PREPARATION, MORPHOLOGY AND STUDY OF SOME NONLINEAR OPTICAL PROPERTIES OF HYBRID CADMIUM SULFIED COATED GOLD NANOWIRES

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The preparation and morphology of hybrid cadumium sulfid coated with gold nanowires were achived in this project. Where the CdS nanowires were produced by chemical vapor deposition (CVD) technique. the CdS nanowires obtained were dipped with gold nanoparticles. CdS NWs was diagnosed through x-ray diffraction (XRD) and scanning electron microscope (SEM). The morphology of hyprid CdS coated with gold nanoparticles was diagnosed with transmission electron microscopy (TEM). Second-harmonic properties of the Cadmium sulfide nanowires were dipped with the gold nanoparticles (Au NPs) was studied by using titinum sappire femtosecond laser with 800nm wavelength and offer an improved optical signal in the near infrared spectral range reached to 6 time improvement of the SHG intensity, Here we take second- harmonic signal of pure cadumium sulfied as a comparsion with second harmonic signal of cadumium sulfied coated gold nanoparticles, so we demonstrated that is cadmium sulfied is a perfact material for nano laser and nano optoelectronic applications.

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1. Introduction

The intraction between two photons of one wavelength are produced single photon at double frequency (2ω) is titled second-harmonic generation:SHG. The radiation behavior second –harmonic generation intensity in nanomaterial's wires shows in Fig. 1 a, a nano wire emits the frequency with half wavelength and double frequency The energy diagram of the Second- Harmonic Generation intensity showin(b).

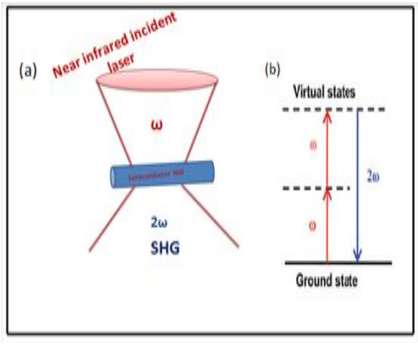

Fig. 1.a Diagram of the SHG in nanomaterials wire: b. SHG energy-level diagram.

The amplitude of laser beam E_0 and angular frequency ω,

$$E = E_0 \sin(\omega t) \quad (1)$$

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The polarization of laser light *P* is define as the interaction between the electric field and the nonlinear crystal matter:

$$P=\varepsilon_0 \chi^1 E_0 sin(\omega t) + \varepsilon_0 \chi^2 : E_0^2 sin^2(\omega t) + \varepsilon_0 \chi^3 : E_0^3 sin^3(\omega t) + \ldots \quad (2)$$

The polarization is also define as the following:

$$P = \varepsilon_0 \chi^1 E_0 \, sin\, 2(\omega t) + \frac{1}{2}\, \varepsilon_0 \chi^2 : E_0^2 (1\text{-}cos2\omega t) + \frac{1}{4}\, \varepsilon_0 \chi^3 : E_0^3 (3sin\, \omega t\text{-}sin\, \omega t) + .. \quad (3)$$

The polarization included nonliner optical second harmonic:

$$P^2 = \frac{1}{2}\, \varepsilon_0 \chi^2 : E_0^2 (1\text{-}cos2\, \omega t) \quad (4)$$

The second - harmonic generation equation contains two important idiom,equation,4 clear that. The first point represent the secondorder polarization included a component at zero frequincy, called optical rectification [1-4] .This state could not get to SHG intensity. The second state represent to SHG [5,6]. Surface-plasmon occurs, when light interacts with electron plasma waves at the surface of metal. The electro-magnetic field related with the surface-plasmons depends on the information of the nano-structure [7]. Localised surface plasmon (LSP), in nano-particle mediated emission has been confirmed as a best device to enhancement the quantum efficiency of light emitting systems [8] due to the relation-ship between the exciton effect of the noble metal surface-plasmons (SP) and the semiconductor excitons [8, 9] . Surface-plasmon enhanced photo catalysis, light-harvesting, and photo voltaic[10,11], surface-plasmon enhanced fluorescence[12], and forster resonance energy transfer[13], as well as the non -linear optical properties of the semiconductors can be improved by the surface-plasmon[7, 14]. These have many uses in nanosystems for instance, nano-laser [15], and frquency doublers[16]. Semiconductor – metal hybrid nanostructures gives the basic information and improved optical properties on the optical coupling of the semiconductor and metal.

