Advanced Materials Science Research

Extended Abstract Open Access

V/Ce Doped in TiO_2 Nanoparticles Synthesized by Dye Sensitized Solar Cells Absorption View Point of Mie Theory

S Shanmugan

Research Centre for Solar Energy, India

Keywords: Mie theory, PV technology, DSC, Energy conversion

Abstract:

At this present work, the highly capable dye-sensitized solar cell (DSC) has been successfully characterized using a Cermic (Ce)/Vanadium (V) doped TiO_2 nanoparticles ($CeVTiO_2$). The solar cell properties of the $CeVTiO_2$ powder films have been investigated by the techniques of spectroscopies accept to Mie theory respectively. The morphology studies are doped solutions in variation rates of reflected in form of XRD values and analysed in TEM and SEM. The view of Mie theory is followed in GC-MS chemical compounds which may responsible to Electrical, optical properties of doping nanoparticles, fill factor absorption of power density results is discussed of Atomic force microscopy (AFM). An enhancement of $CeVTiO_2$ powder films is observed by the energy wavelength range of 520 nm. The photocurrent by the $CeVTiO_2$ powder films are occupied to the absorption efficiency of 43.5%, 26.6% and 9.5% respectively. An 8% overall conversion efficiency has been achieved. It concluded that of the potential materials of solar cells fabricated by $CeVTiO_2$ showed in good performance.

1. Introduction

The green technology is established for healthy nature in as abundance, life stability, less price and non-toxicity. Now days, industrial applications are interesting for the methods of based on Silicon-based solar cells. Few researchers have done of the very importance of based on silicon-solar cells, its developed on good performance of several methods [1-4].

As follows to [5–9] the many researchers have achieved in PV good properties and coated to the solar cells with high efficiency to trapping of light to the surface to attack the plasmon resonance to cover of metallic nano-particles. Recently implementation of silicon solar cells PV by effectiveness of SPR (Surface Plasmonic Resonance) high band cover to electrons of the particles area influencing of nanoparticles [10–12]. The nature size of the nanoparticles is structure, shape, dielectric to average values of constant. The effect of silicon solar cell PV to use of different sizes the metallic nanoparticles layer is focused on monitoring to a result using Mie theory to compare of optical properties.

In this main discussion of the solar cells PV have been doped nanoparticles effectives of the different metallic sizes of coated with effectives of the light trapping to following in the monitoring and verified optical solutions to using of Mie theory. The doped in Au- TiO_2 Nanoparticles are synthesized of the chemical solution to solve the Monocrystalline as following to the flowchart fig.1 and high absorption of the solar rays is performed of potential novel solar cells with conform to followed in Mie theory.

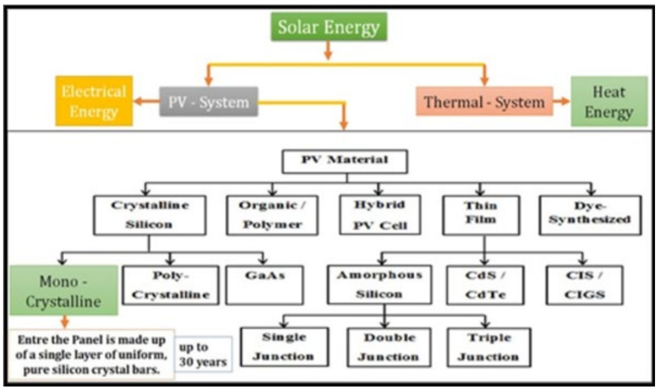

Fig. 1 shows as flowchart of form of PV techniques.

2. Expose to Characteristics of Mie theory:

The solar radiations are absorption of the metal to consider the free electrons with energy band to value to product of metal atoms (coherently). The solar rays forming of the surface area to a metal behavior to expose of dipole oscillation electrons with long travelling to a direction axis of the light beam. The dipole oscillation amplitude electrons are determined to establishing area of SRP. The strong of the SRP values of metal to consider the nanostructure as follow [13,14]. The Mie theory is exposed on intensity, frequency depends of SRP based on electron density with particle area and implemented to a particle with size, shape dielectric constant and electronic structure through the designated.

