CONTACT AND SHEET RESISTANCE MEASUREMENTS ON SOLAR CELLS

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ABSTRACT

Experimental study of contact and sheet resistance of solar cells has been carried out. New testing methods based on DISPOT measuring has been shown. System provides measuring of a lay surface potential, directly on a surface of researching object in chosen axis. This paper offers measuring system and apparatus descriptions and also presents determination of parameters for contact and sheet resistance.

1 INTRODUCTION

In this paper, highly efficient solar cells samples made by Solartech manufacturer have been studied [1]. These are made with modern semiconductors technology (PESC) from monocrystalline silicon. The shape of measured samples is square as shown in Fig. 1, where Side A is illuminated front side and side B is rear. Conducting layers are made by screen printed method of silver. Sintered at temperature more then 800 C. There is also antireflection layer on the surface, which is served for protection of active area.

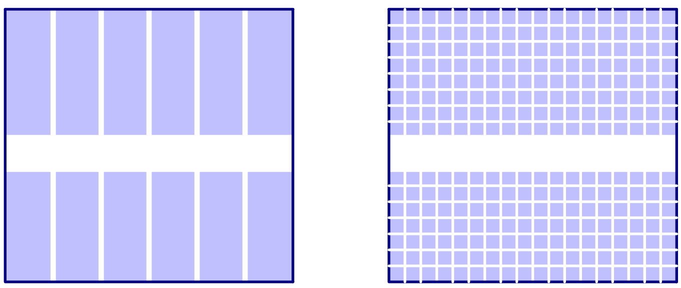

Fig. 1: *Solar cell samples*

2 THE MEASURING SYSTEM

Measuring system consists of a measuring unit supplied from external adapter (12VDC 500mV), LCR Meter Agilent 4263B, GPIB interface, GPIB cable for PC an LCR meter connection and a personal computer with the following specification:

System requirements:

- 400MHz, 64MB RAM, free 10MB
- Free port RS232C
- Installed interface Agilent 82357A (USB/GPIB Interface for Windows) or Agilent 82350B (PCI GPIB Interface)
- Windows® 98,ME,XP

Schematic diagram of the measuring system is shown in fig. 2.

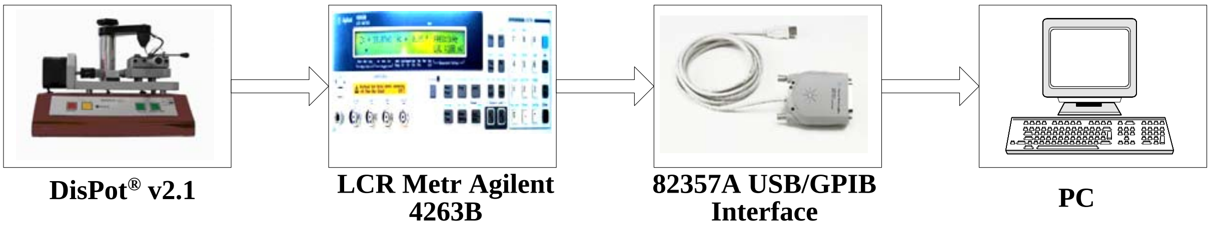

Fig. 2: *Schematic diagram of the measuring system*

2.1 THE MEASURING APPARATUS DISPOT®

This system provides measuring of a lay surface potential, directly on a surface of researching object in chosen axis. Interconnection of measuring system DisPot with peripheral electric is provided on the back side of DisPot system.

Tetrad of BNC connectors on the back side of system is served for system DisPot v2.1 and LCR meter Agilent 4263B interconnection. RS232C interface is served for PC and DisPot communication. Appropriate connector is also emplacement on the back side of the panel, next to the grounding terminal connector. Last connector is for power supply adapter with output voltage 12 V and maximum external current take-off 500 mA.