Cadumium sulfide CdS is a II—VI, semiconductor group with its band-width at room temperature of 2.42 eV. It is used as a window material for solar cells because of the physical and chemical properties it possesses. It is also used in the nonlinear systems applications and as an optical wave guides[17-19].

2. Experiment

The technique of chemical vapor deposition;:CVD" was used as a preparation method of cadmium sulfide; "CdS" nano-wires. A 50.0 mm indoor diameter quartz tube furance at 850 C^o the device technique contained. High purity powder of cadmium sulfide was set into quartz cell that was set in the midle of the furnace tube . Gold thin film coated silicon substrates were set a matters on the head down-stream, representing the substrates of the deposition . Furnace tube was locked , the pure nitrogen gas was passed with 80; "sccm"standard cubic centimeter per minute" of the flow rate.The source has been heated to 850 C^o at a rate of 30 C^o/mint and remain at these temperature for 1 hour, and cooling furnace tube to reach to the room temperature,. Finally, Cadmium sulfide material with a yellow color was deposited on silicon substrate. Gold nano-particles were coated the cadmium sulfide "CdS" wires (10 nm Ciitrate Nano X.act Gold) by submerging with more one time in the gold nano solution. The gold nano colloidal solution was previous synthesized according to Nano X.act corporation. The CdS wires were assumed to be full coated with gold nanoparticles. A Single gold -nanoparticle coated CdS wire was relocated on to the glass substrate to held more characteristics and the tests.

Purity and the phase structure of the produced samples were tested via x-ray diffractometer "XRD, X'Pert PRO, PA Nailytical B. V., Netherllands".Scanning electron microscope (SEM, JSM-6701F and TEM, JEOL-4000.EX) and Energy Dispersive analysis of X-

ray "EDAX" spectrum were used to determined the morphology , particle size and the compositions prepared of CdS NWs. SHG properties were tested by a mode –locked Titanium / Sappire laserr with a wavelength of 800.00 nm as the excitation light source.

2. Results and discussion

X-ray diffraction (XRD; X ':Pert P.R.O, Nal ytical B,V., Nether-lands), field-emission scanning electron microscope (FESEM, Novaii Nano :SEM 4.50) were used to characterize the cadmium sulfide nanowires and cadmium sulfide nanowires coated gold nanoparticles.the SEM images of samples is shown in Figure 2 and display the x-ray diffraction spectrum of materials specimens which approval with :JCPDS; card no. 36--1450, A cadmium sulfide nanowires with a hexagonal phase and the lattice constant of a = b= 0.38nm and c= 0.63nm. As well as the compositions of synthesized CdS NWs were determined by the spectra obtained by Energy. Dispersive analysis of X-ray "EDAX".

