

PAPER • OPEN ACCESS

## The impact of Ag nanoparticles on the parameters of DSS- cells sensitized by Z907

Recent citations

- [Role of spin states in the process of electron energy transformation in P3HT films doped KI salt](#)  
A Nurmakhanova *et al*

To cite this article: N Kh Ibrayev *et al* 2016 *IOP Conf. Ser.: Mater. Sci. Eng.* **110** 012067

View the [article online](#) for updates and enhancements.

Репозиторий Қарғу

# The impact of Ag nanoparticles on the parameters of DSS-cells sensitized by Z907

N Kh Ibrayev, A K Aimukhanov and A K Zeinidenov

Institute of Molecular Nanophotonics, Academician E.A. Buketov Karaganda State University, Karaganda, Kazakhstan

E-mail: niazibrayev@mail.ru

**Abstract.** Research of influence of Ag nanoparticles are in-process undertaken on absorption and on parameters CVC DSS-cells sensitized Z907. It is set that with the height of concentration Ag nanoparticles in tape to the concentration of 0.3% wt%. the absorbance of Z907 in a short-wave stripe grew to the value 1,6. It is set that under reaching the concentration of Ag nanoparticles in the cell of value the 0.3% wt%. efficiency of cell increased to 2.2%.

## 1. Introduction

To increase the work efficiency of solar elements the plasmons excitation can be used on the surface of metallic nanoparticles [1]. Three types of light traps plasmon are known, in their number dispersion in a far field, non communicative plasmon resonance in a near field, and superficial plasmon of polaritons on the border of border metal/semiconductor. A superficial plasmon arising up in metals can be used for the absorption increase of optical radiation or generation of photoelectric in different modifications of solar cells.

In basis of work principle of photodetectors using superficial plasmons, the generation of photoelectric lies in active material of photodetector under the action of variable electric-field of the plasmons excited by a radiation on the metallic nanoparticles surface. Thus an important circumstance is the local strengthening of electric-field of light wave as a result of excitation of superficial plasmon. Strengthening of the field is conditioned by that after the capture of photon the effective volume occupied by the electromagnetic field diminishes the surface of metal (its conversions in a superficial plasmon). Reduction of the field volume results in growth of spatial closeness of the field energy and its increasing.

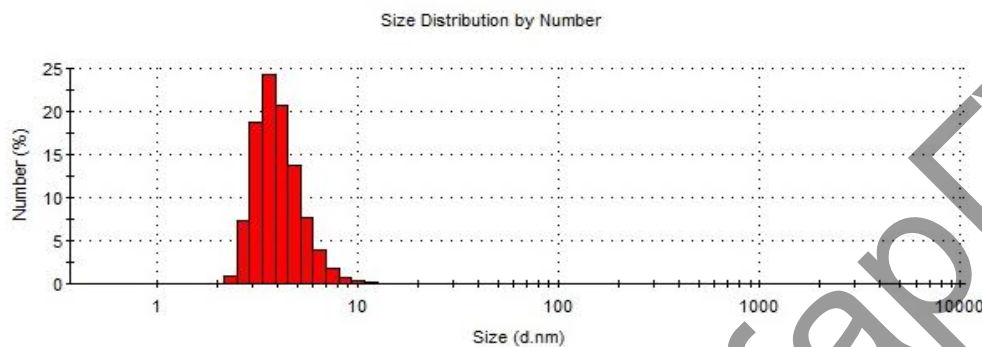
The prosecutions of improvement of DSS-cells descriptions are constantly conducted. One of the perspective methods of this problem decision is the use in the construction of solar battery of the specially formed clusters from nanoparticles, which are possessing plasmon properties [2,3].

In this work the influence of Ag nanoparticles on volt-ampere characteristics of DSS-cells sensitized by Z907 was studied.

