MORPHOLOGY AND CHARACTERIZATION OF $Sr_xCu_{1-x}O$ [X=0.1]

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Abstract

The application of Nanostructured materials is enormous as their physical and chemical properties depend upon size. Here an attempt is made first time to synthesis (Sr_x $Cu_{1-x}O$) nanoparticles by sol–gel method. $Sr(No_3)_2$and $Cu(No_3)_2.3H_2O$ were taken as starting material. Ethanol, distilled water and PVA are mixed with these powders of nitrates and solution was stirred by magnetic stirrer at a temperature of 80 ^0C till a gel was formed. It was then dried at low temperature and finally calcinated at 400 ^0C for four hours. XRD of the sample shows its crystalline nature and particle size was determined to be 34nm by Debye Schherrer formula. The FTIR study shows two broad peak at 1455 $cm^{-1}$and 532 cm^{-1}. The UV-VIS analysis shows a absorption peak at 202nm .The TEM images clearly shows the individual nanoparticles having diameter less than 20 nm. In one image a nano rod is also visible whose further study is also required.

Keywords:*-nano materials, XRD, FTIR, TEM, UV-VIS, band gap, strontium*

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1. INTRODUCTION

Nonmaterials are very much different from bulk material as they have unique chemical, optical and electronic properties. [1, 2]. They show extremely amazing and useful properties, which can be used for a variety of applications [3]. Metal oxide nanoparticles are such nanomaterials that have been synthesized on a large scale for both industrial and household applications. For future applications also they show quite positive behavior [4, 5]. Copper Oxide is such a semiconductor with optical properties that allows stable emission at room temperature and having very much application in sensors, field emission and photonic devices [6]. Nanoparticles of CuO can be used as gas sensors, optical switch, and magnetic storage media due to its photoconductive and photochemical properties [7]. Also it is a promising semiconductor for fabrication of solar cell due to its suitable optical properties. CuO nanoparticles also have immense medical applications [8-10]. It also have useful photovoltaic and photoconductive properties because CuO crystal structures have a narrow band gap [11-12]. For these reason CuO nanoparticles have been applied in different areas, including sensors catalysis, batteries, high temperature superconductors, solar energy conversion, and field emission emitters. Strontium has important medical uses as it is chemically very similar to calcium. Strontium is not needed in the body but strontium is taken up by the bones just like calcium, and is known to promote calcium uptake so it helps in increasing bone density. For patients suffering with osteoporosis strontium ranelate is given as a drug and it helps in strengthening bones and preventing breaks. For treatment of tooth sensitivity strontium chloride is used as an important ingredient of toothpaste. Cathode ray tubes in televisions are also made made of strontium. In the present study we have synthesized strontium doped copper oxide nanoparticles by sol-gel method

2. EXPERIMENTAL DETAILS

In this synthesis process.Strontium Nitrate[$Sr(NO_3)_2$], Copper Nitrate $Cu(No_3)_2$.$3H_2O$ and Ethanol (CH_3CH_2OH) were used as starting materials . Poly vinyl alcohol(PVA) is used as the solvent for forming sol-gel . For synthesis **$Sr_{0.1}Cu_{0.9}O$** we take 2.1163 g of $Sr(NO_3)_2$ and 21.744 g of $Cu(No_3)_2$.$3H_2O$. We mix 50 ml of distilled water in 50 ml of ethanol and then add these two nitrates in this solution with constant stirring.

Then we add 5g of PVA in this mixture. This mixture was then heated at 80^oC at magnetic stirrer. After some time of heating a gel starts to appear. The solution is heated till whole solution is converted in to gel. Then this gel is dried for 24 hrs and then crushed and calcinated at 400^oC. The fine powder is taken out for characterization.

3. RESULTS AND DISCUSSION

3.1 XRD

The figure 1 shows The XRD pattern of the $Sr_{0.1}Cu_{0.9}O$ nanoparticles which is annealed at 400°. The peak positions of the sample show the monoclinic structure of CuO .The ICDD card No 801916 also confirm the same. We do not observe any other impurity peak in the XRD pattern.It shows the single phase sample formation. We use Scherer formula for determining the particle size

$$\text{Particle size} = 0.9\ \lambda/\ \beta \cos\theta \text{-------(1)}$$

where λ is the wavelength of X-ray radiation, β is the full width at half maximum (FWHM) of the peaks at the diffracting angle θ[14]. Crystallite size calculated by the Scherer formula was found to be 34.7 nm.

