Supporting Information

Effect of copper oxide shell thickness on flash light sintering of copper nanoparticle ink

Gyung-Hwan Oh, Hyun-Jun Hwang, and Hak-Sung Kim*

* Institute of Nano Science and Technology, Hanyang University, Seoul, 133-791, Korea

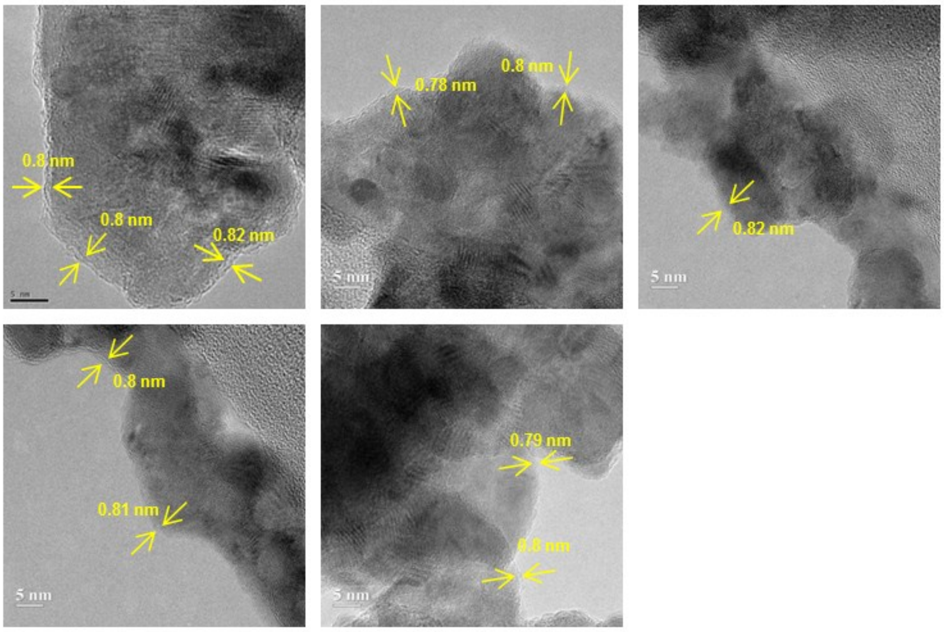
* Corresponding author. Tel : +82-2-2220-2898

*E-mail : kima@hanyang.ac.kr (Hak-Sung Kim)

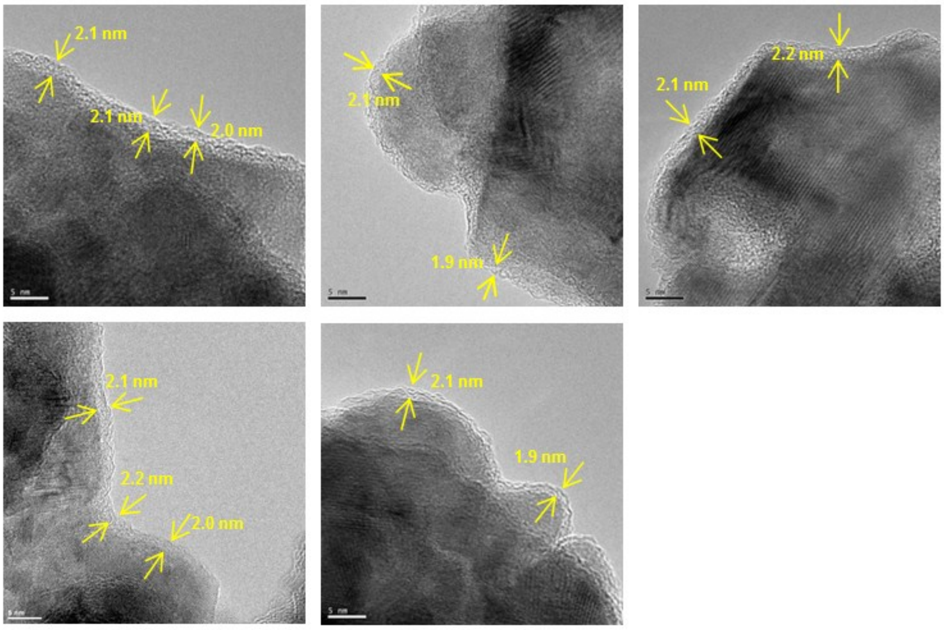
1. Determination of representative thicknesses of oxide shell based on TEM images.

