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Thin Film or Bulk Cu_2O as an Efficient Inorganic Absorbent Semiconductor Type P

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Cu_2O is an important semiconductor type p for solar cell applications, hole-transporting material in perovskite solar cells, and photocathode for solar water splitting [1]. Cu_2O can be obtained by various methods such as oxidation of metallic copper at high temperatures or by Benedict's method [2-3].

In this work, Cu_2O was obtained by a reduction of Benedict's solution with glucose at 50 °C. Benedict's solution consists of a blue solution of copper nitrate, sodium citrate, and sodium carbonate. The volume of the samples was varied in 500, 100, 150 and 50 ml, for the samples P-A, P-B, P-C and P-D, respectively. A sputtering target was prepared from the powder Cu_2O of the sample P-A. A thin film was deposited in a magnetron sputtering with an RF source. The pressure of the chamber during the process remained at $1.2x10^{-2}$ Torr. The deposit was made under an argon atmosphere with a flow of 14.9 cm^3/min. The power used was 30 W. The time and temperature of the deposit were 2 hours and 350 °C, respectively. Morphology and size of the particles were carried out by Scanning Electron Microscopy JSM 7401F JEOL, crystallinity and phases obtained were verified by X-ray diffraction (XRD) by a diffractometer PANalytical. Absorbance thin film and bulk was obtained by UV-Vis spectrophotometer.

The control of pH, the temperature and volume of synthesis allows modifying the morphology and the size of the particles of Cu_2O. Figures 1a), b), c) and d) display the morphology of the Cu_2O powder samples and e) and f) of the thin film samples. In P-A sample can see cubes in the range of 620-970 nm and flower-shaped morphologies in the range of 640-1160 nm. However, a higher concentration of cubes can be observed compared to flower-shaped in a ratio of 3:1. In the P-B sample, a greater part of flower-shaped morphology is observed in the range of 200-520 nm, while the cubes are in the range of 280-490 nm. In the case of P-C sample cubic morphology in a range of 260-380 nm and flower-shaped in the range of 320-430 nm is observed. Finally, in P-D sample cubes in the range of 330-570 nm and flower-shaped in the range of 270-520 nm are observed. The modification of the volume of the solution shows changes appear in the morphology of the samples. Figure e) shows the morphology of the TF-A sample. It is observed that a grain size in the range of 20-90 nm. However, the grain size is very small compared to the grain size of the target used, which is in the order of 600-900 nm. It can be concluded that sputtering deposits do not preserve the grain size of the target used and the temperature is not sufficient to perform that grain growth.

Copper oxide has a cubic structure with a lattice parameter of 4.27 Å and a space group Pn-3m [4]. In Figure 2a) XRD patterns of the powder samples are shown. All samples have the characteristic peaks corresponding to the Cu_2O planes confirming the cubic phase (cuprite) of the Cu_2O (ICDD file PDF2 01-077-0199). The XRD pattern of thin film sample is shown in Figure 2c). The sample can be seen characteristic peaks belonging Cu_2O and Cu. The absorbance spectra measured by reflectance of the Cu_2O powder samples are shown in Figure 2b). The spectra show a very similar form between them. They have a peak absorption in the range of 200-570 nm. The P-C sample has the highest absorbance of all samples. Which, can be attributed to its distribution of homogeneous particle size and morphology, which is mostly flower-shaped, having a few cubes in its composition. Figure 2d) shows the absorbance spectra of thin film sample deposited on glass. It is observed that the absorbance spectra of the thin film is very different from the absorbance of the powder samples. One of the characteristics that the absorbent layer must show is a high absorption coefficient in order to guarantee that the greatest amount of incident radiation is absorbed within this layer and to be able to generate the electron-hole pairs for a current generation. Also, they must transmit as little radiation as possible.

