LOW "C" CELLS FOR CONCENTRATOR OF REFLEXIVE CAVITY (CRC)

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ABSTRACT: The purpose of this work is based on the design and development of conventional one sun silicon PV cells with modified screen printing designs to be used in a Concentrator of Reflexive Cavity (CRC). The concentration ratio of the concentrator is between 10X and 15X. The screen-printing of the cells has been optimized to minimize as much as possible the serial resistance losses and the shadowing effects produced by the fingers and busbars. Two different cavity sizes have been designed for testing two different cell sizes and designs. A theoretical comparison of how the screen-printing affects the efficiency of the cells in the CRC system is carried out.

Keywords: Concentrator Cells, Screen Printing, Solar Cell Efficiencies

1 INTRODUCTION

The design of single crystalline silicon solar cells for a new low concentrator concentration factor device ($C < 15X$) is explained in this paper.

The concentrator is composed by a reflexive concentration optics. The aperture of the concentrator is square or quasi-square to optimize the space factor and efficiency of a complete module.

The concentration factor of the concentrator has been kept bellow 15X because a low profile module (low height) was search.

The focal area of the concentration optics is square and so, the cells designed for this purpose are square. A concept drawing of the concentrator is shown in figure 1.

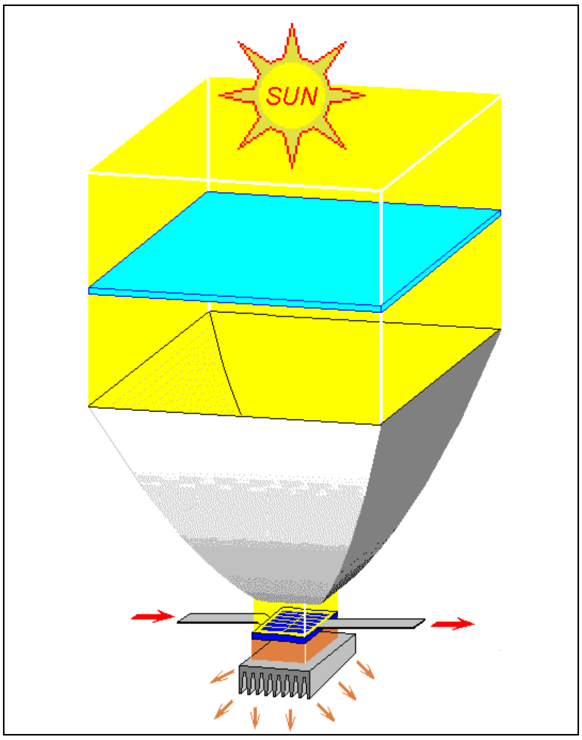

Figure 1: CRC concept.

This concentrator is denominated Concentrator of Reflexive Cavity (CRC) due to the optical characteristics which is based in a reflexive cavity.

Two different concentrator sizes has been designed and consequently, two different cell sizes have been studied.

The two different cell sizes have been chosen in order to get the best use of commercial 6 inches wafers. The cells sizes explored are 16x16mm and 50x50mm, which represent approximately 1/4 and 1/36 of the wafer respectively.

In order to keep cell cost as low as possible, commercial single crystalline solar cells have been used where the only modification has been carried out in the front grid screen printing design.

2 LIGHT DISTRIBUTION OVER THE CELL

In a square reflexive cavity, the contiguous sides of the cells project uniform radiation over the cell, but the aperture corresponding to the four corners do not allow to distribute uniformly the radiation, producing an inhomogeneous radiation pattern over the cell.

2.1 Large cell light distribution

The large cell size is 50x50mm, but only and area of 46x46mm is illuminated by the concentration optics. The reason is because the main current collecting buses are placed near the edges of the cells. This way, the buses do not contribute to shadowing the cell, since the cells are not illuminated in this external area.

The theoretical light distribution over the 50x50mm cell is shown in figure 2 for 1000 W/m^2 in the aperture of the concentrator. The mean optical concentration ratio is 9.9X and the maximum is located in the center with a concentration ratio of 20.2X.

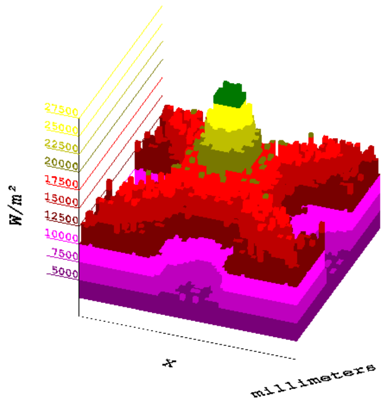

Figure 2: Light distribution over the 50x50mm cell.

2.2 Small cell light distribution

The 16x16mm cell is also illuminated in an area of 14x14mm keeping the buses in the edges of the cell. The light distribution over this cell is shown in figure 3. In this case, the mean optical concentration ratio is 13.3X and the maximum is located near the four corners of the cell with a concentration ratio of 22.7X.

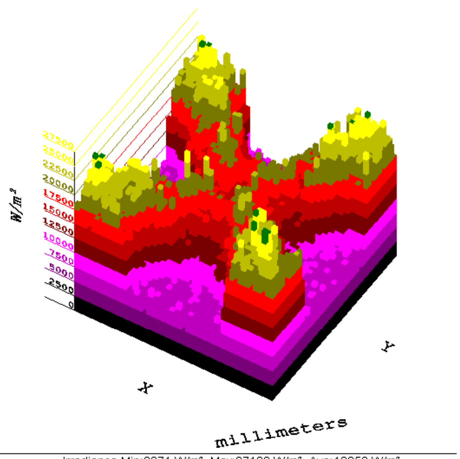

Figure 3: Light distribution over the 16x16mm cell.

