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PVA assisted Copper (Cu) @ cuprous oxide (Cu_2O) nanostructures via hydrothermal method

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ABSTRACT

Poly (vinyl alcohol)(PVA) mediated copper (Cu) @ cuprous oxide (Cu_2O) nanostructures were prepared by hydrothermal method from copper acetate and sodium citrate in the presence of water as a solvent. The obtained sample was characterized by X-ray powder diffraction(XRD),scanning electron microscopy (SEM) and photoluminescence (PL) spectroscopy.The XRD patterns confirm the presence of Cu @ Cu_2O.PL spectrum showed light emission in the visible region can be used for optoelectronic devices.The band gap energies were calculated to be 17.5–1.9 eV from the PL spectra.The possible formation of copper @ cuprious oxide is also discussed.

INTRODUCTION

Metal-semiconductor nanostructures have attracted many interests due to their potential application in many areas [1] and interesting physics involved in the process. Metal @ metal oxide nanomaterials have shown considerable promise in the field of catalysis, sensing etc. because they exhibit dual physical properties of core as well as shell materials [1]. Metal oxidies nanostructures are used for gas sensors, whereas the addition of metallic core inside this oxide improves sensitivity and selectivity of the sensor [1-3].

Copper-based nanomaterials are of great interest because of their optical, catalytical, mechanical and optical properties, resulting in a wide range of applications in the field of metallurgy, catalysis and optoelectronics [4-6]. Cu_2O (cuprous oxide) and CuO (cupric oxide) are two important oxide compounds of copper and mostly behave like n-type semiconductor. Cuprous oxide is a II–VI semiconductor having direct bandgap of ~ 2 eV, while that of cupric oxide has a monoclinic crystal structure with a bandgap of 12.1–15.1 eV [7]. CuO and Cu @ Cu_2O are considered as efficient catalytic agents [8] and good gas-sensing [9] and play an important role in the optoelectronics [10].

In this paper, we report the successful synthesis of PVA assisted copper @ cuprious oxide nanostructures via hydrothermal method were discussed by different characterizations such as powder XRD, SEM and PL studies.

MATERIALS AND METHODS

In a typical process, 1.6 g of copper acetate (Cu (CHCOO).H_2O) was dissolved in 50 mL of distilled water. After that, 0.5g of PEG was added to the above solution. Then 0.5g of sodium citrate ($C_6H_4O_7$ Na_3.2H_2O) was dissolved in the same amount of distilled water drop wise was added to the above copper acetate solution under magnetic stirring for 3 hrs. Then, 1g of NaOH pellets were added into the above solution was kept at 150°C for 15 hrs at a ramping rate of 50°C min^{-1}. The obtained sample was washed with distilled water several times and dried at 60°C for 4 hrs.

The obtained sample was characterized by the powder XRD pattern were collected on a schimedzu model XRD 6000 with Cu K_α radiation (λ=15.417Å). The SEM analysis was carried out by a JEOL- JEM-3010. The PL spectra were recorded by the Fluoromax-4 spectrofluorometer.

RESULTS AND DISCUSSION

The XRD pattern of as-synthesized sample (Fig.1) shows the presence of cuprous oxide (JCPDS NO. 35-109) and metallic copper (JCPDS NO.04-0836) phases [11]. The presence of cuprous oxide could be because of the air oxidation of copper. The average crystallite size of the Cu @ CuO sample is calculated from the XRD analysis, using Debye-Scherrer's equations (D=0.89λ/βcosθ), and found to be ~ 35 nm respectively. The strong and sharp peaks indicate that well crystalline nature of the sample.