In this study, the thickness of the oxide shell is the most crucial parameter and that was measured by the TEM images as shown in figure S1a-f. To obtain the reliability of the measured oxide shell thicknesses, TEM images were taken from various points in each sample due to non-uniformity of thickness of the oxide shell. And then the thicknesses mainly observed from TEM images were selected and averaged to determine the representative thicknesses of oxide shell about each case.

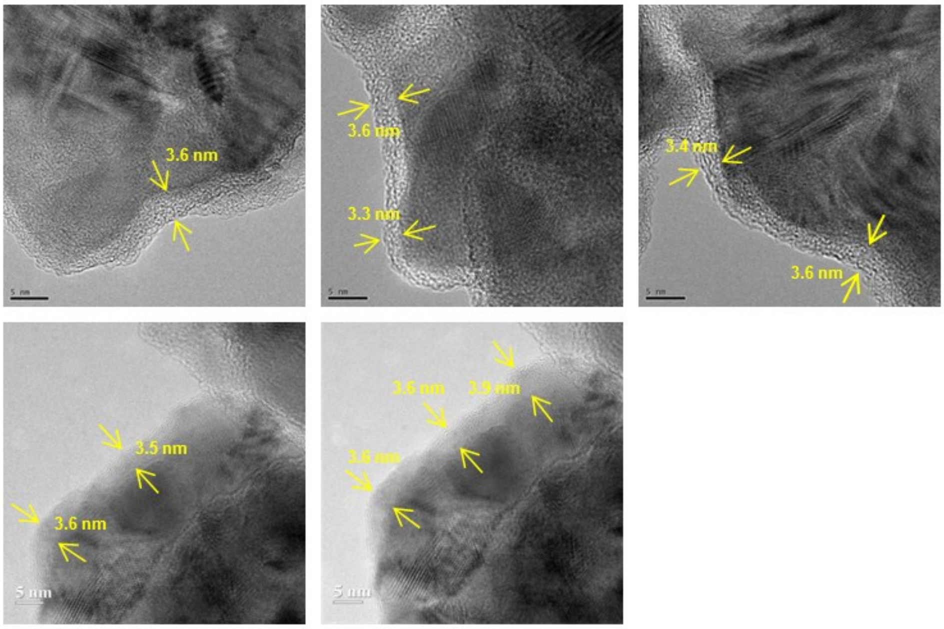
(a) Cu NPs-0 (0.8nm)



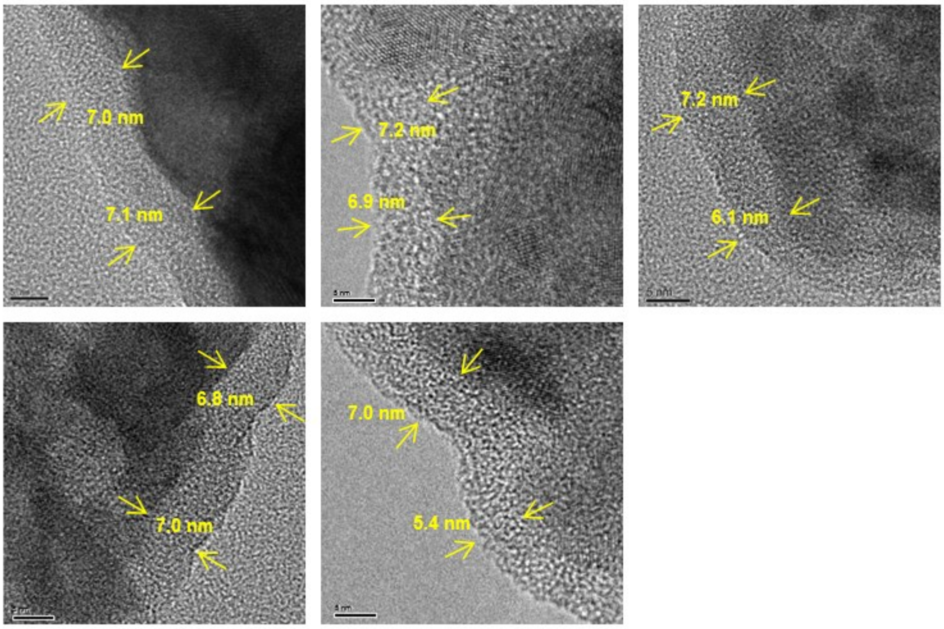
(b) Cu NPs-1 (2.1nm)



