Graphene nano layer as a grid line metalization in solar cell

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Abstract- Since the design and dimension of the grid pattern metallization on the front layer of solar cell is too important on the series resistance, collecting current and finally the efficiency, in this paper we investigate a special design that minimize the power loss of silicon multi-crystal solar cell based on exact calculating of all kind of power losses including shadowing power loss, contact power loss, lateral power loss and metallization power loss and the result is plotted in figures. Finally the improvement of graphene nanolayer as a grid line metalization is discussed.

Discussion

Solar revolution for the last 20 years is one of the most attractive subject. Using the sun light as a power supply is very seductive for us, because it is ideal that one day we can use electricity free for all of our works. The photovoltaic effect was discovered in 1839 and less than half a century it is analyzed that solar energy can convert into electricity directly, but its energy was so inefficient that couldn't be used for running any electrical devices (efficiently). Some years later, made from selenium with gold coating, the first solar cell was built which has 1% efficiency. By using Einstein's theory, photoelectric effect, about frequency of photons as the light after absorbing the solar energy (1905) and a theory of metal-semiconductor barrier layers many successes were achieved. After the growing of the single-crystal silicon, the efficiency of the silicon solar cells got considerably to increase. Cadmium sulfide, germanium, silicon, copper sulfide, and many other material were investigated for their different band-gap thicknesses based on the sun spectrum.These researches illuminated that silicon is the first material which can change enough amount of solar energy into electricity that can be used in electrical devices. Hand made and very expensive, silicon solar cells with 4% efficiency were constructed. But they improved in efficiency step by step whereby they became the main supply of satellites. Less expensive, amorphous silicon photovoltaic cells, which could be used instead of crystalline silicon solar cells, however, their efficiencies were less.The first solar-powered airplane was built in 1981. Thousands of solar cells, which produced a power of 3kW, were placed on it. One year later, the first solar-powered car with 24 km/h as the average speed, were used for 4,000km. That was faster than the first car with gasoline-powered. After a while PEC (Efficient Photo electrochemical cell) that is involved a semiconducting photoanode and a metal cathode and the DSC (Dye-sensitized solar cell) are constructed.By afford of scientists, a photovoltaic solar cell improved in converting about one third of the sunlight to electricity. This was achieved by mixing three layers of photovoltaic substances into one solar cell. By using lenses or mirrors and later by using holographic films as a concentrator of sunlight for the cell, it could work more efficiently.

Up to 2000, the highest power output for any thin-film cells had been about 92 percent. By using nano technology, solar cells construction have improved. For example, hybrid solar cells was built by complex of silicon nanocrystals and poly-3 (hexylthiophene) (P3HT) polymer. Silicon solar cells are most common kind of cells, however, They have some disadvantages**.** Black silicon can used for solar cells because flat silicon surface is normally reflect high rate of sunlight, it causes reduction in converting the solar power to electricity and decreasing the efficiency . Researchers tried to minimize this reflection by using ITO as an anti-reflective coatings and it can usually decrease about 10% of reflection. Recently, scientists make the silicon black and its performance considerably gets better. In addition, the design of the grid pattern metallization on the front layer also is too important on the series resistance, collecting current and finally the efficiency many attempts has done in this field and many shapes have suggested and even have been built[1-6].

Generally, the high efficiency solar cells can be achieved by minimizing their parasitic losses. Any kind of power losses such as shadowing, contact, lateral and metallization cannot be ignored.

In other words, some fraction of the power produced by the cell is necessarily lost by series resistance associated with the grid and by shadowing of cell active area by the grid. There are several approaches to reduction these losses, such as choosing a more efficient pattern, optimizing line spacing, using the suitable kind of metal, and so on.In order to minimize parasitic or resistive losses, one way is optimizing in the shape of metalization contact in front surface of the cell.

Grid patterns of small shadowing area have low masking losses but tend to have contact resistance problems and ohmic losses in the grid structure itself. The problem is further complicated by the need for dense coverage of the cell area with the grid pattern to reduce the power loss caused by the lateral voltage drop in the active layer, and the need to avoid grid patterns that are too fine and too resistive.

All kind of power losses including shadowing, contact, lateral and metallization for 10cm×10cm multi-crystal silicon solar cell with square fingers were analyzed and the situations which the total power loss is minimized are determined[7].

