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Controlled growth of copper oxide nanostructures via local oxidation by an atmospheric pressure micro-afterglow

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The synthesis and fabrication of copper oxide nanomaterials with different morphologies are expected to exhibit more unique optical, electrical and magnetic properties relative to their bulk counterpart. In this study, we report on a process based on an atmospheric pressure micro-afterglow to synthesize copper oxide nanostructures without any template and surfactant. The experimental device consists in a microwave plasma operating with argon - oxygen mixtures at high temperatures (1000 - 2000 K). However, the samples being located far enough from the plasma, their temperature does not exceed 700 K as confirmed by Infra-red measurements and numerical modelling. Active species of an atmospheric pressure plasma exit the reactor through a tiny hole (400 - 600 µm in diameter). They react with copper thin films exposed to the micro-afterglow, which leads to oxidation and nanostructuration. The copper films are deposited before treatment on soda lime glass and silicon substrates by reactive magnetron sputtering of metal targets (thickness: 50 to 300 nm). Oxides grow directly on metal samples in a single step by local selective oxidation. By varying process parameters such as plasma power and composition, treatment time, thickness of the copper thin films and nature of the substrate, different kinds of nanostructures can be synthesized with good reproducibility. Nanograins, nanowalls and nanoneedles are successfully synthesized.
The as-prepared copper oxide surfaces are characterized using various techniques including Scanning Electron Microscopy, Atomic Force Microscopy, Transmission Electron Microscopy and X-Ray Diffraction. Experimental results demonstrate that this flexible process can be used to produce a large range of copper oxide nanostructures. The role of the stress, surface temperature and active species concentration on the growth mechanism of copper oxide nanostructures is finally discussed.

Keywords
atmospheric pressure micro-plasma
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