doi: 10.1063/1.2759689

Solar Cells Noise Diagnostic and LBIC Comparison

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Abstract. This paper is intended to present the results of our experimental study of defect in silicon solar cells. Solar cells defects are diagnosed by LBIC characterization and noise spectroscopy. Low frequency noise is a more sensitive tool for analyzing of degradation phenomena, like electro migration and sort of breakdown. All type of noise - thermal, shot, generation, recombination and 1/f type of noise play a different role in reliability analysis. The correlation between noise and transport characteristic indicates possibility of this diagnostic tool. Therefore the noise spectroscopy and LBIC is a pair of the very useful methods to provide a non-destructive characterization on silicon semiconductor solar cells.

Keywords: noise spectroscopy, LBIC, solar cell.
PACS: 05.40.Ca, 42.62.Eh, 84.60.Jt

INTRODUCTION

The need for increasing the solar cell efficiency implies the application of selective processes within the framework of their structure preparation technology. Under the term selective processes, we understand such processes, in the course of which the solar cell structure is formed within an exactly predefined region.

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Two different groups of solar cells have been prepared for the structure analysis with selection by LBIC. Fist group contains no visible errors and second group contains surface errors detactable by LBIC.

CP922, *Noise and Fluctuations, 19th International Conference,* edited by M. Tacano, Y. Yamamoto, and M. Nakao

LBIC METHOD

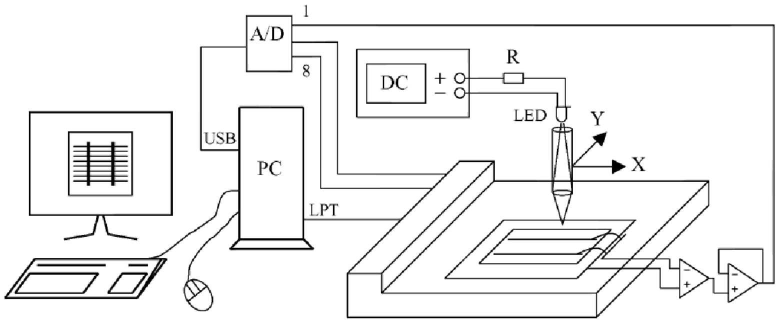

FIGURE 1. Workplace with the LBIC method.

Light Beam Induced Current (LBIC) works on principle of exposure very small area of a solar cell, usually by laser beam focused directly on the solar cell surface. This point light source moves over measured solar cell in direction of both X and Y axis. Thanks to local current response the XY current distribution in investigated solar cell can be measured. Acquainted data are then arranged in form of a current map and the behavior of all solar cell single parts is thus visible. In such current map is therefore possible to determine majority of local defects (Fig.3). Sometimes there is necessary (automatically or by hand) to extend steps of grey on displayed areas for good picture of particular defects.

FIGURE 2. This is the non-defects solar cell G3/1.

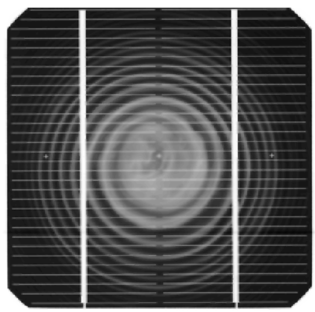

FIGURE 3. This is the solar cell G1/4 with swirl defect.

Accuracy of this method depends on actual size of the light point and on the step of the laser pen movement. By long step the accuracy of the method is low, but whole measurement process accelerates because of reduced number of measured points. On the contrary in the case that the step matches the sizes of the light point the measurement will be highly accurate but also very slow. On this account there is very important to choice the optimum ratio step to light point size. It is obvious that the accuracy of LBIC measurement depends firstly on the light point size. Laser diodes are therefore used because of well mastered technology of focalization of laser beam. Next advantage of laser diodes is very high light beam intensity. Method LBIC (Fig.1) is indeed lengthy and is advisable to use it only at small quantity of solar cells.

Noise analysis

The possibility of the use of noise measurements in analysis, diagnostics and prediction of reliability of electronic devices was studied by many researchers, namely by Van der Ziel and Tong [1], Vandamme et al. [2], Kleinpenning [3]. A new specialization Reliability Physics was created. It is concerned with identification of failure modes and mechanisms as the main sources of problems related to quality assessment and reliability prediction. It is generally supposed that reliability is determined by irreversible processes and that their time dependence is the main parameter for device lifetime prediction.

