SYNTHESIS AND CHARACTERIZATION OF COPPER OXIDE DOPED WITH TITANIUM NANOPARTICLES

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Abstract- Copper oxide (CuO) is a suitable material for the application of photovoltaic where the role of lattice defects is remarkable for shaping its other physical and optical properties. In the present study, we report the structural properties of Ti doped copper oxide (CuO: Ti) (with x=0, 0.0078, 0.0156, 0.0234, 0.0312) nanostructures prepared by sol-gel method. The electrical property of CuO nanoparticles changes with changing the concentration of Ti dopant. The resistivity of undoped CuO is higher than the Ti doped CuO. The XRD (X-ray diffraction) pattern results the formation of pure phase of CuO for x=0 and no impurity phase is observed at 450ºC and 600ºC.

Keywords: Copper oxide, CuO: Ti, sol-gel method, four point probe system and X-ray diffraction.

1. INTRODUCTION

Over the past years, the scientists and researchers have appeared their big interest own transition metal oxide because of their optical, magnetic, electrical properties, specific catalytic [1-4]. The shape, size, properties and the nature of particles has a huge effect in various fields such as in optoelectronic devices, sensors, drug design, batteries, solar cells, synthetic chemistry and catalysis. Facts of detection of crystal at nano-level will provide rigorous information about their wonderful properties which is different from their bulk.

In the modern time, extraordinary efforts were devoted towards the formation of transition metal oxide nanoparticle in accordance of physical and chemical properties. CuO is the excellent choice for the solar application because it uses entire visible spectrum due to its energy (direct or indirect) band gap of 1.2eV. At the present time, doping in CuO has been significantly analyzed because the properties of CuO can be easily controlled by suitable dopant.

Due to photoconductive and photochemical properties of CuO p-type semiconductor, it is used in gas sensing, in catalysis, as antimicrobial agent, and in batteries, magnetic devices, super capacitors, and field emission [14]

Copper oxide has great attention in present years because of their potential application and special properties in the areas of technology [5-7]. CuO have the monoclinic structures. According to their impressive advantages as nontoxic nature, inexpensive, readily stored and easily produced [8]. CuO is used as catalyst among another metal oxide. CuO is also used to produce dry cell batteries.

There are vast ranges if synthetic method for the preparation of oxide likes sol-gel, sonochemical, solid state technique and hydrothermal methods [9-13]. We prepared the nanoparticles by sol-gel method. Sol-gel method is very strong and valid method controlling the size and shape of particles without requirement of any complex apparatus. The sol-gel is the prominent method to synthesis high purity advanced materials. Additionally, sol-gel is a low temperature process so it consumes less energy and creates less pollution.

Copper oxides doped with Ti are promising materials

for optoelectronics and may reduce production costs due to their low cost and inexpensive production methods compared with silicon solar cells which are potentially useful for inexpensive and competitive solar cell construction[15-16].

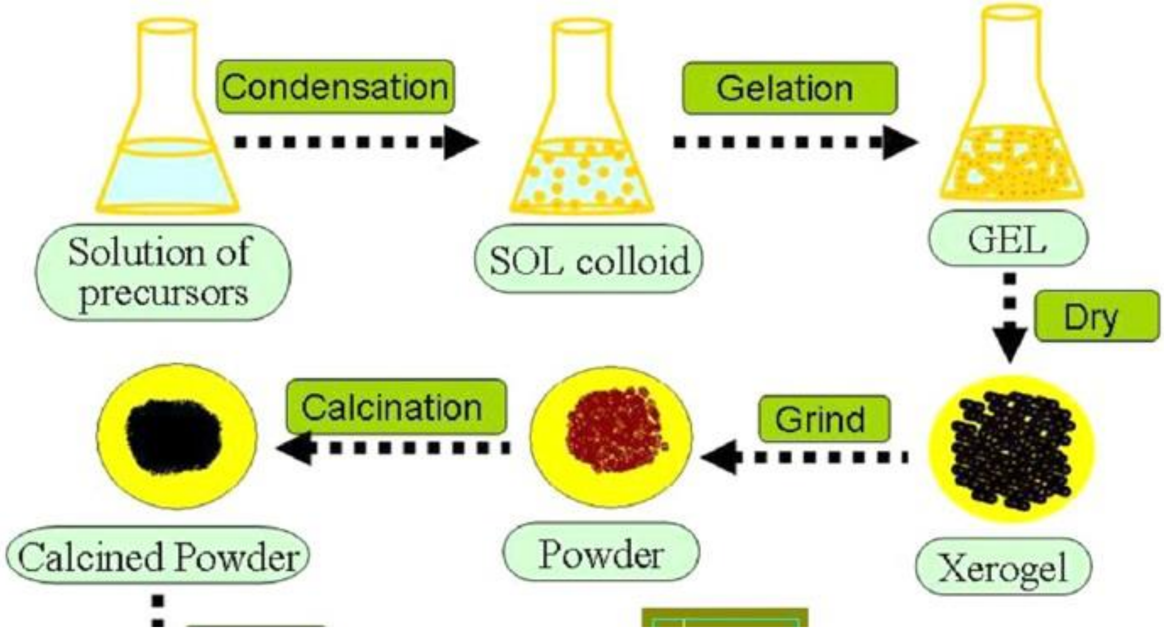
In the past few decades metal nanoparticles (silver and copper) and semiconductor nanoparticles have been used for the antifungal/antibacterial materials with the help of nanoscience and nanotechnology [17].