Recently, few Scientifics are focused to the Mie theory and produced in solar energy conversion based by plasmonic phenomena [15]. Through the metal absorption of the silicon solar cells have been concluded that the nanostructures focus on surface to consider the optical trap frequency. The particles sizes are trap with light to effect of two mechanisms (i) scattering Light (ii) absorption of light [16]. Here, doped nanoparticles to use metal is very high scattering of Wavelength near to SRP and oscillation of electrons to the wavelength of light, the dipole

Expose to absorption, scattering of light is good.

The solar rays are absorption of the surface area to forming of cross section, it can be written as

$$\sigma\_cs = q_s a$$

where q_s is scattering light of the source, a = πr^2 is cross section area of the metal, it can be exposed as follows

$$q_s = q_E - q_A$$

where

$$qE = 2/x^2 \ \Sigma^{\infty}_{(n=1)}(2n+1) \ \ Re1 \ [x_n + y_n]$$

$$q\_A = 2/x^2 \sum^{\infty}_{(n=1)}(2n+1)\ \mathrm{Re1}\ [x^2_n + y^2_n]$$

wherex_n, y_n was Mie coefficient of complex numbers. $x = 2\pi r/\lambda$ have size of different parameters, λ - wavelength of the solar rays, r – radius, the all coefficients are verified by [17]

SRP determination of nanoparticles are Mie theory verified to a software by Mie Plot v.4.2 as by [18]

3. Materials and Experimental Methodology

3.1. Silicon solar cells techniques:

The experimental work is implementation of TiO_2 Nanoparticles with Au doped in deposition of substrate through the monocrystalline silicon solar cells have been made in our research for Solar Energy lab in KLEF. P type is cleaned to single side to use of wafer monocrystalline silicon with resistivity about 1 – 25 Ωcm. It is prepared to the thickness of 1cm and the material substrate sample is 1×5^{cm2}. The preparation of the samples is standard RCA-1 cleanser with homogeneous pyramid development texturization and have used in silicon substrate with dilute KOH solution with exposed in atomic force microscope as Fig. 2.

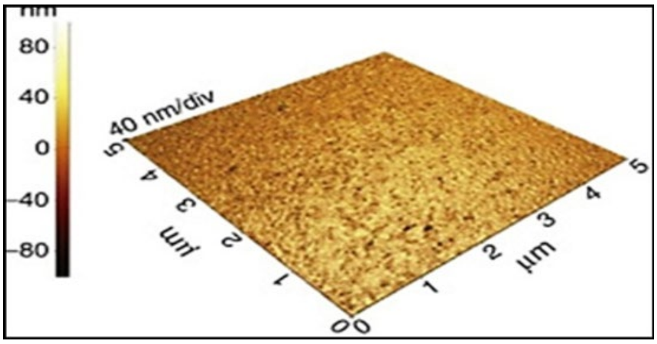

Fig. 2. Expose of AFM image surface area of silicon solar cells after texturization

The solar cells occupied to crystalline form of before and after texturization have been analysed through the X-ray design as follow in Fig.2. Au doped in N combination of element to the P-type wafer have been completed through the diffusion of solid phosphorus effect of P-N junction as [19]. The solar cells in order of Au doped with TiO_2 Nanoparticles coating with active free elections of enhancement to study the electrical and optical properties result of materials. It is developed of the N-front and P-back used interactions with respectively.

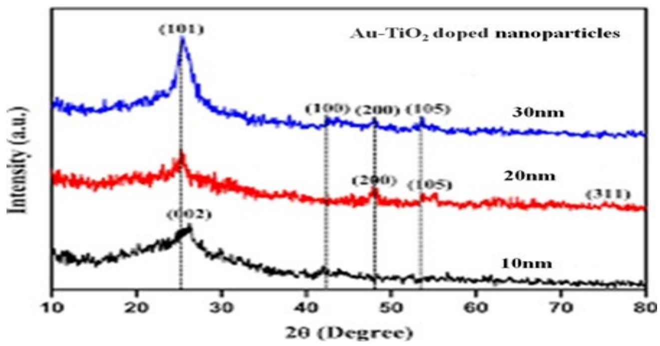

Fig. 2. Expose of doped nanoparticles in XRD- pattern of Silicon solar cell

3.2. Synthesized of Au nanoparticles:

The synthesis of Au-nanoparticles is used method of chemical reduction and PVP is preparation of capping full of adding in $NaBH_4$ with forming as [20, 21]. It is prepared of Au-nanoparticles of different sizes of changing the volume ratio. The aqueous sodium borohydride purely water is topping PVP samples (0.5%) as a particle. If the samples are cooled after absorption to the spectra which established the solidity of organized to Au-nanoparticles.