The table1 shows the parameter of two prominent peaks of the $Sr_{0.1}Cu_{0.9}O$.

Table-1

2θ(DEGREE)	D(nm)	FWHM	Relative intensity	Particle size(nm)
35.540	2.5239	0.251	100.00%	34.7
38.715	2.3239	0.256	94.72	34.3

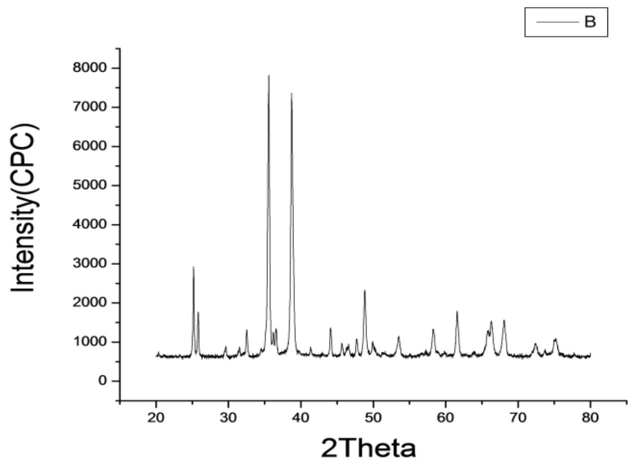

Fig 1:- Xrd of $Sr_{0.1}Cu_{0.9}O$

If we compare it with pure CuO XRD from the paper[15] Then we get this type of curve as shown in fig.2**.** The table2 shows the parameter of two prominent peaks of the CuO Nanoparticles.

Table -2

2θ(DEGREE)	D(nm)	FWHM	Relative intensity	Particle size(nm)
35.5651	0.252222	0.2689	100.00%	31
38.7198	0.232367	0.3700	72%	23

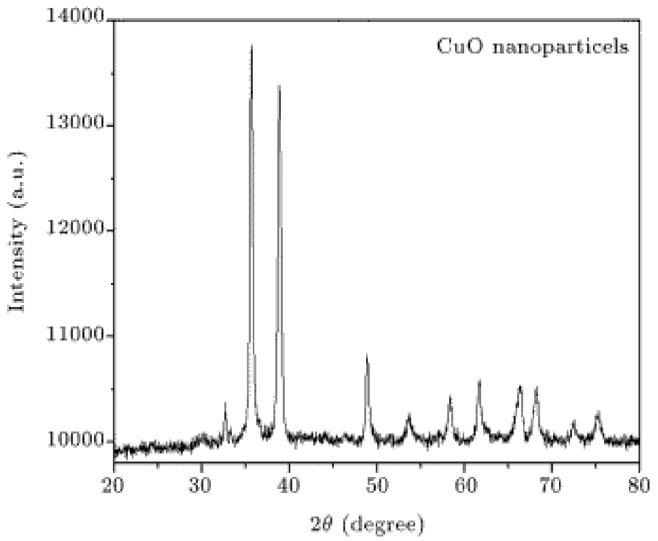

Fig 2:- XRD of pure CuO Nanoparticles[15]

Both these tables agree fairly well for CuO but for strontium we get extra peak at 2θ=25.183 also which keeps growing in intensity when we increase the strontium concentration.