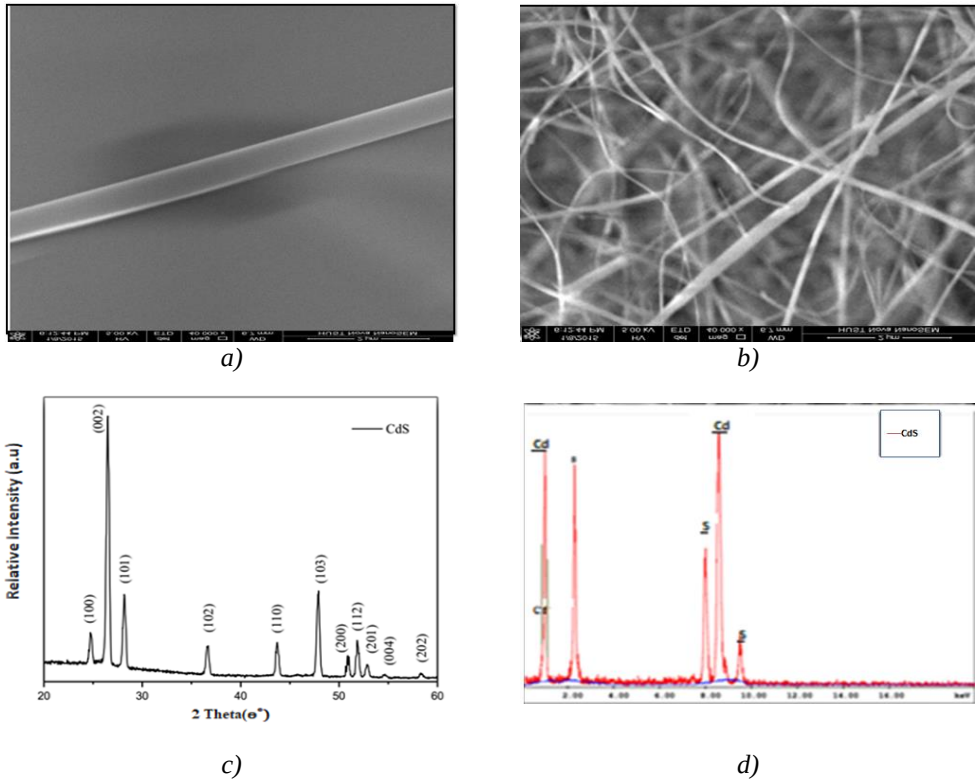
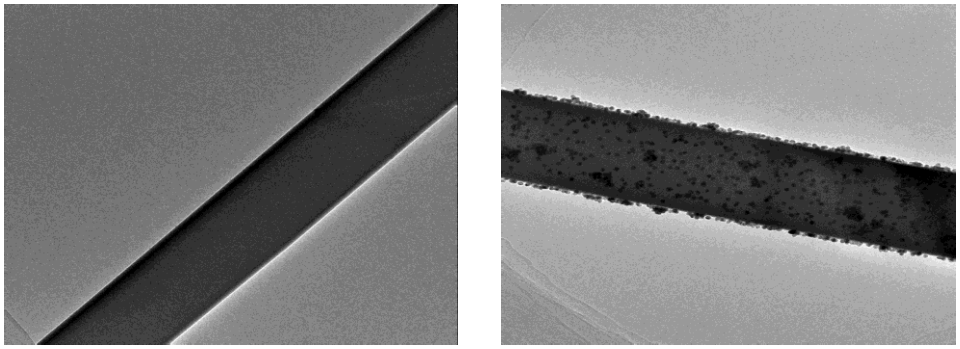


Fig. 2 SEM images of the as-prepared CdS NWs,
a) high; b) low magnification;
c) XRD charactersitic of the CdS nanowires
d) EDAX spectrum of CdS NWS.

To characterize thesecond- harmonic generation properties of the cadmium sulfide nanowires , gold nano-particles were used to coated the wires by a solution process and the TEM image of a coated cadmium sulfide nanowires is shown in Figure 3,From the TEM images, it can be seen that Au nanoparticles are every which distributed on the surface of the wire with a different dimension along the long-axis .



a) *b)*

Fig. 3. Shows TEM images of: a) bare CdS NWs,; b) gold nanoparticles coated CdS nanowires.

