed biased voltage. It is necessary to control reverse current values. High values can create avalanche breakdown in the PN junction and damaged or destroyed solar cell.

For Comparison this analyzing method are following pictures take by another method. The first one is using electroluminescence analysis (Fig. 6). It contains visible swirl defect. The dark areas on figure are places with low current density. Next picture is take by LBIC method (Fig. 7). The swirl defect on solar cell is visible again.

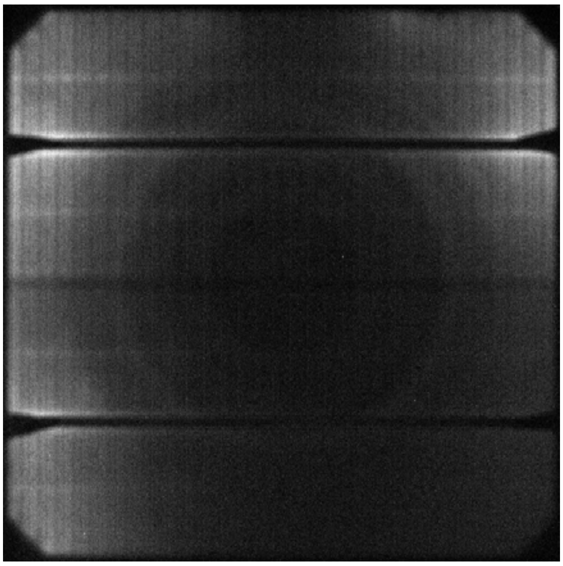

Figure 6: Electroluminescence method –
I_F = 1 A, t = - 20 °C

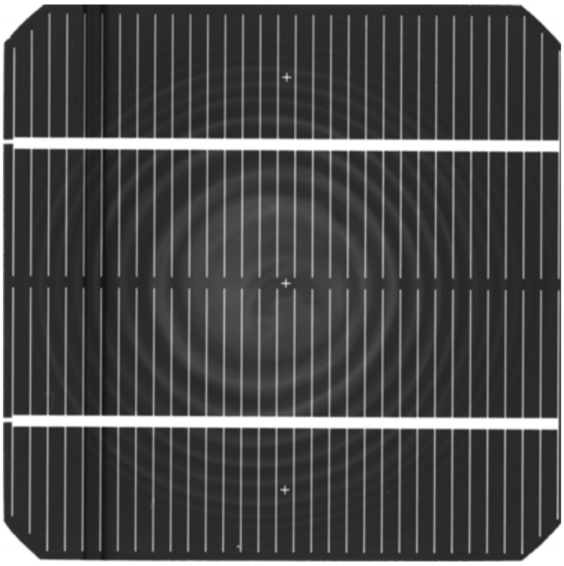

Figure 7: LBIC method – red LED

IV. CONCLUSION

Behavior microplasma sources in the solar cell dependent on connected reversed biased voltage and reason of originate. Counts of microplasma caused by defects in crystal grid increase with connected reversed voltage. Counts of microplasma on edges is not depending on reversed voltage. Only the intensity of emitting light is growing up.

In contrast with figures taken by electroluminescence and LBIC the screens of microplasma do not contain visible marks of swirl defect..

V. ACKNOWLEDGEMENTS

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