Super-Efficient Solar Panels with Nanoantennas

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Abstract— People have been using Solar Power to cook, heat, disinfect, from ancient period. The only limit was human ingenuity. And now with the solar panels you can turn solar energy into free electricity. Depending on construction, solar panels can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence much of the incident sunlight energy is wasted by solar panels. At present, solar panels designed to generate electricity are fairly expensive to produce. We are going to present a paper about using nanotennas in solar panels. This paper presents an alternate to the Photovoltaic (PV) approach, using recent advances in nano-technology, and provides a pathway for nantennas that combine broadband energy collection with high efficiency and low cost. These "nanoantennas" could replace the silicon semiconductors in special solar panels, which could harvest more energy from a wider spectrum of sunlight than is currently possible.

Key words: Nanoantennas, Super-Efficient Solar Panels

I. INTRODUCTION

The main goal of solar power industry is to increase the efficiency of solar panels. Today's solar panels are predominantly based on silicon, a semiconducting material that is only able to convert approximately seven percent of optical solar waves into electricity. The efficiency of solar panels can be greatly increased by creating a solar panel composed of antennas instead of semiconductors. These antennas have enormous potential because of their ability to collect wavelengths across a much broader spectrum of light. The main idea is to adapt classic metallic antennas to absorb light waves at optical frequencies. In order to achieve optimal absorption, the antenna dimensions must correspond to the light's very short wavelength and hence we use antennas less than a micron in length i.e in nanoscale. These antennas are called NANTENNAS (nano antennas).

II. PRESENT PHOTOVOLTAIC TECHNOLOGY

Photovoltaics are best known as a method for generating electric power by using solar cells to convert energy from the sun into electricity. The photovoltaic effect refers to photons of light knocking electrons into a higher state of energy to create electricity. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transduced light energy. Virtually all photovoltaic devices are some type of photo diode. Solar cells produce direct current electricity from sun light, which can be used to power equipment or to recharge a battery. The first practical application of photovoltaic's was to power orbiting satellites and other spacecraft, but today the majority of photovoltaic modules are used for grid connected power generation. In this case an inverter is required to convert the DC to AC. There is a smaller market for off-grid power for remote dwellings, boats, recreational vehicles, electric cars, roadside emergency telephones, remote sensing, and cathode protection of pipelines.

III. LIMITATIONS OF PRESENT SOLAR PANELS

In order to use the solar panels in our homes to power our energy needs, we need to find out how efficient they are. Average solar panels can offer only up to 20% efficiency. However there are quite a few solar panel manufacturers that produce solar panels which can give up to 40% efficiency. But for the solar panels made out of the current silicon material forty percent is the maximum efficiency which even the highest quality solar panels can give. This is why the idea of creating energy from the sunlight with the help of solar panels still not becomes a reality.

Solar Panels can not produce their full rated power. A 100 watt panel can not provide more then 80 watts in full sunlight and cold weather. This is because around 85% of the solar radiation spectrum contains light with shorter than infra-red wavelengths, in the range 0.4-1.6μmMore than a third of the solar energy on Earth arrives in the form of infrared light. Silicon material which used to convert sunlight into electricity cannot capture infrared light’s energy. .During night solar panel doesn’t works, lot of infrared light reaches earth at night only and they cannot absorb IR light this is another disadvantage

IV. WHAT ARE NANTENNAS?

A nantenna is a very small rectenna the size of a light wave, fabricated using nanotechnology, which acts as an "antenna" for light, converting light into electricity. It is hoped that arrays of nantennas could be an efficient means of converting sunlight into electric power, producing solar power more efficiently than conventional solar cells .So what are these nantennas made of? "The nanoantennas are tiny gold squares or spirals set in a specially treated form of polyethylene, a material used in plastic bags. The nanoantenna consists of three main parts: the ground plane, the optical resonance cavity, and the antenna. The antenna absorbs the electromagnetic wave, the ground plane acts to reflect the light back towards the antenna, and the optical resonance cavity bends and concentrates the light back towards the antenna via the ground plane

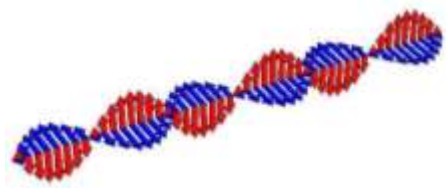

Fig 1: Nantennas

While antennas that collect energy from lower-frequency regions of the electromagnetic spectrum, such as microwaves, are in practice infrared rays have proven more elusive. Nanoantennas for visible and infrared radiation can strongly enhance the interaction of light with nanoscale matter by their ability to efficiently link propagating and spatially localized optical fields change drastically at high-frequency wavelengths.