3 CONTACTING OF MEASURED SAMPLE

Proper contacting of measured sample is necessary for obtaining reliable data. The equipment is arranged for current and voltage four-point measurement. Instruments based on the four-point measurement work on the following principle:

- Two current leads, C1 and C2, comprise a two-wire current source that circulates current through the resistence under test.
- Two potential leads, P1 and P2, provide a two-wire voltage measurement circuit

that measures the voltage drop across the resistance under test.

- The instrument computes the value of resistance from the measured values of current and voltage.

4 SHEET RESISTANCE

Sheet resistance was measured on both sides by DisPot measuring apparatus, which was described before. Fig. 3 shows sheet resistance on sample No 194119Wa where ϕ is potential normalized by the value of measuring current, d is distance in mm. DC and AC current method was applied. For high conducting layers we obtain the same result for DC and AC methods up to frequency 10 kHz as is shown in fig. 3.

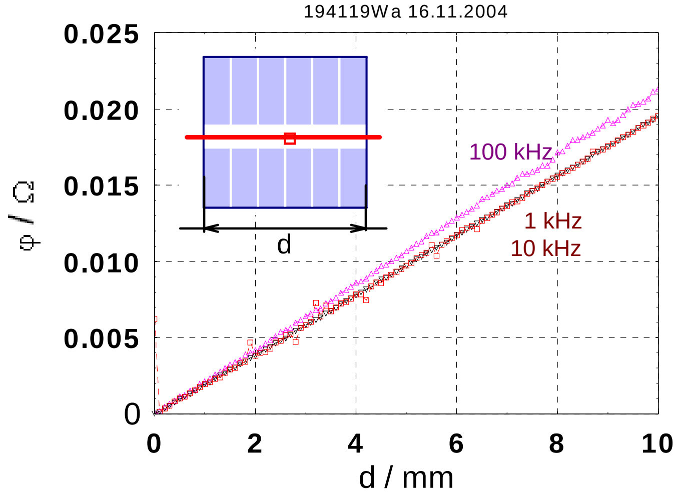

Fig. 3: *Sheet resistance*

Slope in fig. 3 corresponds to normalized potential change on distance 1 mm. With of silver contacting layer is 2 mm then for slope 2 mΩ/mm we have sheet resistance 4 mΩ/mm.

Silver layer sheet resistance varies in width range with a slope m = 2 mΩ/mm to 2.2 mΩ/mm as is shown in fig. 4.

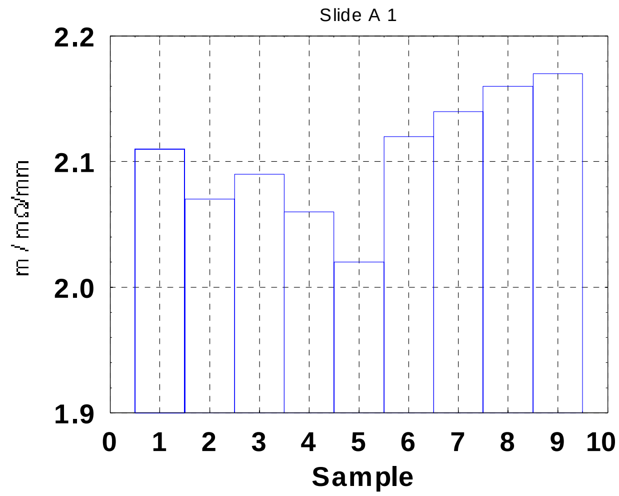

Fig. 4: *Sheet resistance bar chart diagram*

5 CONTACT RESISTANCE

Contact resistance between silicon wafer and silver contacting layer is second important parameter for solar cell technology optimization. When current is flowing from semiconductor to metallic electrode charge curriers must over come potential barrier creating by different work functions of M-S (Metal - Semiconductor) structure.