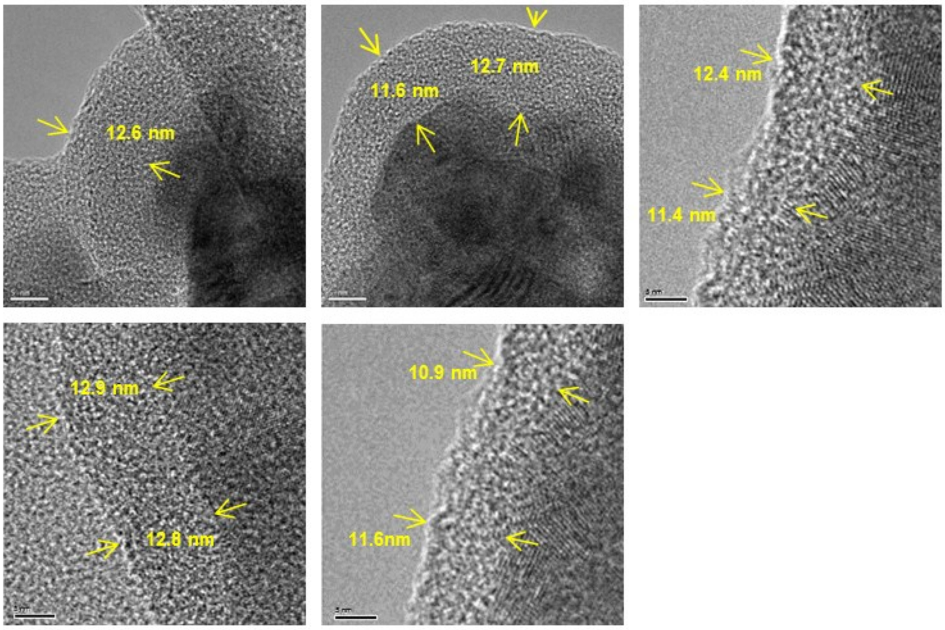
(c) Cu NPs-2 (3.6nm)



(d) Cu NPs-3 (7.1nm)



(e) Cu NPs-4 (12.6nm)



(f) Cu NPs-5 (14.0nm)

