The basic electrical characteristics of silicon cells

Tresh Abdunasser M.
IIDE
Belarusian national technical university
Minsk, Belarus
e-mail: treshnasser@yahoo.com

***Abstract*—The basic electrical characteristics of silicon cells have been fully discussed in this paper.**

Keywords: silicon cells, photovoltaic receiver, cell series resistance

Several researchers pay great attention to silicon wafer characteristics which are base of electric solar power stations [1], [2]. Figure 1 shows a typical silicon cell used in a commercial line-focus concentrator module. The cell area represents one-half of a standard 10 cm square one sun type cell. Dual busbars allow the current to be efficiently extracted from both sides of the cell. The key consideration for cells to be used in low-concentration, line-focus modules relates to series-resistance minimization. Figure 2 shows the impact of total cell series resistance on cell efficiency for the cell shown in Figure 1., when (hat cell is operated at 20 suns irradiance. At this irradiance level, the current output of the cell is 25 30 A. Note that each mΩ of added resistance results in about one percentage point drop in cell efficiency.

Total cell series resistance is due to several components, which can be individually analyzed. Starting at the back of the cell, the current must flow

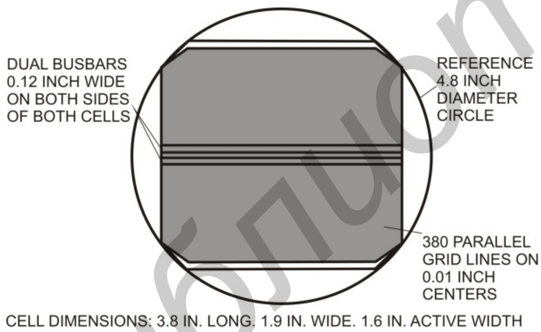

FIGURE 1. Two 20 sun concentrator cells on a single silicon wafer.

laterally across the back metallization, encountering normal metallization resistance. The current must then flow from the back metal into the bulk silicon material, encountering contact resistance between the back metal and the underlying semiconductor. The current must then flow from the backside of the cell to the emitter at the topside of the cell through the bulk silicon material, encountering bulk resistance. The current must then flow laterally in the emitter layer of the cell toward the topside metal gridlines [5], encountering sheet resistance. The current must then flow from the emitter layer into the grid lines, encountering contact resistance between the emitter and metal grid lines. The current must then flow along the grid lines to the busbars, encountering normal metallization resistance. Approximate equations for the key components of series resistance for line-focus concentrator cells can be derived by integrating the voltage drop (or power loss) along the various current flow paths .

To minimize the cell series resistance, very heavy metallization coverage is desirable on both the top and bottom surfaces of the solar cell. However, heavy metallization coverage on the topside of the cell normally carries a penalty relating to incident light blockage (grid shadowing loss). This potential loss can fortunately be overcome by using a prismatic cell cover, as shown in Figure 3. The prismatic cover is made of transparent silicone rubber and includes small refractive elements that direct incident sunlight away from grid lines and onto active silicon material instead. By employing such prismatic cell covers, production cells of the type shown in Figure 1 have been manufactured in 20,000 cell quantities, with average efficiency levels of 18% at 20 suns irradiance and 25°C cell temperature (O'Neill et al., 1991a). These cells were made on low-cost, 0.5- 1.0 Ohm-cm Czochralski silicon wafers and employed 20%-40% topside metallization coverage to reduce total cell series resistance to about 1 mΩ.

To maximize system performance, cells that are series connected into circuits should be current matched. This is generally done by flash-testing individual cells at the design irradiance level, grouping them according to peak-power current, and ensuring that all of the cells in each receiver are from the same current group. Thereafter, modules that are series connected in the field should all employ cells that are likewise current matched.

Bypass diodes are used to prevent reverse-bias power dissipation overheating of cells that become shaded or cracked [6]. Typically, no more than five cells are interconnected in series without a bypass diode protecting them.

All conductors and connectors in a receiver should obviously be capable of handling the highest anticipated module current, which corresponds to short circuit current under hot conditions with peak direct normal irradiance.

Normally, conductors and connectors arc selected based on a performance cost trade off [3]. For example, a conductor can be made larger to reduce resistive power loss, but this increases the conductor cost. The best conductor size is the one that minimizes system cost per unit of system energy delivered.

All electrically live parts of the receiver (including cells, diodes, conductors, and connectors) must be dielectrically isolated from the electrically grounded parts of the module (including heat sink and housing) [4]. Typically, the resistance between the live parts and the grounded parts of a receiver should be at least several hundred million ohms (several hundred megohms).

The complete photovoltaic receiver should be well encapsulated to prevent ground faults (current leakage from the electrically live parts of the receiver to the grounded parts of the module) under both dry and moist conditions. Condensation routinely occurs inside concentrator modules, and small amounts of rain infiltration are not uncommon. Drain holes should be provided at appropriate locations in the module.

[1] A.G. Aberle, Fabrication and characterization ofcrystalline silicon thin-film materials for solar cells, ThinSolid Films, 511-512 (2006) 26-34.