## 2. Experiment

Nanoparticles of silver (Ag NP) were prepared by citrate recovery of AgNO<sub>3</sub> in aqueous solution [4]. In this method, the reducing agent and the stabilizer is a citrate ion derived by dissolving in water sodium trisodium salt of citric acid. When heating of the solution and the citrate ion oxidation the acetonedicarboxylic and itaconic acid are formed. These acids are adsorbed on the particle surface and their growth is monitored. The size measuring of the resulting structures was conducted using the

submicron particles size analyzer Zetasizer Nano ZS. The average particle size of silver is equal to 4 nm. The scatter of the values obtained by dispersion of silver particles is minimal and ranges from 1 to 5 nm (Figure 1).



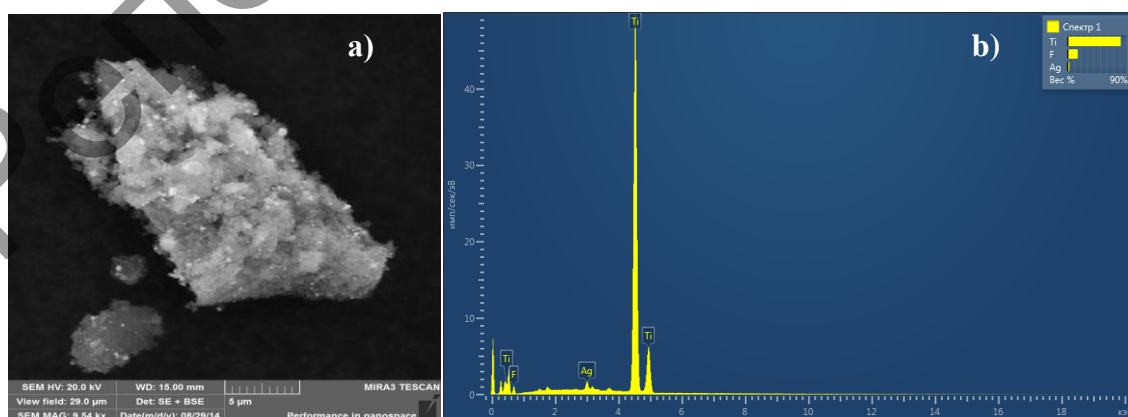
**Figure 1.** Distribution of Ag nanoparticles sizes in water solution.

Registration of absorption spectrums of the investigated standards was made on the spectrophotometer Cary 300 UV - Vis.

Paste on the basis of Degussa P25 powder was prepared by following methodology: 100 mg of colloid  $\text{TiO}_2$  (size of particles of 25 nm) ground in a porcelain mortar with the small amount of deionized water (2 ml) and acetylacetone (0.2 ml). After formation of viscous paste gradually 3 ml of water was added additionally, continuing grinding.

For preparation of tapes from titanic pastes glass samples were used, covered by the conducting layer of FTO ( $6 \Omega/\text{cm}^2$ , Sigma Aldrich) cleared with the use of ultrasonic bath. After a 15 minute ultrasound treatment the samples were washed by the distilled water and ethanol. Then the cleaning of samples surface was conducted by an ionic etch in plasma of argon during 20 minutes. Then paste was inflicted on the surface of conducting glass plate by the stencil printing. Procedure of the stencil printing (causing, drying) recurred to the receipt of suitable thickness of semiconductor tape. After it semiconductor tapes gradually heated in a muffle stove at temperatures:  $325^\circ\text{C}$  for 5 minutes;  $375^\circ\text{C}$  for 5 minutes;  $450^\circ\text{C}$  for 15 minutes;  $500^\circ\text{C}$  for 15 minutes. Introduction of silver nanoparticles in tape of  $\text{TiO}_2$  took place on the stage of preparation.

The study of structure and element composition of titanic pastes was carried out using electronic microscope Mira 3 LMU, Tescan. Microstructure and element analyses of paste with Ag nanoparticles are shown on figure 2a.