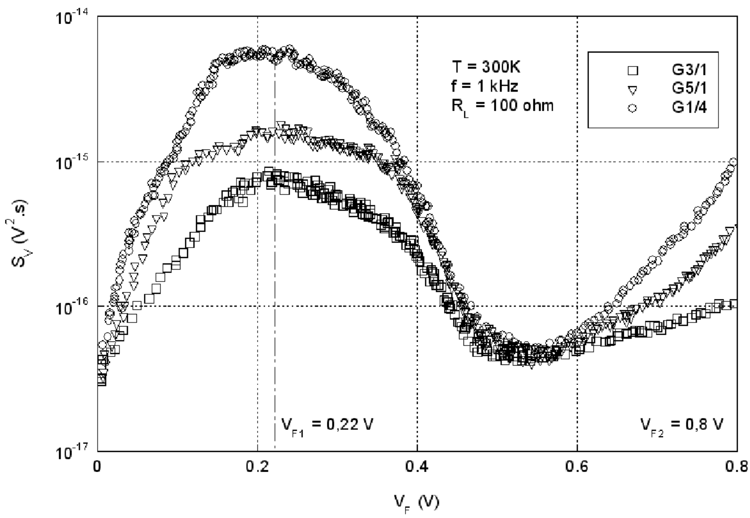

FIGURE 4. The noise spectral density as a function of forward voltage for nos. G1/4, G3/1 and G5/1 solar cells in forward direction.

Fig. 4 illustrates the noise voltage spectral density versus applied DC voltage plot, the noise voltage being picked up across a load resistance R_L=100 Ω, at a band mean frequency of 1 kHz and a bandwidth of 20 Hz.

It is evident that the G3/1 specimen feature a markedly lower magnitude of the noise spectral density, with a maximum of S_{UMX} = 9.10^{-16} V^{2}s at a voltage U_{F1} = 0.22 V as G1/4 specimen and S_{UMX} = 8.10^{-15} V^{2}s. These specimens, G1/4 and G5/1, feature also much higher spectral density increase at low voltages than the above mentioned G3/1.

In a region at a voltage U_{F1} = 0.6 V to 0.8 V we can see accrual of excess noise component which source is in the contact series resistance R_S. Progress of the noise resistance state. Value of S_U reaches at a voltage U_{F1} = 0.8 V as G1/4 specimen S_{URS} = 8.10^{-16} V^{2}s while for specimen G3/1 only value of S_{URS} = 1.10^{-16} V^{2}s.

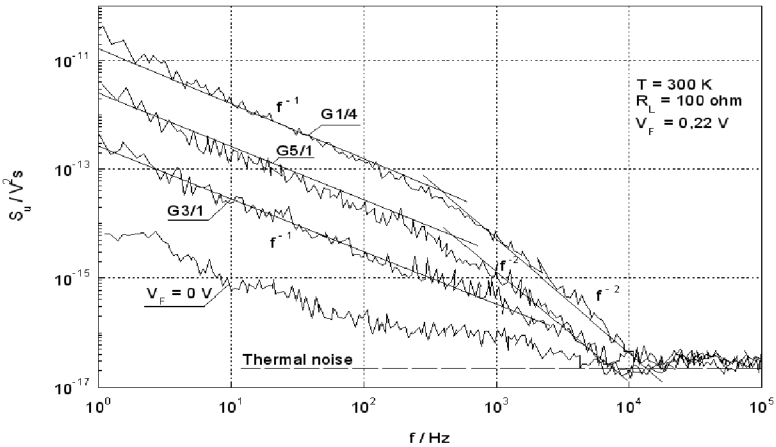

FIGURE 5. The noise spectral density versus frequency for mos. for nos. G1/4, G3/1 and G5/1 solar cells in forward direction

Fig. 5 shows a voltage noise spectral density S_U versus frequency plot, at a temperature T=300 K, the noise voltage being picked up from a load resistor $R_L = 100\ \Omega$ for G1/4, G3/1 and G5/1 specimens. The curve labeled $U_F = 0$ V indicates the measuring setup background noise. The shape of the noise curves of G3/1 and G5/1 specimens for the applied DC forward voltage $V_F = 0.22$V shows the excess noise component to be of the $1/f^1$ type for frequency smaller than 1000 Hz and $1/f^2$ type for G1/4 for frequency 300 Hz<f<10000Hz, which is typical of the generation-recombination (g-r) noise.

CONCLUSION

The measurements have demonstrated a strong correlation existing between the noise parameters and the LBIC characteristic. One of the noise spectroscopy application benefits consists in its much higher sensitivity.

ACKNOWLEDGMENTS

This research has been supported by project of GACR No. 102/06/1551 No. 102/05/P199 and MSM0021630516.

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