3 CELL DESIGNS

3.1 Large cell design

There are two main effects that has been taken into account during the screen printing design process for the 50x50mm cell.

On the one side, the increase in current due to concentration which affects the serial resistance losses in the cell substrate, the fingers and the busbars.

On the other side, the shadowing effect produced by fingers and busbars.

More fingers in the cell will reduce for instance the serial resistance losses but will shade the front of the cell, reducing the incident irradiance available.

The optimization process for this cell has been carried out taken into account the irradiance distribution of figure 1 for each area of the cell and optimizing the number and distance between fingers. The result of the designing process is shown in figure 4.

The thick busbar in the edge of the cell is not illuminated by the concentrator optics, so its thickness does not affect the efficiency of the cell.

Due to the inhomogeneous solar radiation distribution over the cells and in order to decrease the serial resistance, internal buses of small width have been introduced to collect the extra current provided by some fingers.

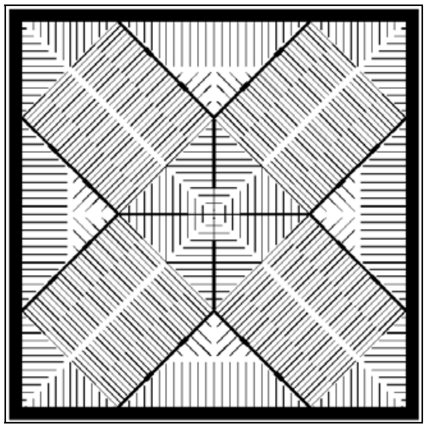

Figure 4: Screen printing front grid of the 50x50mm cell.

3.2 Small cell designs

The 16x16mm cells have been designed following the same principle as in the 50x50mm cell, but using the irradiance distribution of figure 3.

In this case, the external not illuminated buses have also been used but the internal thin buses were eliminated.

Figure 5 shows 9 different designs for this cell size. The main difference between the designs are the number of fingers and also if the fingers meet or not in the middle.

An interesting optimization effect of this design is that high irradiance is located in the corners of the cell, where fingers are shorter producing less serial resistance losses.

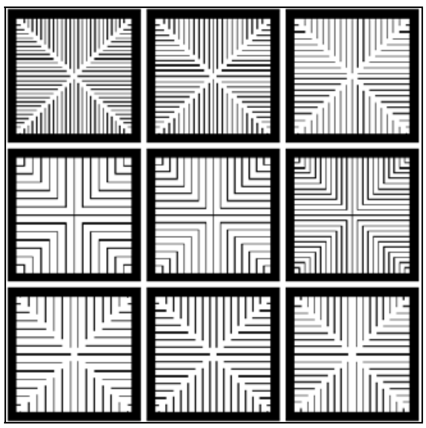

Figure 5: Different screen printing front grids for the 16x16mm cells.

The reason of designing 9 different cells is better understood if we take a look to graph of figure 6. This graph shows the theoretical efficiency of each design with regards to the mean irradiance over the cell.

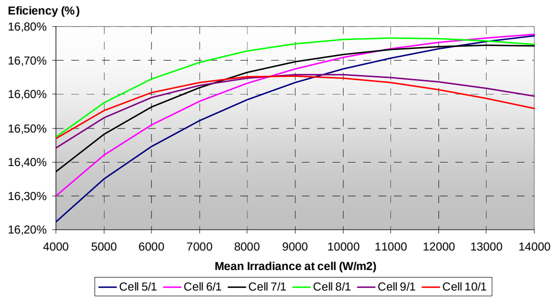

Figure 6: Theoretical efficiency of the different 16x16mm cell designs.

Some cells have a good efficiency at low irradiance values but the efficiency decreases at high irradiance values like cells 9/1 and 10/1. On the contrary, cells 5/1, 6/1 and 7/1 have a good efficiency at high irradiance values and a bad efficiency at low radiation values. Cell 8/1 seems to have the highest efficiency for all the irradiance range considered.

The idea is to check the theoretical differences in cell efficiency under real measurement conditions.

4 FIRST RESULTS

The stencil for the front grid screen printing design as well as the cells for testing have been manufactured. The cells have been tested at one sun. Table I and II shows the results obtained.

Figure 7: screen-printing stencil.

Table I shows the efficiency obtained over the whole area of the cell. However, all the area of the edges is not effective since it is not illuminated. Table II shows what the efficiency of the cells would be taking into account this issue.

Table I: Cells measured at 1 sun (efficiency over full cell area).

Cell	Pmpp (W)	Area (cm^2)	Eff(%)
50x50mm	0.248	25.00	9.9
16x16mm (5/1)	0.021	2.56	8.2

Table II: Cells measured at 1 sun (efficiency over effective cell area).

Cell	Pmpp (W)	Effective Area (cm^2)	Eff(%)
50x50mm	0.248	21.16	11.7
16x16mm (5/1)	0.021	1.96	10.7

5 FUTURE WORK

The optics for testing the two cell sizes under real concentration light are under construction. A validation of the theoretical study will then be completed.

6 ACKNOWLEDGEMENTS

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