3.3. Characterization of Au nanoparticles:

The different sizes of prepared of Au-nanoparticles was improved with studies of HR-TEM (high resolution transmission electron microscope – Equipment model of JEM-2100) and UV/Vis absorption spectra use of equipment - Camspec M501. The optical properties are verified to use of Mie theory which it is using software [18]. Deposition of the silicon solar cells is uniformed to form of the sizes surface area to substrate of Au-nanoparticles has to use of hot furnace range of 67°C for 35min after formed to the thin layer.

4. Results and discussion

Au-TiO_2 doped nanoparticles have been prepared in different sizes of form with TEM images in Fig. 3. (A), (B), (C) the overall efficiency in different sizes was 10 ± 2 nm, 20 ± 2 nm, 30 ± 2 nm respectively.

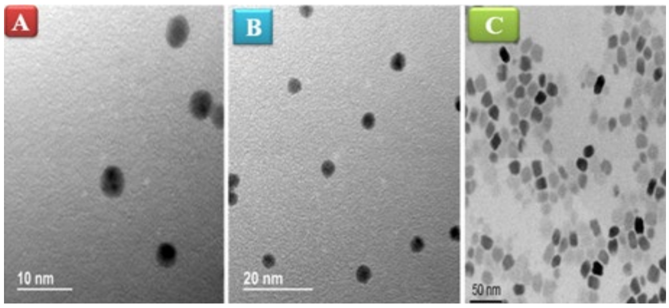

Fig. 3 (A), (B), (C) exposed in TEM image of the overall efficiency in different sizes of prepared Au-TiO_2 doped nanoparticles ~10, 20, 30 ±2 nm.

The pure Au-TiO_2 doped nanoparticles as follows in absorption to the spectra of UV/Vis have been exposed in Fig. 4. It is established that the determined of wavelength maximum use in band of plasmon and the doped nanoparticles are expressed of 404nm, 436nm and 449nm. The sizes of nanoparticles about 10nm, 20nm and 30nm with respectively. In these doped nanoparticles are indicated in consistent band of Gaussian plasmon in shape of spherical in agreed by Solomon et al. [22].

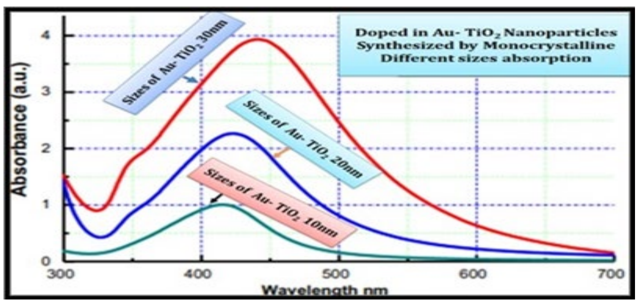

Fig. 4 Exposed in Synthesis of Au doping on the TiO_2 nanoparticles

The pure Au-TiO_2 doped nanoparticles have been verified of Mie theory software and size of nanoparticles have analysed in theoretically. It is calculated in radius of the particles about 10 to 45nm and verified in experimental UV/Vis absorption spectra. The maximum plasmon band wavelength is 410nm the values agree to absorption as follow in Fig.5. The pure Au-TiO_2 doped nanoparticles are analysed of optical properties range of 10nm and productivity of scattering spectrum is some improved to higher than the efficiency of absorption spectrum as agree to Fig.5. Moreover, Fig. 6 and 7 are the maximum wavelength of plasmon band range of 410 and 440 nm agreement of spectra absorption of Au-TiO_2 doped nanoparticles same size of exposed in Fig. 4. It concluded that to be nanoparticles size increases and compared to the absorption and scattering efficiency increases. The delivery of Au-TiO_2 doped nanoparticles have been used in morphology of Silicon solar cells coated with different sizes of nanoparticles are obtainable in Fig. 8 using scan electron micro- scope (SEM).