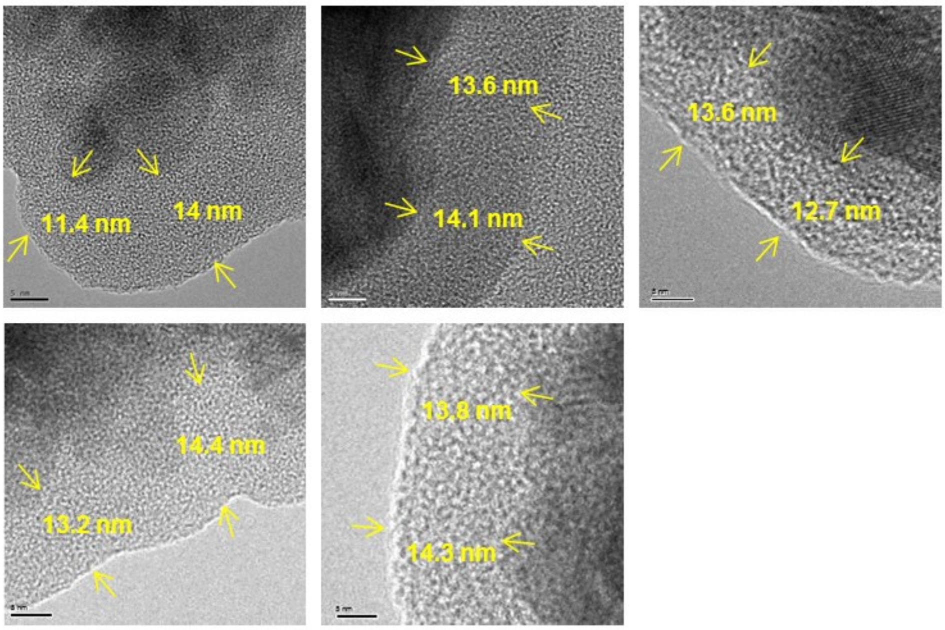


Figure S1. HR-TEM images of oxidized copper nanoparticles at (a) 0 ^{o}C, (b) 100 ^{o}C, (c) 200 ^{o}C, (d) 300 ^{o}C, (e) 400 ^{o}C and (f) 500 ^{o}C

2. The agglomeration of Cu NPs resulting from oxidation.

In this work, Cu nanoparticles with an oxide shell (20-50 nm in diameter, copper(II) oxide shell; QSI-nano) were used to fabricated Cu NP-inks. Cu NPs with various oxide shells were prepared by heating at different temperatures. The prepared Cu NPs were dispersed in a mixed solvent of diethylene glycol (DEG, 99 %; Samchun Chemical) and poly (N-vinylpyrrolidone) (PVP, MW 40,000; Sigma Aldrich) using a three-roll mill. During oxidation process, the thick oxide shell caused agglomeration in Cu NPs as shown in Figure S2a-c because hydrophilic copper oxide enhanced the agglomeration of NPs due to their highly polar nature. The agglomeration of NPs reduced the surface area for PVP adhesion, resulting in an incomplete reduction of Cu oxide and a low uniformity in the Cu NP-ink films (Figure S2d). For these reasons, the resistivity of the sintered Cu NPs with oxide shells thicker than 7.1nm (> 300 °C) dramatically increased.

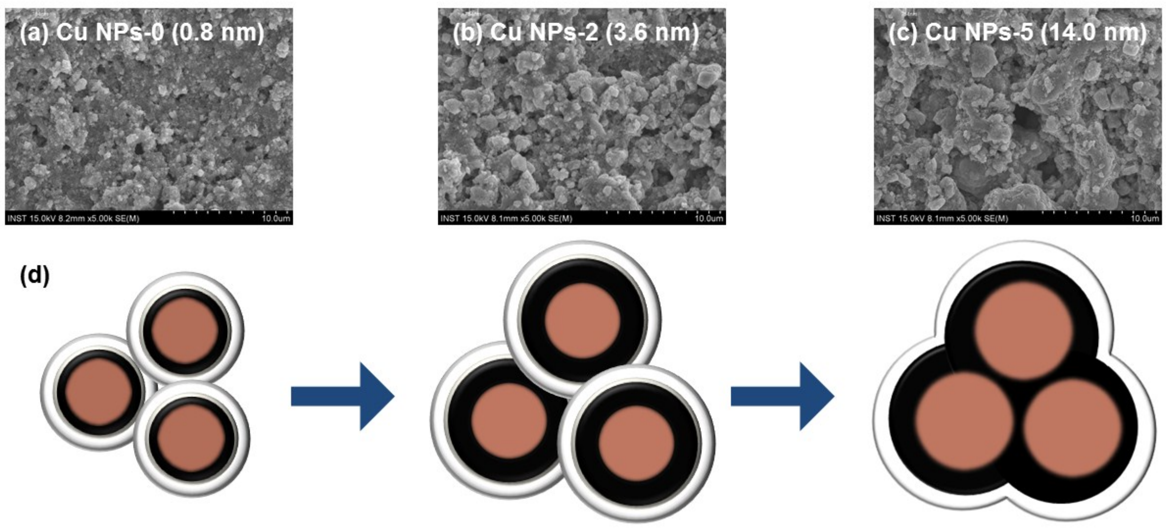


Figure S2. The SEM images of oxidized Cu nanoparticles before flash-light sintering (a-c) and schematic of agglomeration of Cu NPs.