

## International Journal of Innovative Research in Science, Engineering and Technology

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# A Novel Approach towards Highly Efficient Solar Cells

Puspendu Roy, Baishali Bera, Dr. Subhajit Ghosh

Researcher, Supronics Enterprise, Kolkata, India

Researcher, ESL Technology, Kolkata, India

HOD, Department of ECE, CIEM College, Kolkata, India

**ABSTRACT:** Research is blooming in every sectors now a days. One such sector where the whole world is investing and expecting a positive outcome is renewable energy such as wind, solar etc. Solar Energy research has taken leaps and bounds in terms of advancement.

The main constraint has been the issue regarding the efficiency of the solar cells. Several approaches have been used till date.

In this paper we propose a method of using meta materials to design highly efficient solar cells. Metamaterials are having highly exotic properties not attainable in nature. Different applications using cloaking, sensing and high absorption is studied. Major aim is to use a negative refractive index that requires both effective dielectric permittivity and magnetic permeability to be negative. Nano crystal; line thin films is also studied.

**KEYWORDS:** Metamaterials, nanocrystalline thin films.

## I. INTRODUCTION

With the emergence of a new field of electromagnetic metamaterials are newly artificially fabricated materials with unusual properties such as negative indexes. In these new artificially fabricated materials - termed as negative index materials (NIM) or double negative (ONG) media or left handed (LH) materials or backward wave (BW) media - all these material parameters are negative. One such property to overlapping of four resonance frequencies, and the mechanism of absorption is investigated by the distribution of electric field. The frequency of each absorption peak can be flexibly controlled by varying the size of the corresponding metallic ring. The proposed is applicable to other types of absorber structure and can be readily scaled up to the structures that are working in microwave frequency range. The proposed structure has applications in detection, imaging, and stealth technology

## II. BACKGROUND STUDY

a) **BASICS OF SOLAR CELLS A SOLAR CELL** (also called a photovoltaic cell) is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Photovoltaic effect is the production of current due to the voltage difference across a p-n junction, as a result of the absorption of photons on the top layer of n-type material. This N-type material is often made of a shiny reflective material so it may send photons bouncing Figure

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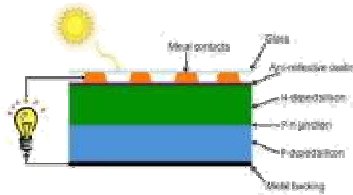


Figure 1 : Basic structure of a silicon solar cell.: Picture showing various parts of solar cell with proposed design.

b) Limitations of the Solar Cells Even the best of today's silicon solar cells cannot use about 30 percent of the light from the sun: that's because the entire spectrum of sunlight, from infrared to ultraviolet, covers a range of about 0.0012 eV to about 4 eV, the semiconductors do not respond to the entire spectrum of sunlight. Solar cell works only in the visible spectrum. Photons with at least the band gap energy will be able to free electrons to create a current. Photons with energy less than material's band gap pass through the cell and are not absorbed, which wastes incoming energy. Also some sunlight is always reflected off the surface of the cell even though the surface is usually texturized and coated with an anti-reflective coating. Furthermore, some energy is lost from local recombination of newly created holes and electrons.

### III. METAMATERIALS FOR SOLAR CELLS

Applicability of Metamaterial on Solar Cells i. Metamaterials of Sawtooth Structure According to Nicholas X. Fang, the Brit (1961) and Alex (1949) d'Arbeloff, Associate Professor of the Department of Mechanical Engineering, MIT, the thinnest materials used to fully capture light are limited to a very narrow range of wavelengths and the angles of incidence. They proposed a design composed of a pattern of wedge-shaped ridges whose widths are precisely tuned to slow and capture light of a wide range of wavelengths and the angles of incidence. These metamaterials could be made extremely thin, saving weight and cost. Also, Kin Hung Fung, an MIT postdoc has proposed a design of multilayer sawtooth structure to absorb a wide range of frequencies with an efficiency of more than 95 percent [4].

In case of normal solar cell only 1 band gap can be used but in case of sawtooth tapered ridges multiple bandgaps are possible. One such reference graph is shown below.

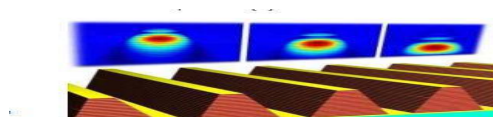


Figure 2: Sawtooth tapered ridges developed at MIT Lab

### IV. POLARIZATION AND ABSORPTION EFFECT

L. Huang and H. Chen, the Electromagnetics Academy at Zhejiang University, have shown that the metamaterial absorber is almost insensitive to the polarizations of the incident wave due to the symmetric pattern of the closed rings [5]. Figure 4 shows the performance of the metamaterial absorber for different polarizations of the incident wave. It is found that, refractive index  $\mu$  change from  $0 \pm$  to  $40 \pm$  (the measurement for  $\mu$  from  $50 \pm$  to  $90 \pm$  is same to that from  $0 \pm$  to  $40 \pm$  due to the rotational symmetric of the closed rings), the absorption frequency only shift 0.8% and the absorptions are all lower than 15 dB, reflecting the insensitiveness of the metamaterial absorber to the wave polarizations. Because metamaterial has no polarization effect, by using metamaterial in solar cell