Doping of different transition metals vary their optical and structural properties in CuO. Thus we report the effect on the structural properties of CuO due to doping by sol-gel method and four point probe system at different concentration of Ti ion.

2. EXPERIMENTAL

The materials used were copper oxide, nitric acid, ethylene glycol, citric acid and TALH (Titanium ammonium lactato dihydroxide) and double distilled water for the preparation of nanopowder.

Sol-gel method has synthesized the pure and Ti doped CuO at different doping concentration (x=0, 0.0078, 0.0156, 0.0234, 0.0312). A precursor was produced by the liquefying copper in double distilled water under stirring and then was added drop wise with constant stirring. Then citric acid and ethylene glycol was added to give the gel. The gel was heated at room temperature for 3-4 hours and we get the powder form of CuO. Powder were decarbonized and denitrified at 450ºC and further annealed at 600ºC.



3. CHARACTERIZATION TECHNIQUE

3.1 X-ray Diffraction

When an X-ray is incident on a crystal, it diffracts the structure characteristic. The diffraction pattern is obtained by the powder of the material in powder X-ray diffraction. Powder diffraction is more convenient comparatively than single crystal diffraction because XRD does not require individual crystals to be made. A pattern obtained by the diffraction plots intensity against 2θ, the angle of the detector.

A pattern obtained by the diffraction determines the purity of a sample. The composition of any present impurities can also be determined. Determination and refinement of the lattice parameters of a crystal structure can be done. The obtained samples were characterized for the analysis of structural and phase purity obtained with a step size 0.02 in the range of 2θ from 30 to 80º with the help of X-ray diffractometer.

The glass substrate was used for the thin film deposition of CuO doped with Ti by using the four point probe system and measuring the resistivity of CuO with increasing the concentration of the Ti ion [16]. Table 1. Shows the sheet resistance of thin film of CuO: Ti nanoparticles with Ti concentration after annealed at 300 °C.

Table-3.1 Sheet resistance of thin film of CuO: Ti nanoparticles with Ti concentrations after annealed at 300 °C [16]

	PURE CuO	X1	X2	X3	X4
Ti Sputtering power (W)	0	1	2	4	10
Ti concentration (%)	0	0.049	0.099	0.19	0.598
Sheet resistance (Ω/square)	~6x 108	~ 8x 106	~5x106	~2x106	~5x105

4. RESULT AND DISCUSSION

Study of structure with the help of XRD release monoclinic single crystalline phase of $Cu_{1-x}Ti_xO$ for all the synthesized samples with (x = 0, 0.0078. 0.0234, 0.0156 and 0.0312) at two different temperatures i.e. at 450°C for 6 hours and 600°C for 2 hours . All the samples are present in single phase. No peak of impurity phases is detected. This emphasizes that Ti is successfully incorporated in monoclinic structure of CuO. Shifting of (111) diffraction peak to lower angles hints towards the increase in the lattice parameters. Further increasing the concentration of Ti dopant peak intensity decreases, this showing the dependence of crystal quality on Ti concentration. Indeed, in the lightly doped CuO: Ti nanoparticles, due to proper substitution of Ti in CuO lattice, no secondary defect phases are observed. However, in the highly doped CuO: Ti nanoparticles, the presence of more Ti-induced crystalline disordering resulted in lattice imperfection degrading the crystal quality of nanoparticles.

The effect of Ti concentration on the electrical conductivity of CuO: Ti thin films were investigated using a four point probe system. As shown in Table 1, the pure CuO exhibits a higher resistivity than the Ti doped CuO. Higher incorporation of Ti decreased the resistivity of CuO: Ti nanoparticles continuously and the value were found to decrease by three orders of magnitude when the Ti concentration was 0.598%. This significant reduction of resistivity of CuO: Ti can be explained on basis of charge compensation effect.
It was found that it is possible to improve the conductivity of the CuO: Ti nanoparticles by tuning the doping of Ti.

