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Cu_2O nanowires produced by oxidation of Cu nanowires: a comparison between microwave irradiation and furnace annealing in atmospheric conditions

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Cuprous oxide (Cu_2O) nanowires are known to have remarkable physical properties. The present work reports the production of Cu_2O nanowires through oxidation of copper nanowires using either annealing under atmospheric conditions or microwave irradiation. Long Cu nanowires (~10 □m in length) can be achieved using copper acetate or nitrate [1] as precursors and must be followed by a subsequent complete conversion of the metallic Cu to Cu_2O in order to guarantee the semi-conductor behavior of the nanowires.
The annealing temperatures varied from 200 to 300 ºC and the experiments were carried out for 6 to 48 h in air. X-Ray diffraction (XRD) measurements revealed that for higher annealing temperatures (≥ 250º C) and lower annealing times (12 h), a considerable presence of cupric oxide (CuO) with metallic copper could be detected (Fig. 1 (a)). For annealing temperatures below 225 ºC, in addition to Cu_2O, Cu was consistently identified even for the longer annealing times (48 h) (Fig. 1 (c) and (e)), whereas for temperatures above 250 ºC and annealing times of 24 h, an extensive conversion to CuO occurred (Fig. 1 (b) and (d)). Total conversion of metallic copper into Cu_2O occurred under microwave irradiation, however minor CuO peaks could also be observed (compare Fig. 2 (a)). The reaction temperature was found to lie close to 150 ºC with an optimal reaction time of 45 min under microwave radiation at 200 W. The controlled pressure provided by microwave synthesis played an important role on the copper oxidation. For power inputs lower than 150 W, the required pressure (250 Psi) has not been achieved, and longer reaction times were needed, which resulted in a larger presence of CuO. Higher power inputs (above 200 W) caused a significant formation of CuO (Fig. 2 (b)).
The Cu nanowires (Fig. 3 (a)) annealed in air displayed nanocrystals on the surface (around 30 nm in diameter). Considering higher annealing temperatures (> 225 ºC), shorter and porous nanowire cores could be observed (Fig. 3 (b)), suggesting vaporization of the Cu core [2,3]. Microwave radiation induced the oxidation in the form of larger crystals, originating chain arrangements (Fig. 3 (c)), nevertheless the nanowire structure has been maintained.

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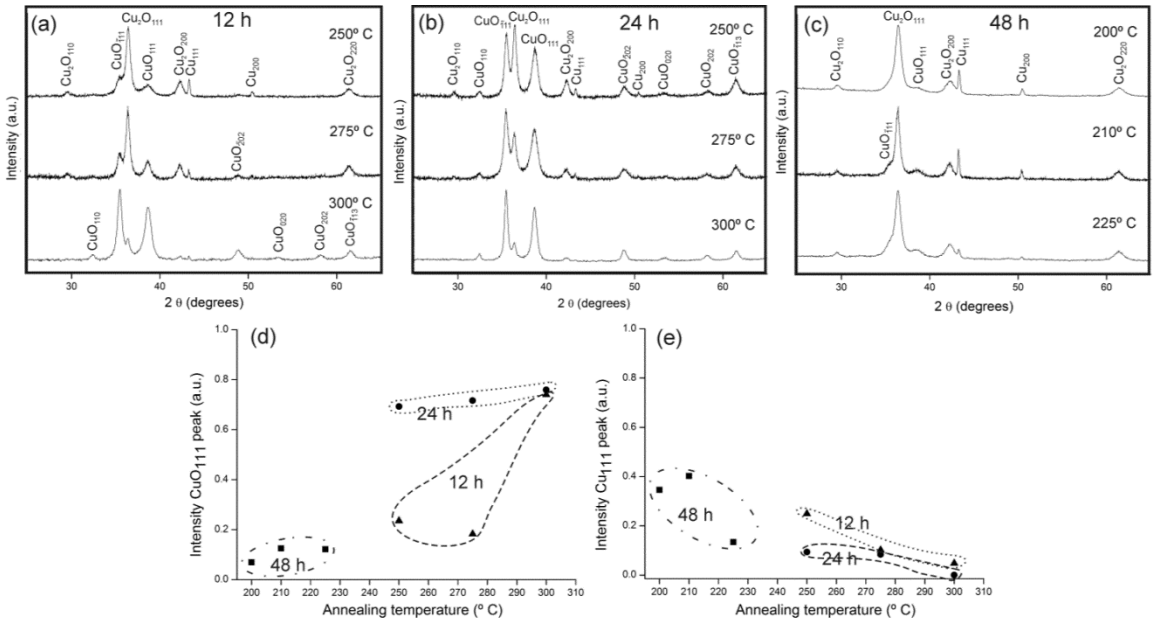