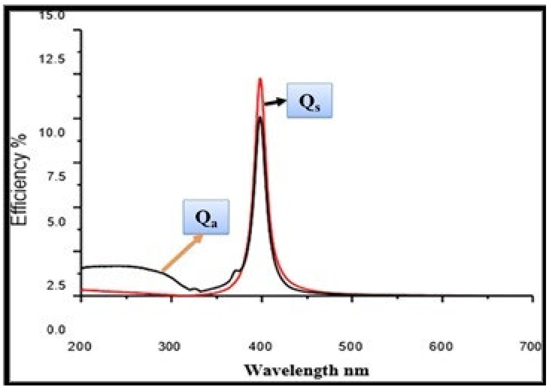

Fig. 5. expose in optical properties of 10nm Au-TiO_2 doped nanoparticles.

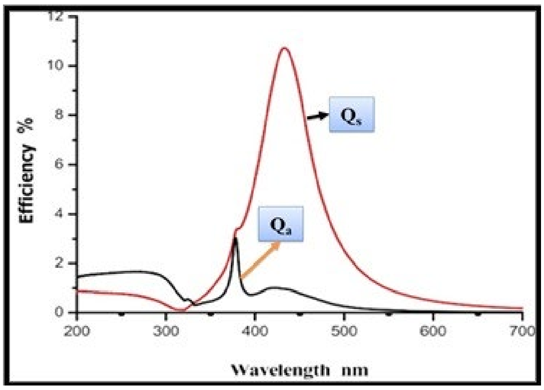

Fig. 6 exposed in optical properties of 20nm Au-TiO_2 doped nanoparticles.

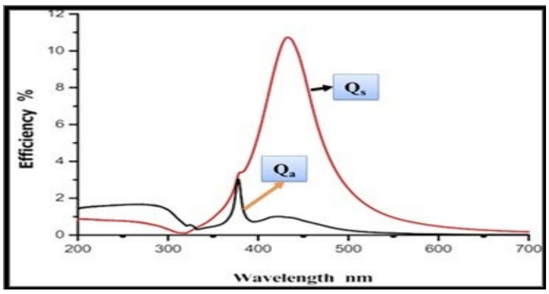

Fig. 7. exposed in optical properties of 30nm Au-TiO_2 doped nanoparticles

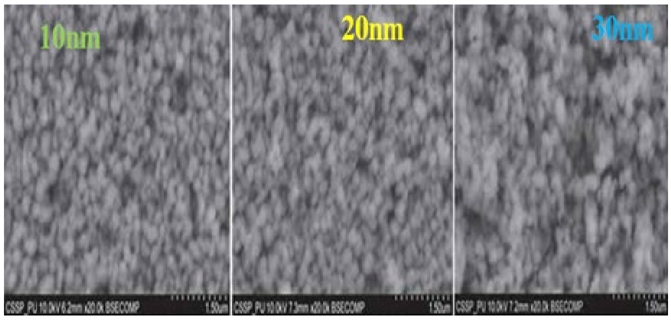

Fig. 8. Exposed in SEM images of Silicon Solar Cells coated by different Au-TiO_2 doped nanoparticles: (i) 10 nm, (ii) 20 nm, (iii) 30 nm.

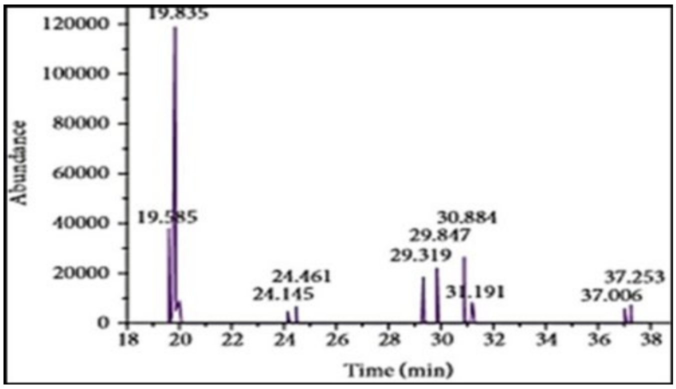

Fig. 9 exposed in GC-MS Silicon Solar Cells coated by different Au-TiO_2 doped nanoparticles.