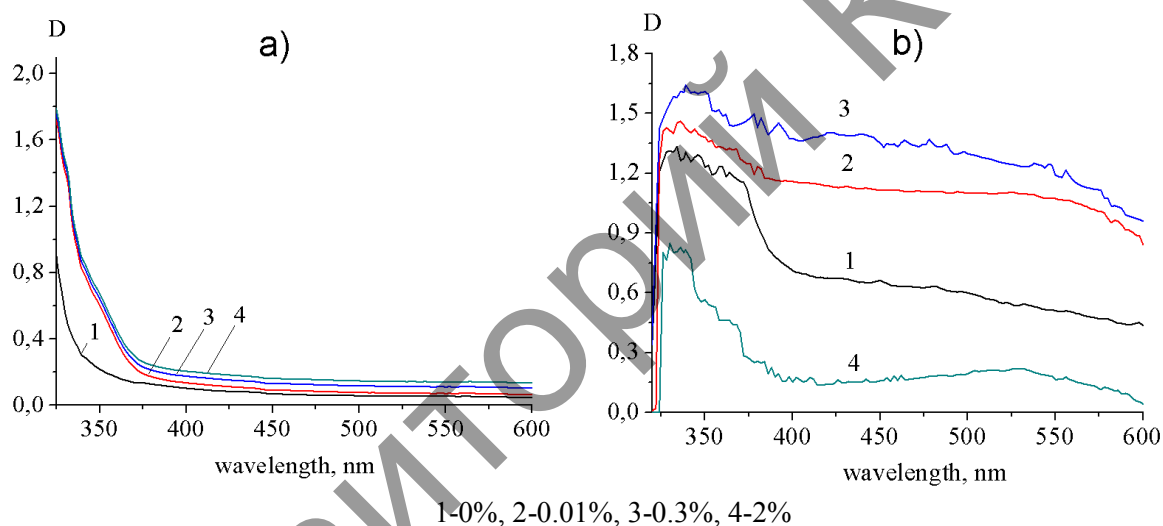
**Figure 2.** SEM images (a) and element analysis (b) of paste with Ag nanoparticles.

Figure (a) shows that paste is a porous structure with disseminations of Ag nanoparticles. The study of element composition of tapes showed the presence of titan atoms, oxygen and silver (figure 2b).

### 3. Results and discussion

Figure 3 (a) shows absorption spectrums of titan tapes with presence of Ag nanoparticles in tape at different wt% concentrations. Picture (a) shows that the increase of Ag nanoparticles concentration in tape results in the increasing of absorbance of titan tapes.

Adsorption of photoactive Z907 molecules by the surface of titan tapes from ethanol solution with the concentration of dye  $10^{-3}$  mol/l was further conducted. Tape was maintained in solution of phosphor during 20 hours. Then the tape was extracted from solution and dried out in a drying closet ( $T=80^{\circ}\text{C}$ ) for 3 hours. Figure 3 (b) shows absorption spectrums of Z907 of titan tapes at Ag nanoparticles presence in different wt% concentrations. The figure shows that with the increasing the concentration of Ag nanoparticles in tape results in the increasing of dye absorbance.

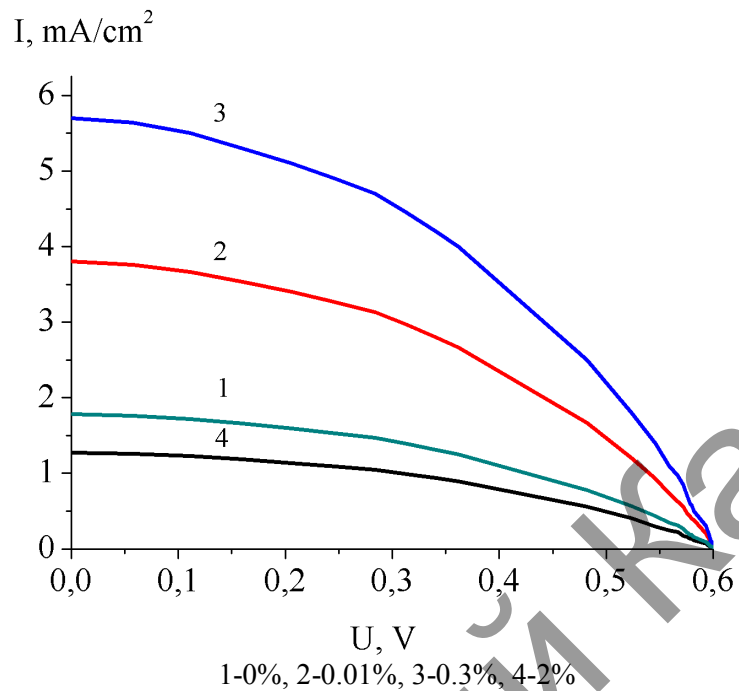


**Figure 3.** Spectra of absorption of titan tapes (a) and Z907 in titan tape (b) at different Ag nanoparticles concentrations.