V. NANTENNAS IN SOLAR PANELS

It is possible to develop solar panels using array of nantennas that collects almost 95% of the sunlight falling on it. The panel is a thin foil which can be foldable and covered with a thin layer of nano antennas which absorb infrared radiation too. So if we need to draw electricity from these antennas, it is possible to attach tiny capacitors on the antennas. Another approach in capturing the sunlight

VI. THEORY OF OPERATION

Every semiconductor, including silicon, has a "bandgap" where light below a certain frequency passes directly through the material and is unable to generate an electrical current. By attaching a metal nanoantenna to the silicon, where the tiny antenna is specially tuned to interact with infrared light. When infrared light hits the antenna, it creates a "plasmon," a wave of energy that sloshes through the antenna's ocean of free electrons radiation is that using an AC/DC converter to capture electrons and use it to generate electricity.If this is possible these solar panels could offer as much as eighty percent efficiency. The idea behind this new solar panel is that the sunlight is available in abundance and the sunlight consists of infrared radiation which is available even at night. We are able to capture infrared radiation in the night with the help of our TV antennas of high wavelengths. In the same way we can also capture the IR radiation of small wavelengths by using small antennas except that the wavelength being very small the antenna length should also be small.hence we can use nano antennas for such purpose.

An array of nantennas, printed in gold and imaged with a scanning electron microscope is shown in the fig

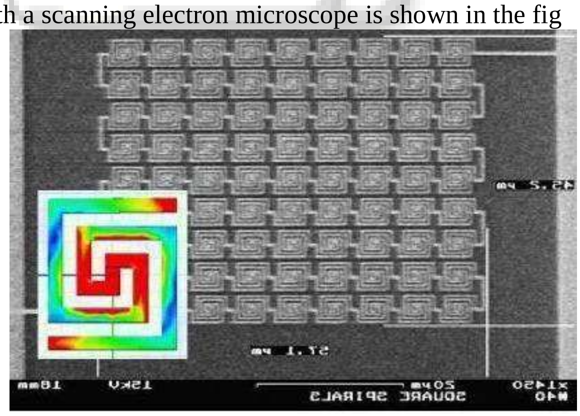

Fig 2: Nanoantennas Array for Solar panels

It has been known that plasmons decay and give up their energy in two ways; they either emit a photon of light or they convert the light energy into heat. The heating process begins when the plasmon transfers its energy to a single electron — a 'hot' electron Patterning a metallic nanoantenna directly onto a semiconductor to create a "Schottky barrier .The infrared light striking the antenna would result in a hot electron that could jump the barrier, which creates an electrical current. This works for infrared light at frequencies that would otherwise pass directly through the device

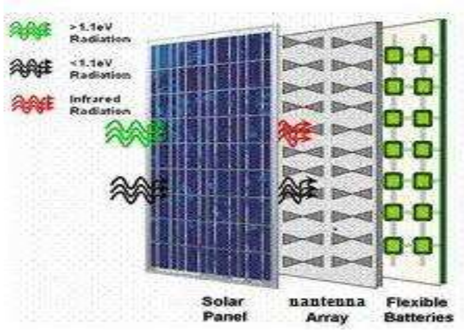

Fig 3: Circuit parts

The nantenna part of the circuit collects the sunlight and converts them to electric current. The rectifier converts the generated ac current to dc which is then stored. This forms the basic circuit that is to be used in the solar cell. The output of the rectifiers can be dc-coupled together, allowing arrays of antennas to be networked together to further increase output power capacity

VII. HIGH EFFICIENT ENERGY SOURCE

Nanoantennas can provide us with a large energy source. The sun radiates a lot of infrared energy. Because of the small size of nanoantennas, which approximately as wide as 1/25 the diameter of a human hair, it absorbs energy in the infrared part of the spectrum, just outside the range of what is visible to the eye. Nanoantennas can absorb energy from both sunlight and the earth's heat, with higher efficiency than conventional solar cells.