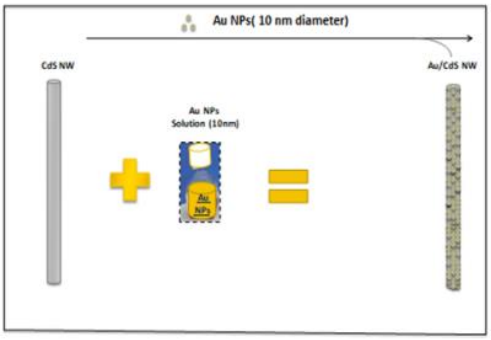
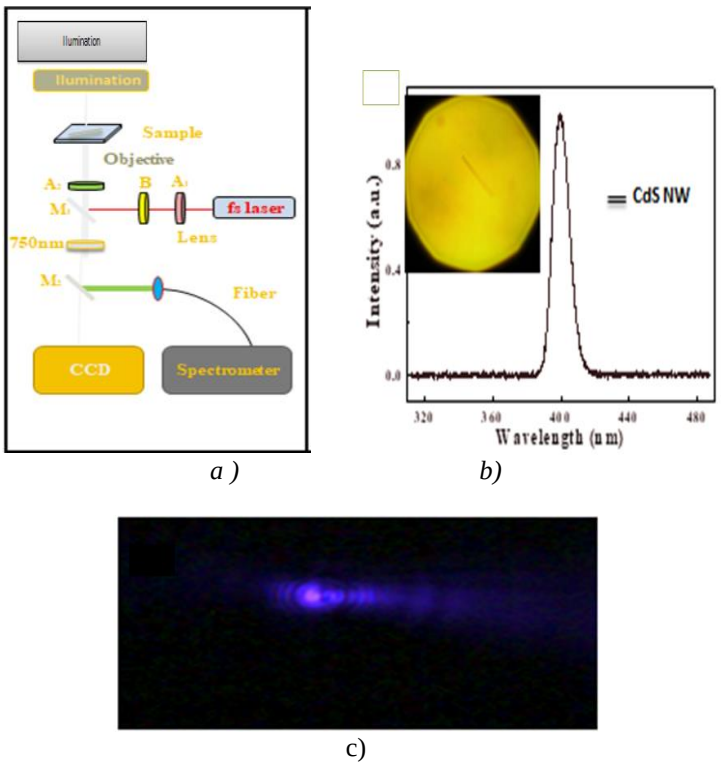


Fig. 4. Shows the mechanism growth of the gold nanoparticles coated CdS NW.

Second- harmonic generation properties of specimens were studied by a microscopy device as shown in Figure 5. A mode-locked Ti- sapphire femtosecond laser at 800 nm wavelength, 50 fs pulsed width and 76 M Hz repetition frequency. Through the workout, the pumping laser was focused to ~4.00 um by a 4.0× objective and the reflected SHG intensity was composed by the same objective. A 700 nanometer filter was used to separate out the laser radiation energy. The second harmonic generation, "SHG" intensity of the cadmium sulfide nanowires was studied through get to energy laser radiation with the half-wave plate "A2".For avoiding the mutual effect, the pumping of laser propagates should be to the long of the Z- axis, and (an isolated CdS NWs or gold nano particles coated CdS NWs sitbacks to the long of the the *X*- axis. The isolated CdS NWs or with coated gold nano particles NWs was measured.

The pattern intensity in Figure 5 points to the high peak at 400nm, which is just so the half wavelength of the energy laser radiation . It referes to that the orginal signal from the samples is the SHG signal. Furthermore, the inset in Figure 5 represent to photo - field of nanowire got of CCD camera. And the dark field image of nanowire .



a) *b)*

c)

Fig. 5. Nonlinear optical experiment: a) the experimental set up,
b) spectrum of the CdS NWand the inset picture represent to the photo field of CdSnano
c) the dark field image of nanowire.

The observed improvement can be attributed to the localized surface plasmon of Au NPs. The plasmonic resonance of the metallic Au NPs locally improves the electric field of the incident fundamental light near the CdS NWs. second harmonic generation improvement led to the transfer the charge directally without take the importance the gap between sem iconductor and metal .

4. Conclusions

Great improvement of the second harmonic generation intensity of CdS NWs by incorporating Au nanoparticles and amended by the interaction between CdS nanowires excitons and the metal surface plasmons. Second -harmonic generation SHG improvement is due to the local electro-magnetic field improvement of the surface plasmons metal and the improvement of second - harmonic generation in a nanowire due to the attachment Au NPs. we obtain the improvement of the SHG intensity is observed to be 6 times. Cadmium sulfide nanowires is considered on of the best nominee of the many applications like nano-photonic and non-linear optical spectrums.

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