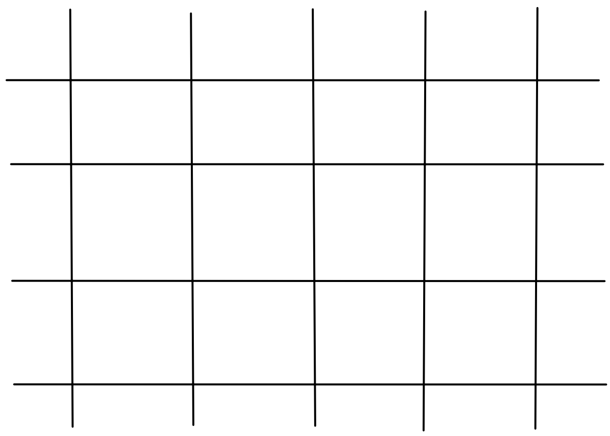

Fig.1: A kind of metallization shape

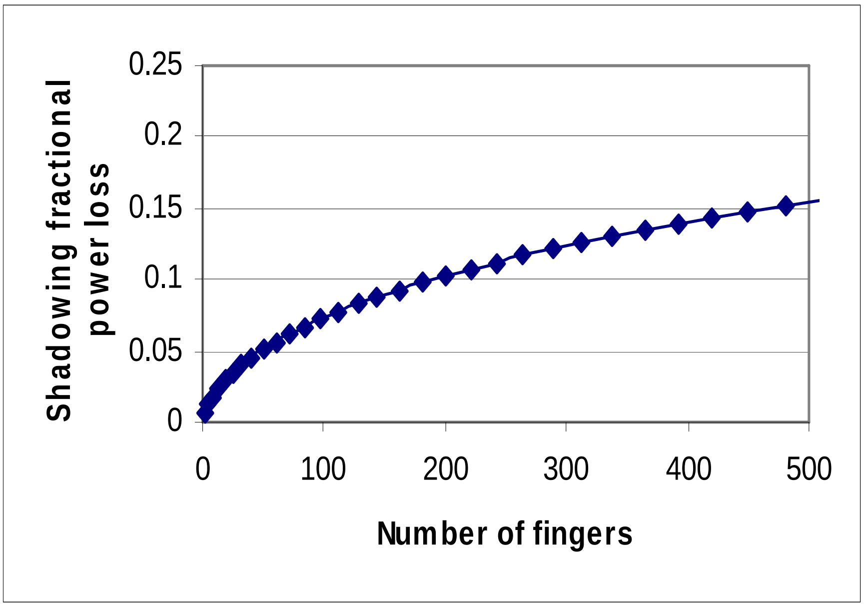

Fig.2: percentage of shadowing power loss as a function of fingers number.

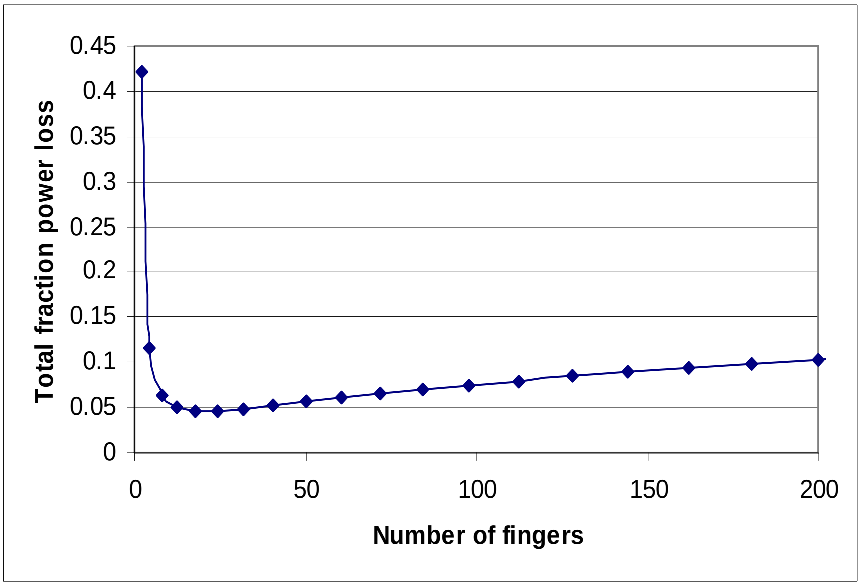

Fig.3: percentage of total power loss as a function of fingers number.