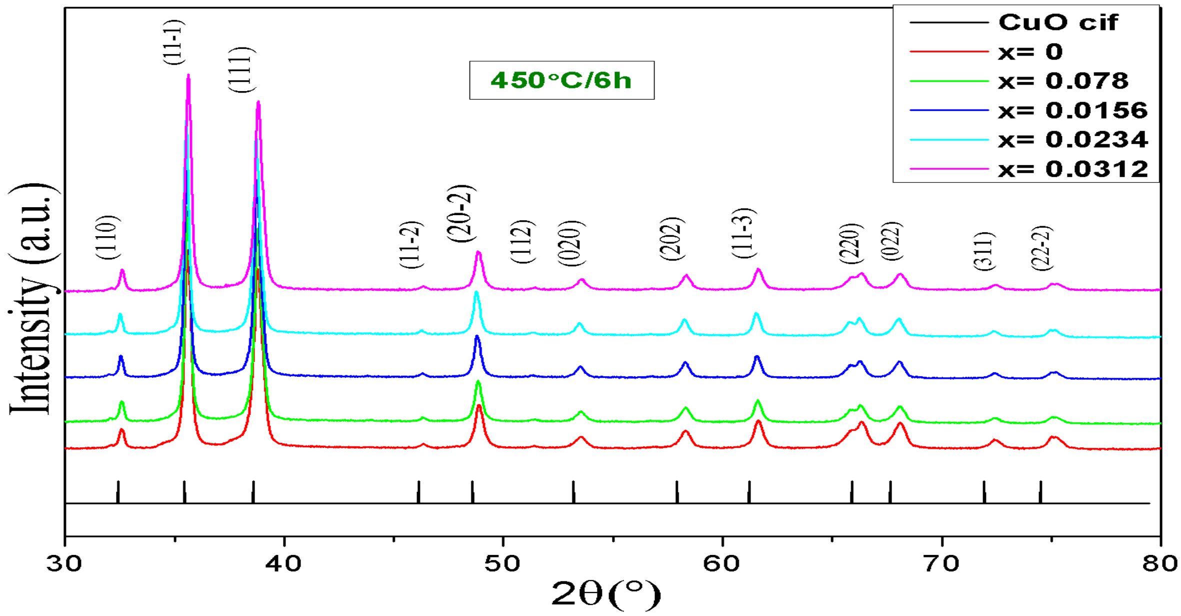


Fig. 4.1 X-ray diffraction pattern of CuO: Ti nanoparticles annealed at 450 °C for 6 hours

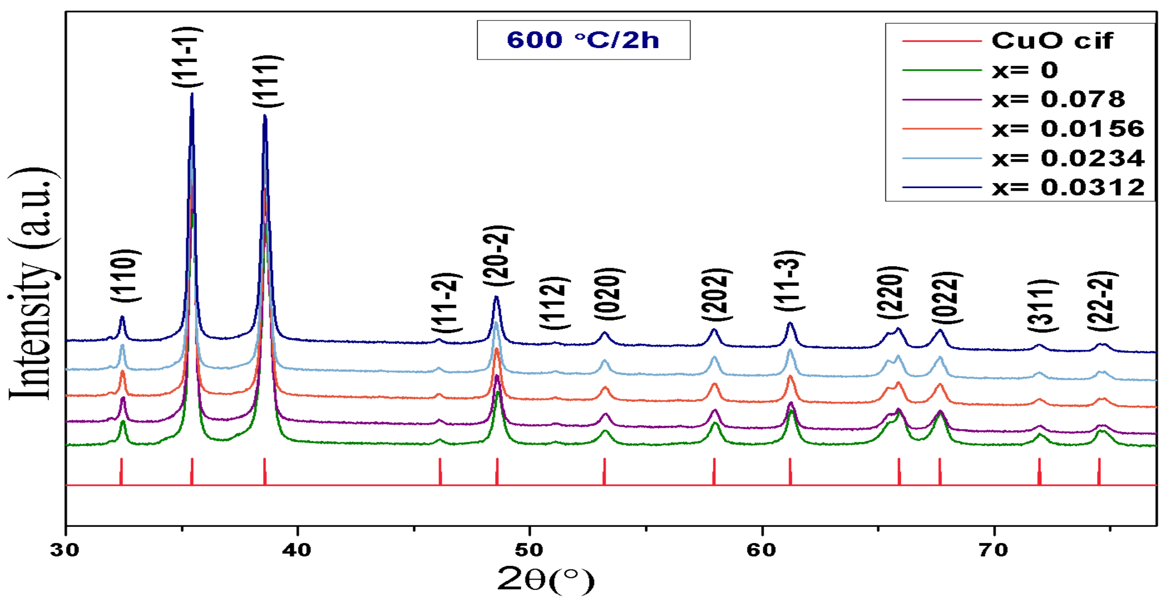


Fig. 4.2 X-ray diffraction pattern of CuO: Ti nanoparticles annealed at 600 °C for 2 hours

CONCLUSION

The structural properties of Ti ion substituted CuO nanoparticles with different doping concentration with x=0, 0.0078, 0.0156, 0.0234, 0.0312) have been studied by sol-gel method. The pattern obtained by XRD tells about the pure phase of CuO and no impurity phase is observed in Ti doped CuO at 450ºC and 600ºC. The effect of Ti concentrations on the resistivity of CuO has been studied by the four point probe system. It was found that the pure CuO exhibits a higher resistivity than that of Ti doped CuO. Higher incorporation of Ti in Cuo lattice decreased the resistivity of CuO: Ti nanoparticles continuously. The present report provides a possible solution for the growth of Ti doped CuO for photovoltaic devices.

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