ICAM2009
11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25

TEM Characterization of Oxidation-Resistant Copper Nanoparticles Covered by Biopolymer Nanoskin

K. Ida[(1,2)], K. Sasaki[(1)*], Y. Sugiyama[(1)],Y. Chujyo[(1)], M. Tomonari[(2)], T. Tokunaga[(1)], K. Kuroda[(1)]

(1) Depart. of Quantum Engineering, Nagoya University, Nagoya, 464-8603, Japan, e-mail: khsasaki@nagoya-u.jp
(2) Functional Materials R & D Division, Ishihara Sangyo Kaisha, LTD, Yokkaichi, 510-0842, Japan
* Corresponding author.

Abstract – Copper nanoparticles with gelatin protective layer synthesized by the wet chemical method were characterized using transmission electron microscopy (TEM). The nominal size of 50, 100 and 200nm particles were consist of 60, 50 and 40% of single crystals, and the shape of them were identified as sphere, spheroid and faceted shape, respectively. The surface gelatin layer was observed with the thickness between 2 and 5 nm. The {111} twin boundaries were observed in some particles

Size and shape controlled metal nanoparticles have been studied intensively because of their potential applications in many fields [1]. Copper nanoparticles with gelatin protective layer synthesized by the wet chemical method [2] were characterized using transmission electron microscopy (TEM).

The particles were able to stored more than a half year without any oxidation in the atmosphere condition [3]. The nominal size of 50nm (Type C50), 100nm (Type C100) and 200nm (Type C200) were observed in a conventional 300kV type TEM (Hitachi H-9000). The cross sectional specimens of Type C100 and C200 particles were prepared using focused ion beam (FIB) technique in order to observe the inside structure of the particle.

The typical bright field (BF) image of a single crystalline particle of Type C50 specimen is shown in Fig. 1. The selected area diffraction pattern SADP of <110> zone axis was observed as indicated in the inset of Fig. 1. The 60% of particles were single crystal which was confirmed by SADP analysis. Some of the particles include twin boundaries as shown in Fig. 2. The single {111} and doubled {200} spots indicated by 200_{t1} and 200_{t2} in Fig. 2b and the orientation relationship between Fig.2a and b indentify the {111} twin boundary in the particle. The circular shape of TEM images in all particles suggests that the particles have the sphere shape. As observed both in Fig.1 and 2, the thickness of surface gelatin layer was between 2 and 5 nm. Figure 3 shows BF images of Type C100 particles. The oval shape of images suggests that the particles have the spheroidal shape. The SADP analysis showed that 50% of particles were single crystal. Most frequently observed size of the particle was about 140nm which was larger than the nominal size of Type C100 specimen. Figure 4 shows a typical faceted shape of Type C200 particles, which suggest enough crystal growth after initial nucleation. The SADP analysis showed that 60% of the particles were polycrystalline particles consist of three or more crystals.

For the application to the inkjet printing technology [4], Type C50 particles will be useful to avoid the clogging of the microcapillary nozzle. However, considering the sintering process of particles, polycrystalline Type C100 or C200 particles could also be useful, because the size of crystal in the particle is possible to be smaller than the single crystalline Type C50 particle, which will lower the sintering temperature.

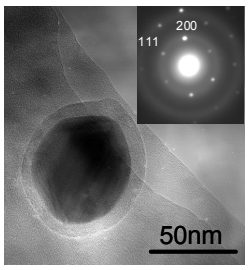

Fig. 1: Typical BF image of single crystalline particle in Type C50 specimen.

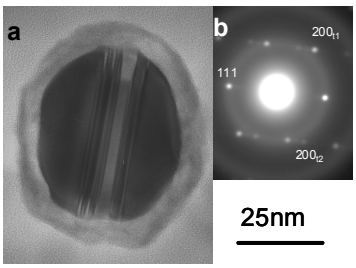

Fig. 2: Dark field image (a) and SADP (b) of a Type C50 twined particle.

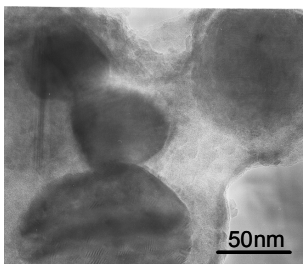

Fig. 3: BF image of Type C100 particles.

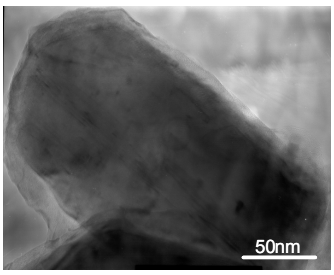

Fig. 4: BF image of a faceted Type C200 particle.

References

[1] M. P. Pileni, Nature Materials, 2 (2003) 145 -150.
[2] M. Tomonari, K. Ida, H. Yamashita, T. Yonezawa, Journal of Nanoscience and Nanotechnology, 8 (2008) 2468 - 2471.
[3] M. Tomonari, K. Ida, Journal of the Surface Finishing Society of Japan, 59, (2008) 18 - 22 (in Japanese).
[4] J. U. Park, et. al., Nature Materials, 6, (2007) 782 - 789.