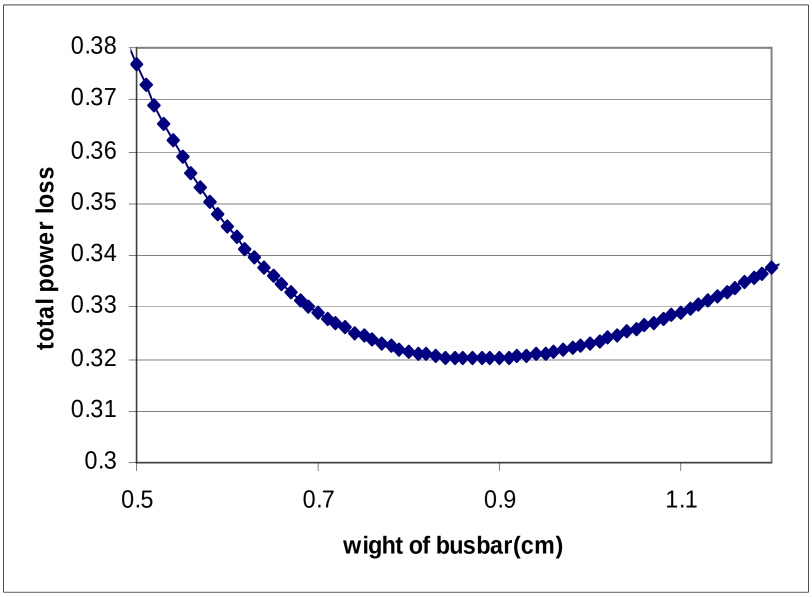

Fig.4: percentage of total power loss as a function of busbar width.

In comparison, the Graphene is an excellent conductive, good transparent (in both the visible and near-infrared regions), very stable (in both chemical and thermal), and adjustable. Its surface is ultra smooth with tunable flexibility. Therefore, it can be used instead of metallization layer in front contact of solar cells. In this case, there are not parasitic losses as much as the case of the metallization grid lines. For example, there is not shadowing power loss, which has the most effective on efficiency reduction, because of graphene's transparency.

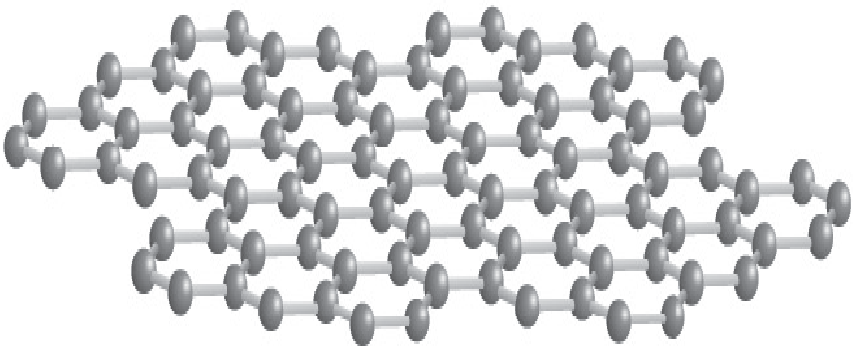

Fig5. A schematic plot of Graphene nano layer

2.Conclusion

By using the graphene, which is excellent conductive and transparent, instead of Ti/Pd/Ag on the front contact of a multi-crystal silicon wafer, efficiency can be improved.

3.Reference

[1] A.Luque, P.Gidon, M.Pirot, I.Anton, L.J.Caballero, I.C.Del Canizo, C.Jausseaud, "Performance of front contact silicon solar cells under concentration", Progress in Photovoltaics, v 12, n 7, 517-528 ,2004.

[2] A.Luque, I. Tobias, P.Gidon, M.Pirot, I.Anton, I.C.Del Canizo, C. Jausseaud, "Two dimensional modeling of front contact silicon solar cells ", John Wiley & Sons, 503-516, 2004.

[3] H. Ohtsuka et al,"Bifacial silicon solar cells with 21.3% front efficiency and 19.8% rear efficiency ", John Wiley & Sons, 385-390, 2000.

[4] M. Radike, J. Summhammer, "Electrical and shading power losses of decorative PV front contact patterns", John Wiley & Sons, 399-407,1999

[5] A.R. Burger, "How to design optimal metallization patterns for solar cells", John wiley & Sons, Apll 7, 457-461, 1999

[6] Xuan Wang, Linjie Zhi, and Klaus Mllen,*Nano Lett.*, 2008, 8 (1), 323-327 • DOI:10.1021/nl072838r

[7] Roya Jalali , Edris Faizabadi, Ebrahim. A. Soleyman**; "**Optimization of front contact grid patterns for solar cells", ICOL2005