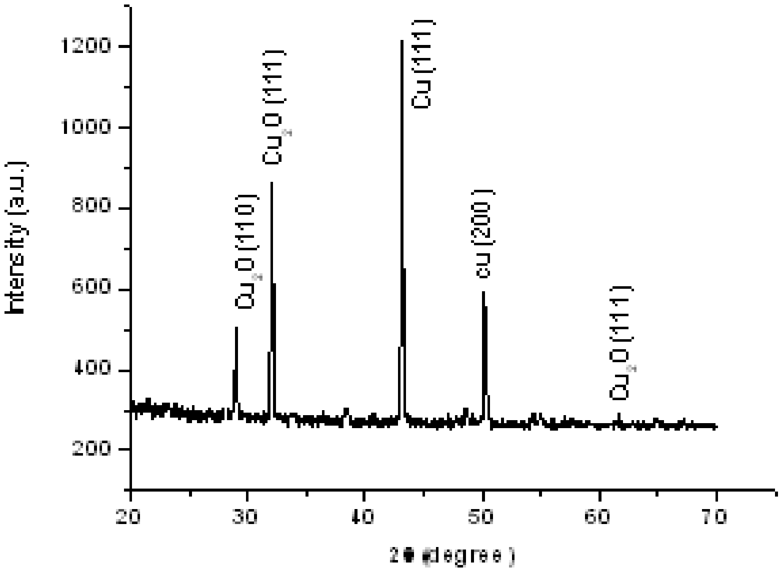

Figure .1 XRD pattern of Cu @ Cu_2O sample

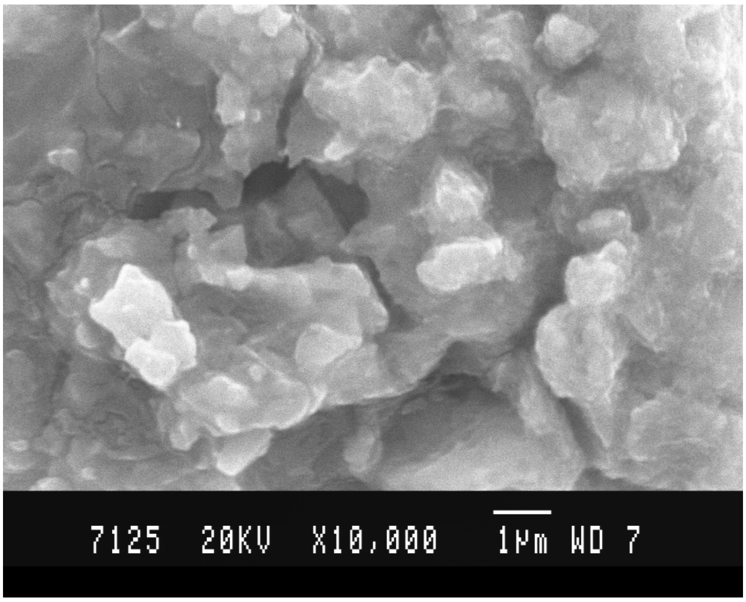

Figure.2 SEM image of Cu @ Cu_2O sample

The SEM image (Fig.2) shows that the particles were obtained in an agglomerated state. The agglomerated spherical-like morphology was observed from Cu @ Cu_2O sample with the size ranging from ~3040 nm, which is good agreement with XRD analysis.

Initially, copper acetate was dissolved in distilled water. After that, the surfactant PVA was added to the copper acetate solution. Similarly, sodium citrate was dissolved in same amount of distilled water mixed with drop wise to the copper acetate solution. Probably, with hydrothermal temperature kept at 150°C, the nanostructures formed via a reconstructive transformation from Cu(OH) aqueous solution involving partially dissolution reaction followed by the crystallization of Cu @ CuO.

PL spectrum carried out at room temperature is shown in Fig.3. Visible emission with a peak wavelength position of around 400-600 nm (corresponding band gap to 17.8 -2.1 eV) is dominantly observed. The visible emission known is related to the defect levels. These visible emission regions can be used for opto electronic devices.

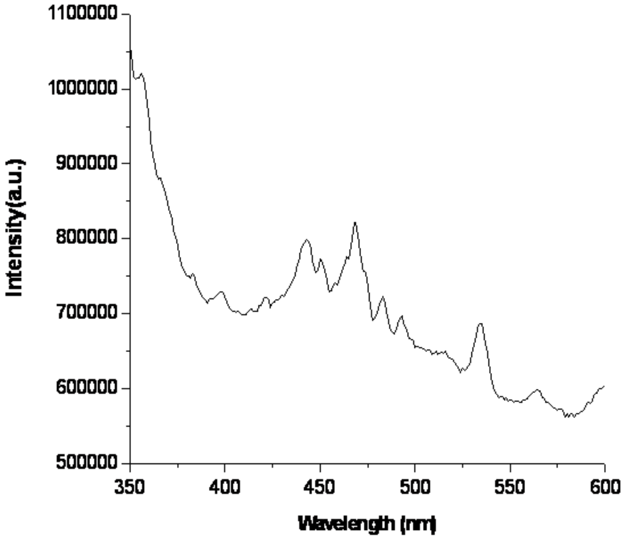

Figure.3 PL spectrum of Cu@ Cu_2O nanostructures

CONCLUSION

In summary, we have synthesized PVA assisted Cu @ CuO nanostructures by hydrothermal method. Structural and morphological characterization indicates that the agglomerated spherical Cu @ CuO particles with the size ranging from ~ 3040 nm. Optical measurements show that the Cu/CuO particles generate a visible light emission that may be exploited in optoelectronic devices.

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