1470
DOI: 10.1017/S1431927605506858
Microsc Microanal 11(Suppl 2), 2005
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A Transmission Electron Microscopic Study of CuO/ZnO Nanostructured Catalyst

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Recently, we successfully prepared CuO-ZnO nanostructured catalyst, where CuO nanoparticles were supported on ZnO nanotetrapods. This catalyst with larger surface area may be used for ambient temperature carbon monoxide oxidation. Here we report the morphology, crystal structure, composition of the catalyst characterized by a start-of-the art transmission electron microscope, JEOL JEM-2100F, with various powerful capabilities such as atomic resolution Z-contrast STEM imaging, spectrum imaging (new generation Gatan Image filter) and sub-nanometer EDS analysis (Oxford system).

The CuO-ZnO catalyst was prepared by two steps, ZnO nanotetrapods were firstly synthesized by the thermal evaporation process and CuO nanoparticels were then precipitated onto ZnO with an impregnation method [1]. The TEM sample was prepared by dispersing the catalyst in alcohol and mounting it onto an ultra thin holy carbon film supported by a Ni grid.

The typical morphology of the catalyst is shown in Fig. 1, where ZnO looks like tetrapods with legs of about 100nm in diameter and a few hundred nanometers in length, and CuO particles attached to ZnO legs are in the range of 10 nm to 100 nm. The composition of the catalyst is determined by EDS and EELS using an1 nm STEM probe. Two EDS spectra shown in Fig. 2 come from a ZnO tetrapod and a CuO particle, respectively. Zn and O related signals show up in Fig. 2a, and Cu and O related signals in Fig. 2b. The Ni related signal in Fig. 2 is from the Ni grid and can be used to check the calibration. No CuO/ZnO solid solution was observed. Fig. 3 contains a set of energy filtered images recorded with a three-window technique, showing the distribution of elements Zn, Cu and O, respectively. These energy-filtered images support the conclusions drawn from EDS and EELS point analysis. EELS spectrum imaging was done to further confirm the results of energy filtered images. HRTEM imaging and electron diffraction studies indicate that both ZnO tetrapods and CuO particles are crystalline. Some CuO particles are displayed in Fig. 4a where lattice fringes are clearly seen. The ZnO tetrapods are single crystal with some planar defects parallel to the (0001) plane. The growth direction of ZnO tetrapod legs is [0001], as shown in Fig. 4b.

In summary, nanostructured CuO-ZnO catalyst is successfully prepared. Catalytic experiments of the catalyst and further work on controlling particle size are in progress.

[1] Z. Q. Zhang, C. B. Jiang, S. X. Lia, S. X. Mao, J. Crystal Growth, (in press, 2005)

https://doi.org/10.1017/S1431927605506858 Published online by Cambridge University Press

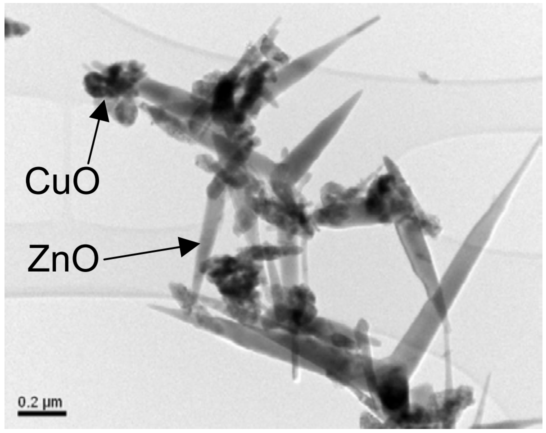

Fig. 1: The morphology of CuO-ZnO catalyst.

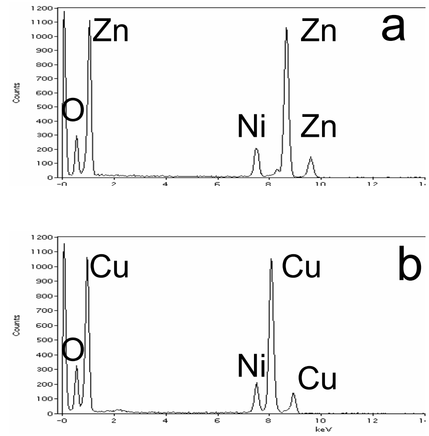

Fig. 2 EDS spectra from a) ZnO tetrapod and b) CuO particles. Ni signal is from Ni supporting grid.

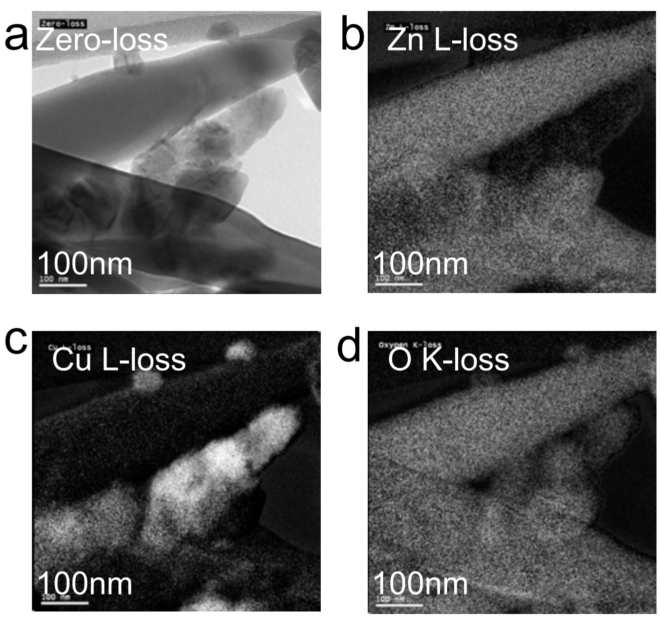

Fig. 3 Energy filtered images of the CuO-ZnO catalyst, a) zero-loss, b) Zn L-loss, c) Cu L-loss and d) O K-loss.

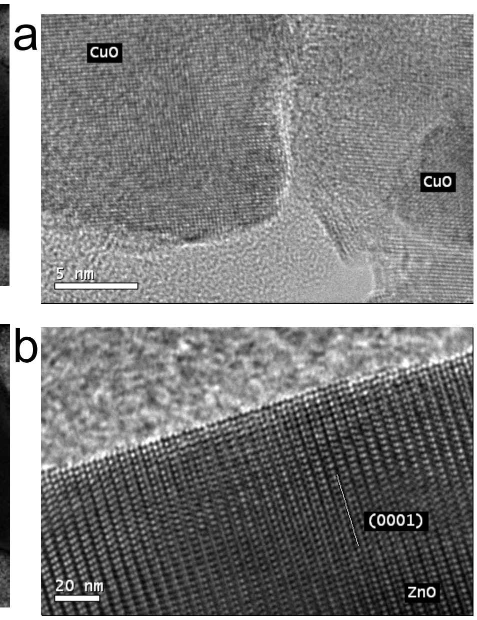

Fig. 4 HRTEM images of a) CuO particles, and b) partial ZnO tetrapod where the ZnO edge is parallel to the [0001] growth direction.

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