It was investigated that increasing the concentration of Ag nanoparticles in tape to the concentration of 0,3wt% the absorbance of Z907 in a short-wave stripe grew to the value 1.6. After further increase of Ag nanoparticles concentration the reductions of Z907 absorbance to the value 0.7 is observed.

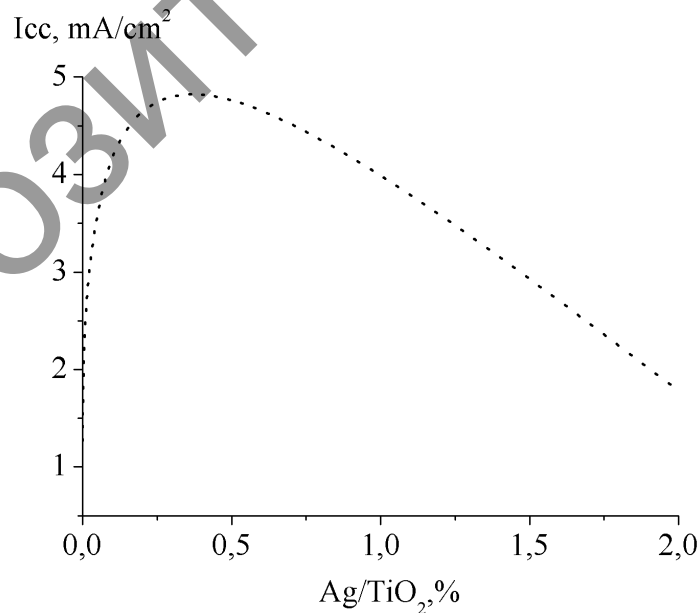
CVC of DSS-cells with different Ag nanoparticles concentrations in tape is shown on a figure 4. Figure shows that CVC is nonlinear. Values of tension of idling ( $U_{oc}$ ), current of short circuit ( $I_{cc}$ ), fill factor (FF) and efficiency determined from CVC.

Analysis of CVC on a figure 4 shows that adding of silver nanoparticles into DSS-cells substantially changes the parameters of CVC. Adding the silver nanoparticles 0.3 wt% into the porous layer of  $\text{TiO}_2$  results in the increasing of short circuit current in 3.3 times. After this concentration the reductions of short circuit current was observed below of primary value.



**Figure 4.** CVC of DSS-cells with Ag nanoparticles.

Dependence of value of cell short circuit current on silver nanoparticles concentration is presented on a figure 5. Figure shows that dependence passes through a maximum that is observed during the concentration of Ag 0.3 wt%. Efficiency of cells during a concentration the 0.3 wt% changed from 0.7% to 2.2%, Fill factor of CVC changed from 50% to 54%.



**Figure 5.** Dependence of value of cell short circuit current on a concentration of Ag nanoparticles.

#### 4. Conclusion

Thus, the work was investigated the effect of plasmon silver nanoparticles on the photovoltaic properties of DSS-cells. It was found that with increasing the concentration of silver NPs in the film to the concentration of 0.3 wt% the Z907 absorbance in the short band increases in 1.3 times. And this leads to an increase the efficiency of DSS-cells in 3 times.

#### References

- [1] Pillai S, Catchpole K R, Trupke T and Green M 2007 *Journal of Applied Physics* **101** 093105-1-093105-8
- [2] Ishi T, Fujikata J and Makita K 2005 *Japanese Journal of Applied Physics* **44** L364-L366
- [3] Liang Tang, Sukru E K and Salman L 2008 *Nature Photonics* **2** 226-229
- [4] Sheng R S, Zhu L and Morris M D 1986 *Analytical Chemistry* **58** 1116-1119

Репозиторий КарГУ