3.2 FTIR Analysis

Infrared spectroscopy is used to determine the presence of certain functional groups The FTIR spectra of Sr doped CuO nanoparticles is shown in fig 3 which show strong bands at around 532 cm^{-1} Which is due to the vibrations of Cu(II)-O bond.There is sharp peak observed at 601 cm^{-1} in the spectrum CuO nanoparticles which is the characteristics of Cu-O bond formation. Bands around 858.57 cm-1 may be due to Cu-O stretching vibration The band around 1455 cm^{-1} Is attributed to the stretching vibrations of C = O, C = C and C-H groups in ethanol species, which suggests its presence as it is absorbed on the surface of nanoparticless. The broad absorption peaat around 3432.6cm^{-1}corresponds to stretching mode of OH group and is caused by the absorbed water molecules since the nano crystalline materials exhibit a high surface to volume ratio and thus absorb moisture. The peak around 2924.63 cm^{-1} may be due to C-H bond

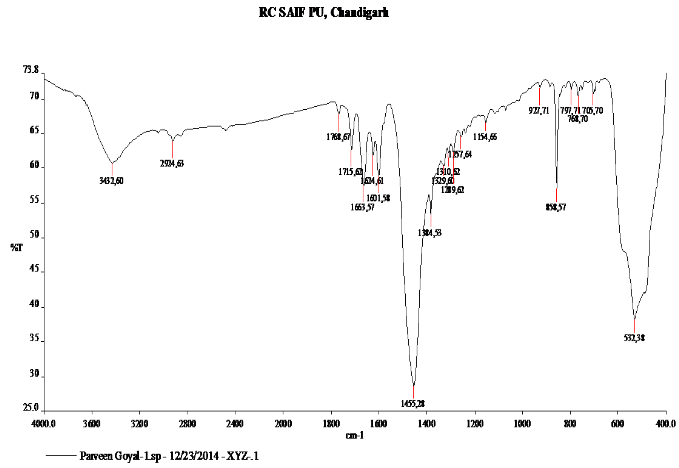

Fig 3:-FTIR of $Sr_{0.1}Cu_{0.9}O$

3.3 UV VIS Analysis of $Sr_{0.1}Cu_{0.9}O$

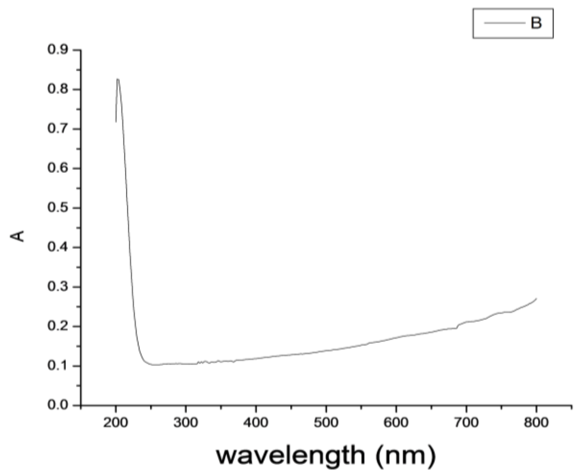

Fig 4:- UV-VIS Analysis

The optical properties of the Synthesized nanoparticles was studied by optical absorption spectrum . From this study we can determine the band gap and the type of electronic transitions. An electron is transferred from the valence band to the conduction band when a semiconductor absorbs a photon having energy larger then band gap so there occurs a sudden increase in the absorbency of the material to the wavelength corresponding to the band gap energy. The relation between the absorption coefficient (A) and the incidental photon energy depends on the type of electronic transitions. If the electron Momentum is conserved in this transitions , then this transition is called direct transitions , but if the momentum does not conserve in this Transition then it must be accompanied by a photon this is called indirect electronic transition [16-18]. By using absorption spectra we are able to study energy band gap of these materials. The fig.5 Exhibits the optical absorption spectrum of CuO:Sr nanoparticles .The UV visible spectra displayed absorption peak at 204 nm. It shows the absorption edge at 232 nm. The material is found to be having direct band. **Determination of Band gap energy from UV absorption Spectra:-**

As we now that .