The GC-MS analysis of solar cells extract of Silicon coated by different size of Au-TiO_2 doped nanoparticles revealed that the atoms contained a wide range of chemical compounds which may responsible for its electrical potentials. The chemical compounds are recognized expose six peaks and this suggests the occurrence of six chemical compounds in the excerpt by Fig. 9. The active Silicon solar cells coated on nanoparticles principle area is Retention Time (RT), peak concentration (%), Molecular Formula (MF) and Molecular Weight (MW) in the methanol of silicon solar cells.

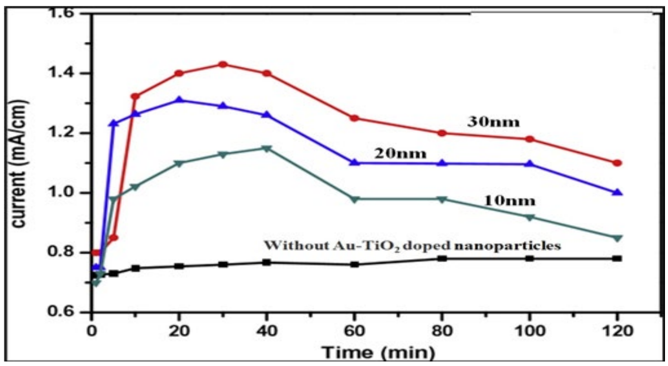

Fig. 10 exposed in Photocurrent of Solar Cells as occupation of contact time to 250mW diode laser.

Au-TiO_2 doped nanoparticles size of difference solar cells have been coated by 10nm, 20nm and 30nm as followed in Fig. 10 and it is 0.68, 0.74 and

0.80 mA/cm2 respectively. The solar radiation is absorption of the solar cell's values increased from 25min after to higher 1.15,1.25 and 1.45mA/cm2. Again, constant exposed to diode laser for one hours the delivery of 0.89, 0.96 and 1.20mA/cm2 and improvement of output currents verified by Mie theory. It is scattered current output of 56.2%, 61.2% and 73.0% and absorption efficiency is 43.5%, 26.6% and 9.5% respectively. It is the resulting in decreasing their output current by 10.4%, 9.7% and 10.5% respectively.

Conclusion:

In these performances of doped in Au- TiO_2 Nanoparticles have been successfully synthesized and characterisation using monocrystalline is verified by Mie theory. They are prepared in different sizes of nanoparticles are 10nm, 20nm and 30nm. The structural properties of systematized solar cells studied with XRD analysis it confirms the monocrystalline nature of absorption materials. The morphology of solar cells is considered by TEM and SEM analysis it illustrations that the length of absorption beam of source increases with doped in Au- TiO_2 Nanoparticles. Expose of AFM image surface area through the texturization and GC-MS is analysed of silicon solar cells different coated by chemical compounds which may responsible for its electrical potentials. Au-TiO_2 doped nanoparticles to the solar cells is confirmed for the pristine crystalline nature. The photocurrent by the solar cells occupied to the absorption efficiency of 43.5%, 26.6% and 9.5% respectively and its potential application of solar cells absorption good performance for the materials.

Data Availability:

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest:

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

[1] H. Huang, M. Sivayoganathan, W.W. Duley, Y. Zhou, Efficient localized heating of silver nanoparticles by low-fluence femtosecond laser pulses, Appl. Surf. Sci.331 (2015) 392–398.

[2] A. Wang, H. Yin, M. Ren, Y. Liu, T. Jiang, Synergistic effect of silver seeds and organic modifiers on the morphology evolution mechanism of silver nanoparticles, Appl. Surf. Sci. 254 (2008) 6527–6536.