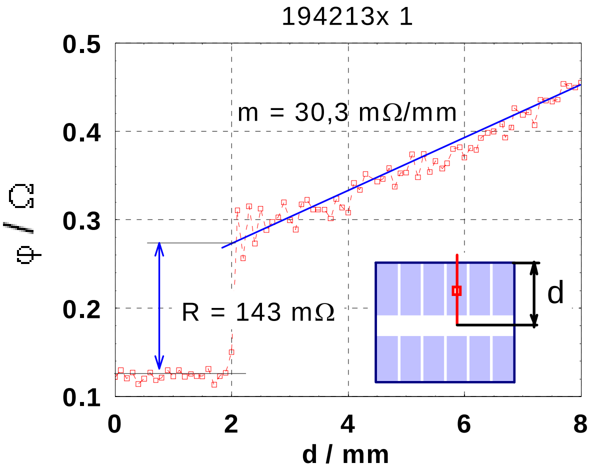

Fig. 5: *Sheet and contact resistance*

Experimental value of contact resistance measurement on sample No 194213X 1 is in fig. 5. Sheet resistance where is from 100 to 400 m $\tilde{\Omega}$. Bar chart diagram of contact resistances measured on ensemble 1 samples is in fig. 6, where 1 to 4 measurement correspond to different positions at the same sample.

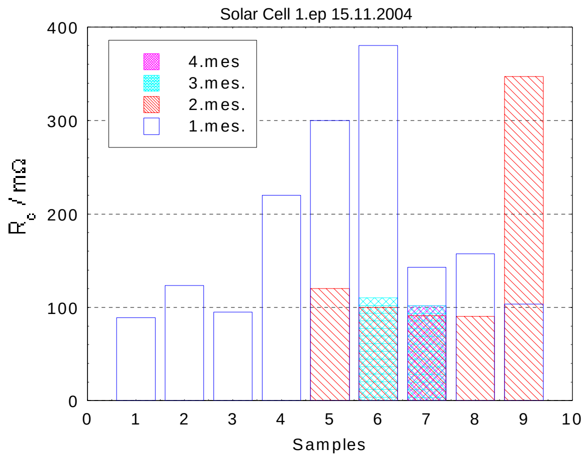

Fig. 6: *Contact resistance bar chart diagram*

We suppose that contact resistance between silicon and silver layer play much more important role then silver layer sheet resistance and technology must by optimized for both parameters – silver layer sheet resistance and silver silicon contact resistance.

Describes method based on DisPot apparatus allows to measure the sheet resistance of silicon wafer. Results of this measurement are shown in fig. 5 and statistics is in fig. 6.

Bar chart diagram of silicon sheet resistance gives information on silicon wafer and from fig.7 we have slope of normalized potential *m* varying in wide range.

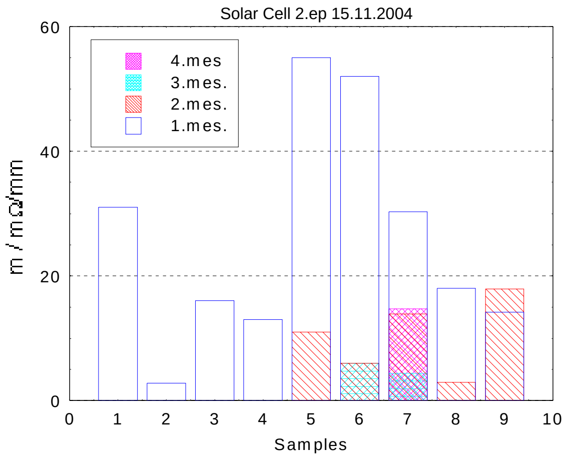

Fig. 7: *Silicon sheet resistance bar chart diagram*

6 CONCLUSION

Experimental results of contact and sheet resistances of solar cells shows that silver layer sheet resistance is 4 mΩ/mm with corresponds for layer thickness 20 μm specific resistance about 5 time higher than silver volume specific resistance.

Contact resistance between Si and Ag layer is about 100 mΩ. This value is dependent of sample area, work function of silicon and silver. This parameter must by optimized for given technology.

REFERENCES

[1] Hruska P. et al.: Analysis of solar cell transport propertis, Proc. of Int. NODITO Workshop, July 18-20,1995, Brno University of Technology, 1995

[2] Majzner, J.: DisPot apparatus description, Phys. Department, Brno University of Technology, 2004