[2] L.A. Dobrza□ski, A. Dryga□a, Processing of silicon surfaceby Nd:YAG laser, Journal of Achievements in Materialsand Manufacturing Engineering JAMME 17 (2006) 321-324.

[3] A. Goetzberger, V.U. Hoffmann, Photovoltaic solar energy generation, Springer-Verlag, Berlin, (2005).

[4] M.J. Jackson, G.M. Robinson, M.D.H. Gill, and W. O'Neill, The effect of nozzle design on laser micro machining of M2 tool steels, Journal of Materials Processing Technology, 160 (2005) 198-212.

[5] E. Klugmann-Radziemska, E. Klugmann, Alternative sources of energy. Photovoltaic energy. WEi, Biaystok, (1999) (in Polish).

[6] D. Kray, S. Baumann, K. Mayer, A. Eyer, G.P. Willeke, Novel Techniques for low-damage microstructuring of silicon, 20th European Photovoltaic Solar Energy Conference and Exhibition, Barcelona, (2005), 156-159

[7] Трещ А.М Исследование характеристик солнечных батарей/ А.М. Трещ// Мат.респ. научно-практич. конф. "Современны информационные технологии в системе научного и учебного эксперимента: опыт, проблемы, перспективы" г.Гродно, 4-5апреля 2011г., с45-47.

[8] Tresh A.M. MATLAB/SIMULINK MODEL FOR SIMULATION OF PHOTOVOLTAIC MODULE P.P. 111-115

TOTAL CELL SERIES RESISTANCE (mΩ)

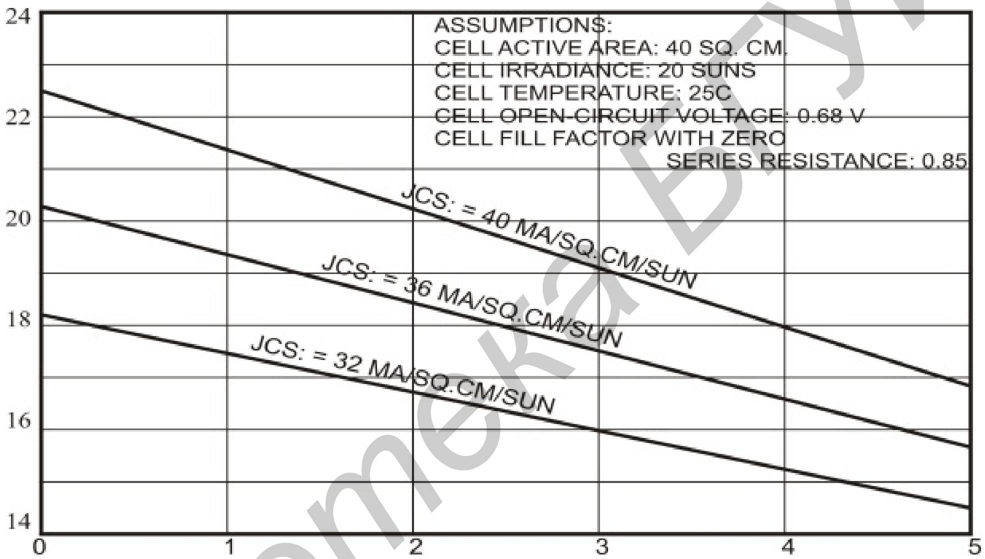

FIGURE 2. Calculated 20 sun cell efficiency versus total cell series resistance.

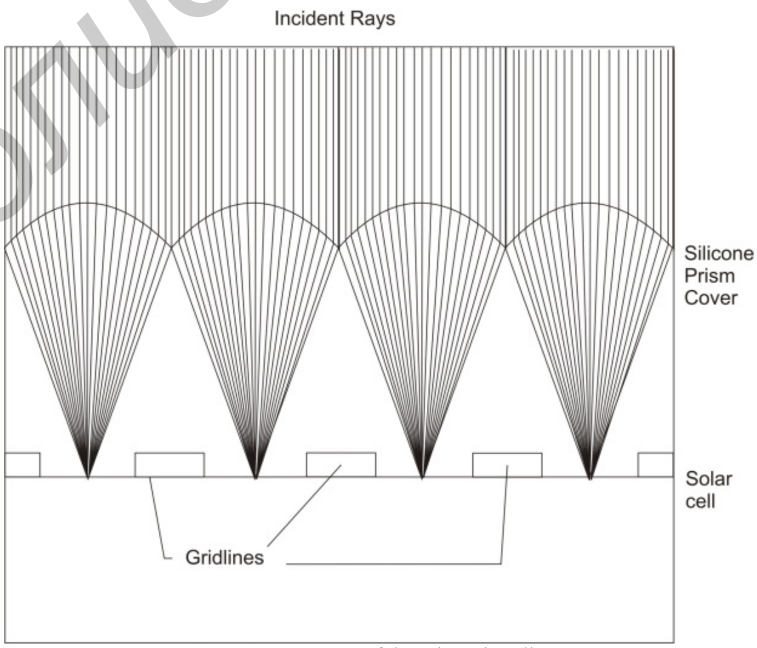

FIGURE 3. Ray trace of the prismatic cell cover.