$$E = h\upsilon = hc / \lambda g. \qquad \text{----- (2)}$$

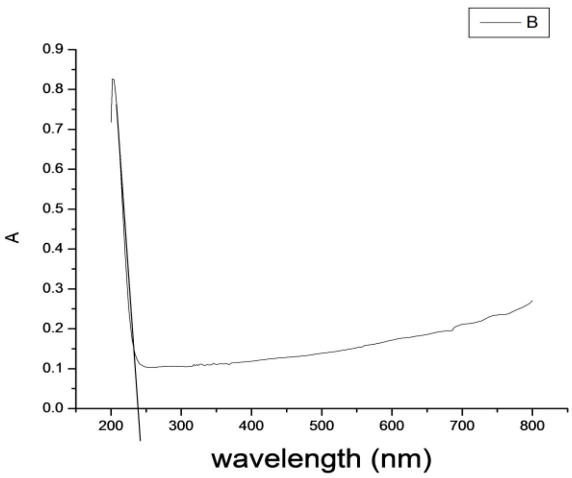

Fig:- 5

E denotes the optical band gap.

This energy gap is obtained by extrapolating the linear portion of the absorption spectrum to zero as shown in fig 5**.** The energy band gap for Sr doped CuO is calculated using λg =232 nm as 5.3 eV. But the standard band gap energy for CuO nanoparticle is 4.68 eV. On doping with strontium, band gap energy increases. This blue shift is due to quantum confinement.

3.4 TEM Images of $Sr_{0.1}Cu_{0.9}O$

TEM images of $Sr_{0.1}Cu_{0.9}O$ is shown in fig 6-9 at different resolutions.