VIII. ADVANTAGES OF NANOANTENNAS

A. High Theoretical Efficiency

One of the main advantages of using nanoantennas is their high theoretical efficiency. For example, the theoretical efficiency of single junction solar cells (30%). In contrast, in the case of nanoantenna the theoretical efficiency will be greater than 85%.

B. Absorb frequency of light

Another advantage, it is the most apparent advantage of nanoantennas have over semiconductor photovoltaics is that nanoantenna arrays can be designed to absorb any frequency of light. By simply varying the size of the nanoantenna in the array, the resonant frequency of the nanoantenna can be engineered to absorb a specific wavelength of light (resonance frequency scales approximately linearly with antenna size

C. Low Cost

Nantennas (just the nano-antenna part, not the rectifier and other components) are cheaper than photovoltaics.

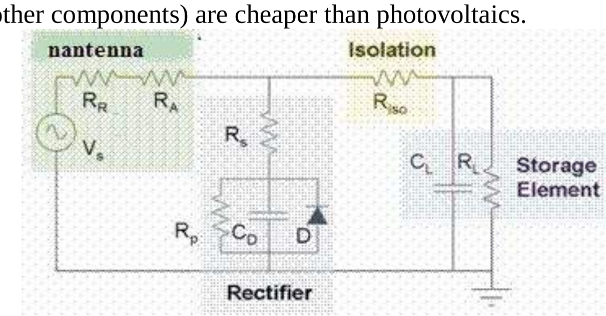

Fig 4: Schematic Nantenna Circuit

While materials and processing of photovoltaics are dear (currently the cost for complete photovoltaic modules is in the order of 430 USD / m² in 2011), it is estimated that the current cost of the nantenna material itself as around 5 - 11 USD / m^2 in 2008.With proper processing techniques and different material selection, that the overall cost of processing, once properly scaled up, will not cost much more

IX. Applications of Nantennas

We have seen that nantennas could be used as a solar panel that could beat all current efficiencies at a much lower cost. But it turns out that nantennas have dozens of other uses. These include:

- Passive, energy-neutral cooling by converting infrared radiation into radiation that we don't feel as heat (like radio waves)
- Passive heating by turning radiation we don't feel as heat into infrared radiation
- Extremely efficient lighting by basically broadcasting photons from the nantennas. As it's basically the solar process in reverse (photons from electrons, instead of electrons from photons), this is just as feasible as the solar applications
- Passive heating or cooling within clothing
- Electricitiy production in clothing by harnessing our bodies' radiation

X. Importance & Future

Traditional Solar panels absorbs less than 20 percent of solar energy which is very inefficient. In contrast, using nanoantennas the scientists estimate individual nanoantennas can absorb close to 80 percent of the available energy. These nantennas could one day make very inexpensive solar panels.

Manufacturing methods will continue to be refined to support roll-to-roll manufacturing of the nanostructures. Future work will focus on designing the nantenna structure for operation in other wavelengths. By further shaping the spectral emission it may be possible to concurrently collect energy in the visible, near infrared and mid-infrared regions

The work represents an important step towards the ultimate realization of a low-cost panel that will collect, as well as convert this radiation into electricity, which will lead to a wide spectrum, high conversion efficiency, and low-cost solution to complement. The largest problem is not with the nantenna device, but with the rectifier. Present-day diodes are unable to efficiently rectify at frequencies which correspond to high-infrared and visible light. Therefore, a rectifier must be designed that can properly turn the absorbed light into usable energy.

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XI. Conclusion

The idea described in this paper explores a new and efficient approach for producing electricity from the abundant energy of the sun, using NANTENNAS in solar panels. As such, nantennas will be complementary to photovoltaics offering increased energy efficiencies when coupled to present solar panels.

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