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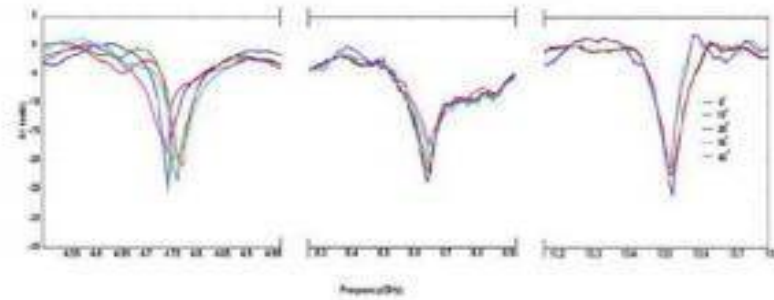


Figure 3: the performance of the metamaterial absorber for different polarizations of the incident wave.

## V. NANO CRYSTALLINE LAYER

In this paper we propose the use of nano crystalline optical thin film layer over the ridges for better absorption and efficiency.

In the referene paper [7] **Development of Optimal Nanocrystalline Absorption Layer for Thin Film Silicon Solar Cell Applications**

[C. Álvarez-Macías](#) [J. D. Escobar-Carrasquilla](#) [A. Dutt](#) [E. Mon-Pérez](#) [L. González](#) and [G. Santana](#) we find that their research on Nano crystalline thin film research where RF pwer was varied the crystalline factor gave us the crystalline factor ina suitably better range that clearly indicates better photosensitivity and thus a better efficient solution to the lagging problem. The thin film can be prepared using Chemical Vapor deposition process.

## VI. CHEMICAL VAPOR DEPOSITION

Chemical vapor deposition (CVD) is a widely used materials-processing technology. The majority of its applications involve applying solid thin-film coatings to surfaces, but it is also used to produce high-purity bulk materials and powders, as well as fabricating composite materials via infiltration techniques. It has been used to deposit a very wide range of materials.

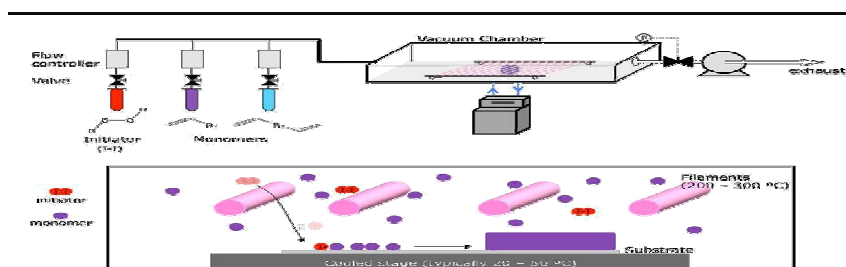


Figure 4: CVD process description by MIT Labs : The process of CVD is explained in the diagram. The various phases are shown accordingly.

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## VII. CONCLUSION

Based on the above studies we can conclude that the sawtooth structured coupled with nanocrystalline thin films can give us better efficient solar cells with higher sensitivity. There are certain limitations to metamaterials based proposals.

As there has been a very little work on metamaterial solar cell research, the main emphasis of this work was to demonstrate theoretically whether metamaterial on solar cell would increase the overall efficiency or not. Also, most thin materials used to capture sunlight are limited to a very narrow range of wavelengths and the angles of incidence. The proposed design uses a pattern of wedge-shaped ridges whose widths are precisely tuned to slow variation and thus made enable to capture light of a wide range of wavelengths and angles of incidence. Because of using metamaterial, there is no polarization effect of unpolarized sunlight, thus the efficiency has increased manifold. Some difficulties had been faced during this study. The first and foremost is that there was no open source reference software that could be used for designing metamaterial solar cell. Also there was not any complete metamaterial solar cell model to compare; also the lack of physical implementation in the third world country likes Bangladesh. Despite of all the difficulties, proposed metamaterial model shows promising feature for achieving high efficiency solar cell; hopefully this work would be beneficial to the scientists and engineers.

## REFERENCES

1. Towards High Efficiency Solar Cells: Composite Metamaterials By Galib Hashmi, Masudul Haider Imtiaz & Shahida Rafique
2. Martin A. Green, Keith Emery, Yoshihiro Hishikawa, Wilhelm Warta and Ewan D. Dunlop, Solar cell efficiency tables (version 39), Published online in Wiley Online Library ([wileyonlinelibrary.com](http://wileyonlinelibrary.com)). DOI: 10.1002/pip.2163.
3. Satyen K. Deb, Recent developments in highefficiency pv cells, National Renewable Energy Laboratory. 3. P. J. Reddy, Science and Technology of Photovoltaics, 2nd edition, CRC Press, Leiden (2010).
4. <http://web.mit.edu/newsoffice/2012/metamaterialabsorbs-light-0309.html>.
5. Yang Liu, Yitung Chen and Jichun Li, Solar cell design using metamaterials, UNLV Center for Energy Research. 6. Soteris A. Kalogirou, Solar Energy Engineering Processes and Systems, Academic Press, Elsevier - 2009 edition
6. A brief intro to metamaterials, K/S/khetrimayum, IEEE digital library.