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ScienceDirect

Procedia Computer Science 92 (2016) 549 – 553

Procedia Computer Science

2nd International Conference on Intelligent Computing, Communication & Convergence

(ICCC-2016)

Srikanta Patnaik, Editor in Chief

Conference Organized by Interscience Institute of Management and Technology

Bhubaneswar, Odisha, India

Plasmonic Effect due to silver nanoparticles on Silicon solar cell

Ralli Sangno[a], Santanu Maity[b,]*, R.K. Mehta[c]

[a]*Department of Electrical Engineering, National Institute of Technology, Arunachal Pradesh-791112*
[b]*Department of Electronics and Communication Engineering, National Institute of Technology, Arunachal Pradesh-791112*
[c]*Department of Electrical Engineering, North Eastern Regional Institute of Science & Technology,Nirjuli-791109*

Abstract

Plasmonic effects in thin film silicon solar cell are an emerging technology and area of rigorous research for the researchers from past couple of years. It has promising application in solar cells fabrication industries where it used nonoscale properties of silver or gold nanoparticles that incorporated in interface between the metal and dielectric contacts that enhance the light trapping properties of thin film silicon solar cells by increase absortence capacity and generation of hot-electrons that enhance the photo currents in the solar cell. In this paper, we had taken two different thickness of silver thin film (AgNPs) of 5.9 nm and 7.8 nm in 2 X 10^{-4}(Torr) and 2.5 X 10^{-4}(Torr) pressure environment for investigation purpose. Samples were annealed at different temperature ranges for definite time period under vacuum condition of 4.5 X 10^{-6} Torr. From this experimental study reflectance reduces 13 % to 11% due to plasmonic effect and enhancement in the conversion efficiency of the solar cell.

Peer-review under responsibility of the Organizing Committee of ICCC 2016

Keywords: SPs, ARC, AgNPs, solar cell;

* Corresponding author. Tel.: +91-9436272773
E-mail address: santanu.ece@nitap.in

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doi:10.1016/j.procs.2016.07.381

1. Introduction

Surface plasmonic was emerged in the early 20th century and became very popular and hot topics for researched since 1990s. Their applications and researched started in various fields but actual applications and researched in the field of photovoltaic application begins in 2005 only as we can witness from recent publications in some reputed journals [1]. As we know that the conventional source of energy that we utilizing in this modern days is getting exhausted after a few years and it's depleting very fast along with the ever increase in the global population and overused of the resources also caused adverse effect in our environment too. So it is a big challenge for the world population to have alternate source of energy which is sustainable, lower cost, eco-friendly and most importantly should be abundant in nature that can meet the power demands of ever expanding world population. In this context renewable source of energy in the form of solar energy has the potential to quench the power requirement with potential to make a large contribution to solving the problem of environmental issues and many researchers are working in this renewable energy field particularly in solar photovoltaic for the past ten years. The best used of solar energy is in solar photovoltaic (SPV) but due to high cost of solar photovoltaic module as compare to fossils limited their wide applications as around 40% of the cost of a solar module made from crystalline silicon is the cost of the silicon wafers only in fact it is the costliest material in a SPV system [2]. The industrial photovoltaic cells that available are basically made up of crystalline silicon wafers which has been further improved the light absorbing capacity in the form of thin film solar cells and theoretically existed third generation solar cells having higher efficiency and lower cost but the major drawbacks still lies in this thin film technology is that the photons that striking near its bandgap energy (1.1eV) never contributed to generation of free electrons to enhance photo current instead its causes heat dissipation leads to heat losses particularly its occurred in indirect band-gap silicon solar cell. So effective photon harvesting technique is needed by re-configuring the geometrical lattice structure of crystalline silicon solar cell so that the sufficient amount of photon can be trapped inside efficiently to increase the absorptence capacity by reducing reflectance as well as increased efficiency [3]. This can be achieved with the help of surface plasmons (SPs) technology. In this plasmonic light trapping with the help of metallic nanoparticles like silver or gold (AgNPs/AuNPs) nanoparticles, we enhance the efficiency of thin film solar cells. Here, the interface between a metal and a semiconductor consists of good numbers of conducting electrons that oscillating in both metal and semiconductor. On excitation with silver AgNPs, oscillating dipoles is created due surface electrons. Oscillating dipoles directed electromagnetic wave toward the higher permittivity material where it is concentrate in the vicinity between the metal-semiconductor interfaces so that it can propagate and trapped light at the interface. Although some other metals also support surface plasmons but silver and gold are popularly used for experimental research in this field. The performance parameters of SPs largely depend on shape and size of the particles, properties of material and dielectric property of surrounding environments. Apart from utilizing it as light absorber layer to improve the solar cell efficiency by trapping or concentrating light at the absorber layer it can also be used as a back contact or a cheap anti-reflective electrode [4-11].

In this paper experimental study of silver nano particles is done using thermal evaporation technique. Reflectance of silicon reduces 13 % to 11 % due to deposition of silver nanoparticle.

2. Experimental setup

In experimental study thermal deposition technique is used to get thin silver film. We have used different silver film for getting proper silver nanoparticles. Table 1 shows the two different thickness of silver thin film of 5.9 nm and 7.8 nm in 2 X 10^{-4}(Torr) and 2.5 X 10^{-4}(Torr) pressure environment. After that sample was annealed the sample by using 250 ^{o}C for 2 hours. Due to annealing thin silver film reformed to the silver nanoparticles. Schematic representation of silver thin film and silver nanoparticle is shown in figure 1.