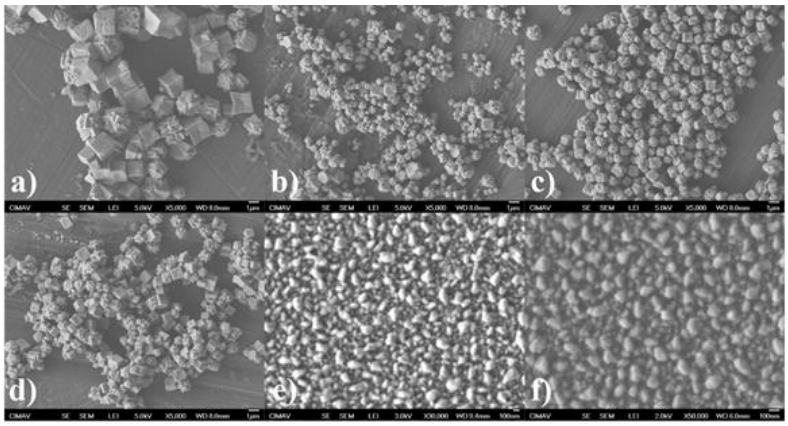

Figure 1. Morphology by SEM Cu2O powders a) P-A, b) P-B, c) P-C, d) P-D, and thin films e) TF-A and f) TF-B morphology thin films

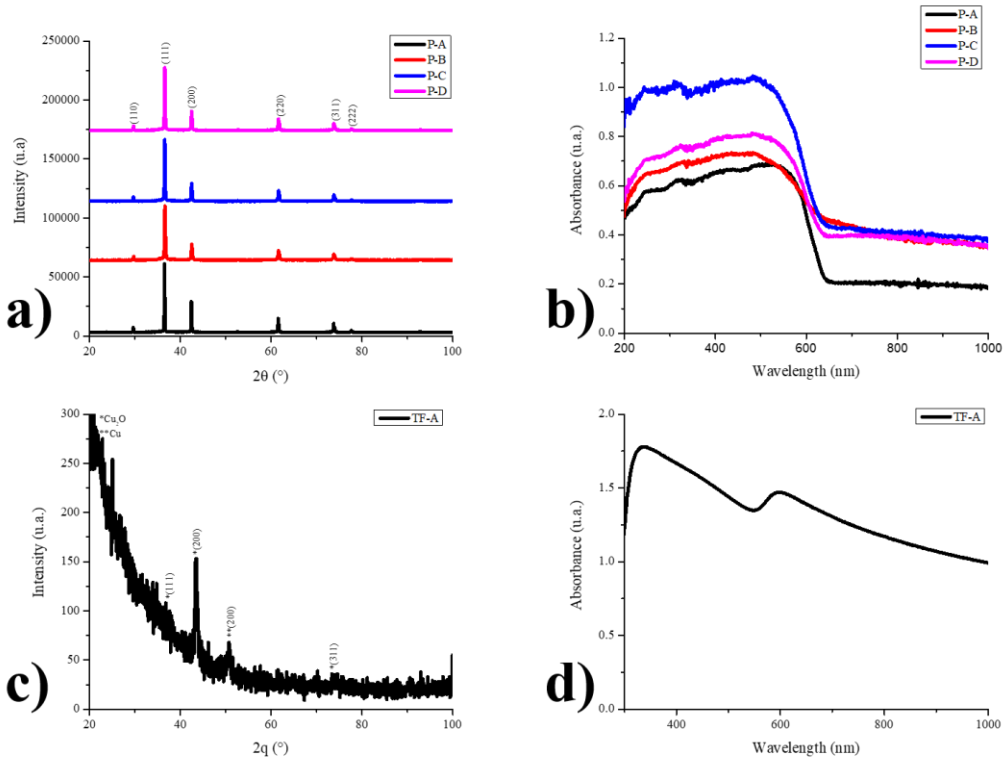

Figure 2. a) Powder samples and c) Thin films samples XRD, and b) Powder samples and d) Thin films samples absorbance by UV-Vis.

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