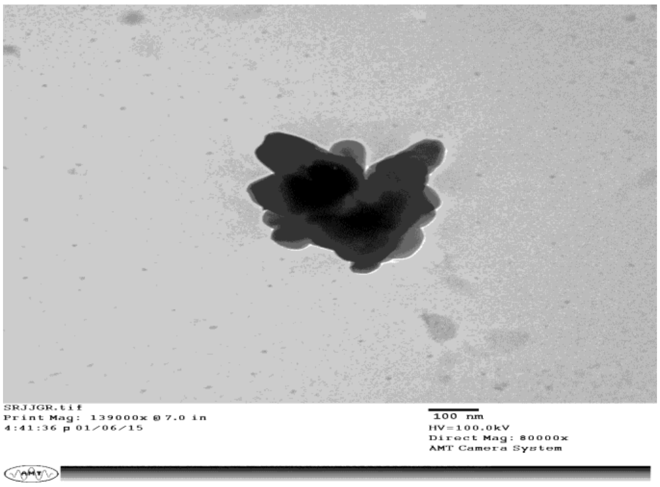

Fig 6

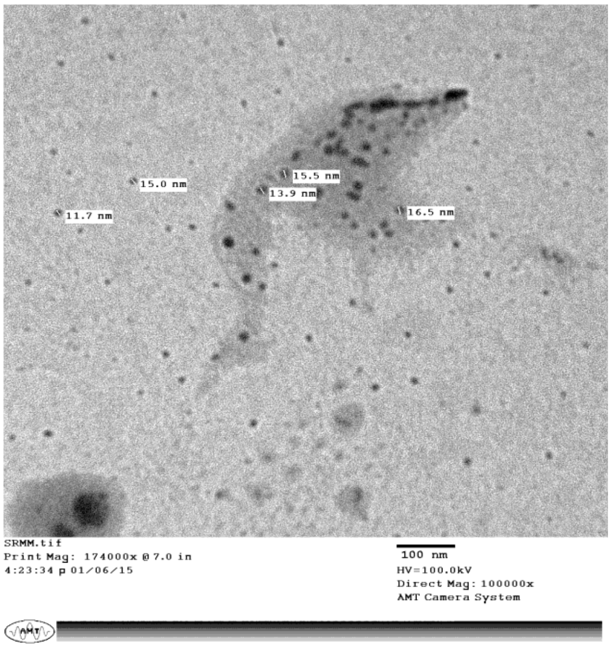

Fig 7

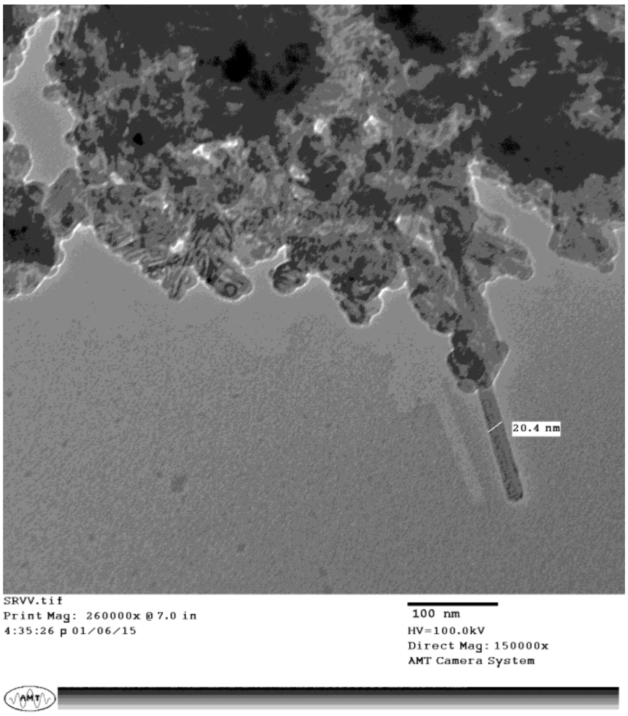

Fig8

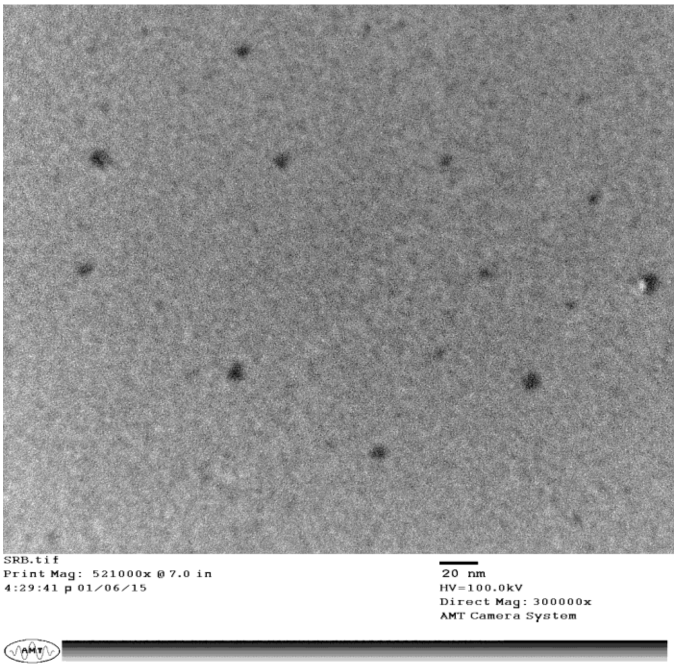

Fig9

We observe An agglomeration of nano particles. Images further show a uniform distribution and homogeneous morphology. TEM studies were performed to find out exact particle size of synthesized nanoparticles . It shows that the nanoparticles are monoclinic and size of the obtained nanaoparticles lies in the range of 12-35nm.The result is in close agreement as found with XRD study.

4. CONCLUSION

$Sr_{01.}Cu_{0.9}O$ nanoparticles with monoclinic structure were synthesized successfully first time by Sol gel method. The addition of strontium shows a change in the typical XRD of CuO .

A peak is observed at about 25 degree which grows in intensity with increase of dopant (Strontium) concentration.Strong bands at around 532 cm^{-1} is attributed due to the vibrations of Cu(II)-O bond. Sharp peak at 601 cm^{-1} in the spectrum is due to CuO nanoparticles which is the characteristics of Cu-O bond formation. Bands around 858.57cm^{-1} may be due to Cu-O stretching vibration. Uv-vis shows blue shift which means band gap increase with strontium addition. The energy band gap for Sr doped CuO is calculated using λg =232 nm comes out to be 5.3 eV. From TEM study, it was found that particles were monoclinic with average size of 12-35 nm.

ACKNOWLEGEMENTS

The authors are very thankful to Dpartment of Physics, M.D.University Rohtak for carrying out experimental work. Authors are thankful to SAIF Punjab University Chandigarh and DCRUST Murthal for carrying out characterization of the samples.

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