[3] L. Mulfinger, S.D. Solomon, M. Bahadory, A.V. Jeyarajasingam, S.A. Rutkowsky, C. Boritz, Synthesis and study of silver nanoparticles, J. Chem. Edu. 84 (2007) 322–325.

[4] C. David, J.P. Connolly, C. Chaverri Ramos, F.J. García de Abajoa, G.S. Plaza, Theory of random nanoparticle layers in photovoltaic devices applied to selfaggregated metal sample, Sol. Energy Mater. Sol. Cells 109 (2013) 294–299.

[5] N. Lagos, M.M. Sigalas, E. Lidorikis, Theory of plasmonic near field enhanced absorption in solar cells, Appl. Phys. Lett. 99 (2011) 063304.

[6] P. Spinelli, V.E. Ferry, J.V.D. Groep, M. Lare, M.V. Verschuuren, R.E.I. Schropp, H. A. Atwater, A. Polman, Plasmonic light trapping in thin-film Si. Solar cells, J. Opt. 14 (2012) 024002–024011.

[7] C. David, J.P. Connolly, C. Chaverri Ramos, F.J. García de Abajoa, G.S. Plaza, Theory of random nanoparticle layers in photovoltaic devices applied to self- aggregated metal sample, Sol. Energy Mater. Sol. Cells 109 (2013) 294–299.

[8] N. Lagos, M.M. Sigalas, E. Lidorikis, Theory of plasmonic near field enhanced absorption in solar cells, Appl. Phys. Lett. 99 (2011) 063304.

[9] B. Cai, B. Jia, Z. Shi, M. Gu, Near field light concentration of ultrasmall metallic nanoparticles for absorption enhancement in a-Si solar cells, Appl. Phys. Lett. 102 (2013) 093107.

[10] F.J. Beck, A. Polman, K.R. Catchpole, Tunable light trapping for solar cells using localized surface plasmons, J. Appl. Phys. 105 (2009) 114310.

[11] S. Pillai, K.R. Catchpole, T. Trupke, M.A. Green, Surface plasmon enhanced silicon solar cells, J. Appl. Phys. 101 (2007) 093105.

[12] J. Bonsak, M.Sc. of Chemical synthesis of silver nanoparticles for light trapping applications in silicon solar cells, Oslo, Norway, 2010.

[13] H. Fang, X. Li, S. Song, Y. Xu, J. Zhu, Fabrication of slantingly-aligned silicon nanowire arrays for solar cell applications, Nanotechnology 19 (2008) 255703–255708.

[14] B.Y. Yu, A. Tsai, S.P. Tsai, K.T. Wong, Y. Yang, C.W. Chu, J.J. Shyue, Efficient inverted solar cells using TiO2 nano tube arrays, Nanotechnology 19 (2008) 255202–255206.

[15] K.R. Catchpole, A. Polman, Plasmonic solar cells, Opt. Express 16 (2008) 21793–21800.

[16] Y.A. Akimov, K. Ostrikov, E.P. Li, Surface Plasmon enhancement of optical absorption in thin-film siliconsolar cells, Plasmonics 4 (2009) 107–113.

[17] R.G. Grainger, J. Lucas, G.E. Thomas, G.B. Ewen, Calculation of Mie derivatives, Appl. Opt. 43 (2004) 5386–5393.

[18] The "MiePlot" Software from Philip Laven at: http://www.philiplaven.com/ mieplot.htm.

[19] Phos Plus High-Purity Planar Dopant Sources, further information on these materials, http://www.techneglas.com.

[20] K.L. Mirkin, G.C. Kelly, J.G. Schatz, Zheng, Photoinduced conversion of silver nanospheres to nanoprisms, Science 294 (2001) 1901–1903.

[21] A. Wang, H. Yin, M. Ren, Y. Liu, T. Jiang, Synergistic effect of silver seeds and organic modifiers on the morphology evolution mechanism of silver nanoparticles, Appl. Surf. Sci. 254 (2008) 6527–6536

[22] L. Mulfinger, S.D. Solomon, M. Bahadory, A.V. Jeyarajasingam, S.A. Rutkowsky, C. Boritz, Synthesis and study of silver nanoparticles, J. Chem. Edu. 84 (2007) 322–325.