Figure 1. XRD diffractograms of the oxidized Cu nanowires. (a) Nanowires annealed in air for 12 h, (b) for 24 h and (c) for 48 h. Evolution of CuO (d) and Cu (e) phases as a function of temperature and time.

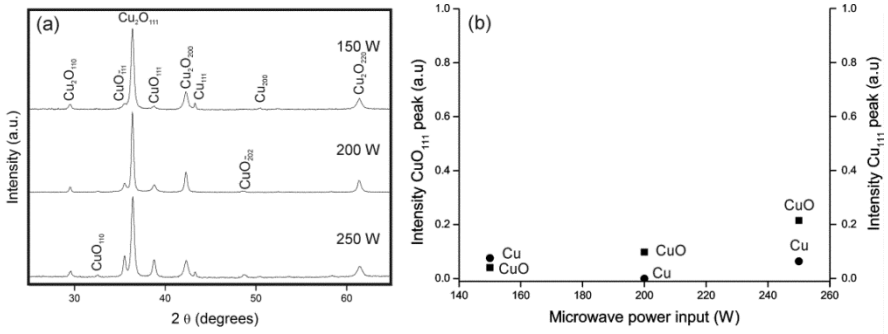

Figure 2. (a) XRD diffractograms of the oxidized Cu nanowires under microwave radiation. (b) Evolution of the CuO and Cu phases with the microwave power input maintaining time and pressure constant (45 min at 250 Psi). The optimal condition for the metallic Cu total conversion has been established to be at 200 W, 250 Psi for 45 min.

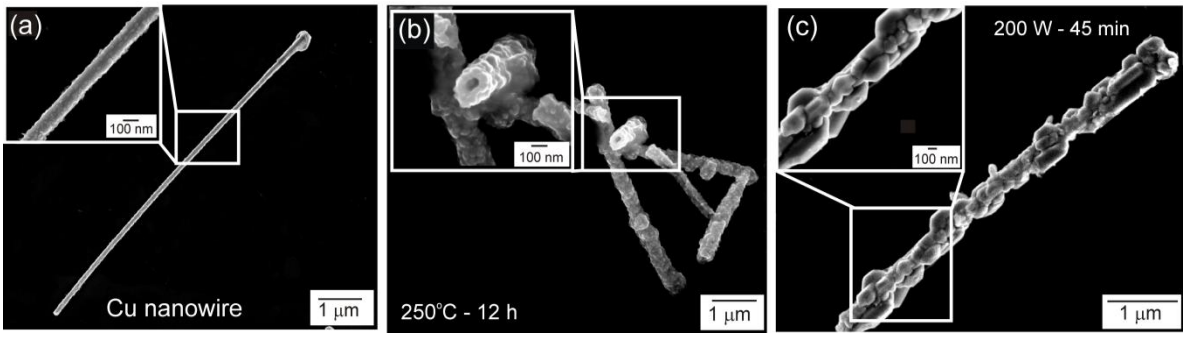

Figure 3. Scanning electron microscopy (SEM) images of a Cu nanowire (a), nanowires oxidized after annealing in air (b), and microwave exposed nanowires (c).

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