

Silicon Oxide Whisker Formation during In-situ Oxidation of CuO and Si Compounds in Transmission Electron Microscope

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The copper electrodes have been increasingly used because the copper wiring has become widely applied for high-speed devices, since copper electrodes have higher conductivity than aluminum ones and the conductivity of copper is not much lower than the conductivity of the gold. One of problems of the copper electrode is an oxidation which occurs during sintering of nano-sized copper particles. In this paper evaporated nano-particles of copper and copper oxide have been examined by in-situ oxidation experiments using a specimen-heating/gas-injection holder in a transmission electron microscope. New phenomenon of silicon oxide whisker formation was observed during in-situ oxidation of CuO and Si compounds.

A Hitachi H-9000NAR operated at an accelerating voltage of 300kV, equipped with a Gatan GIF 1000 and a Gatan model 627 CCD camera was used. The gas injection nozzle permits gas flow around the specimen setting on the two heating elements made of fine W filament as shown in Fig. 1. One of the heaters was for heating the substrate, and the other one was for evaporating the sample. The pressure of the electron gun chamber could be kept in the range of 10^{-5} Pa while the pressure at the specimen chamber was maintained at the range of 10^{-3} Pa[1~3].

Fig. 2(a) shows the electron micrograph of a SiC substrate on the heater. CuO nano-particles were formed on the SiC substrate by the evaporation of CuO powders heated around 1000°C. Fig. 2(b) indicates CuO nano-particles on the SiC substrate. After heating CuO nano-particles and the SiC substrate up to 700°C and subsequently 800°C, whiskers were formed on the SiC substrate as shown in Fig. 2(c) and (d), respectively. Formation of whisker was observed on the Si substrate as shown in Fig. 3 and also on Si₃N₄ substrate. Elemental mapping images by GIF shown in Fig. 3 clearly demonstrate that the whiskers are silicon oxide. Copper oxides seem to play a role of catalysis, since no whisker formation was observed in the oxidation of Si and Si compound substrate only.

References

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FIG. 1. Gas environment double heating wire holder

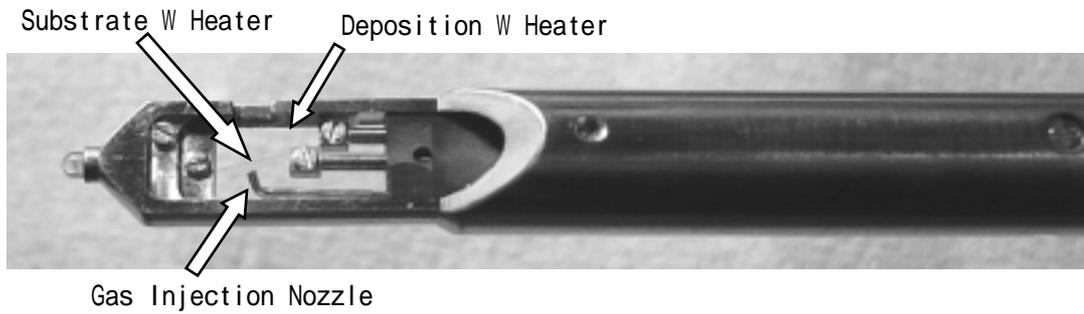


FIG. 2. Electron micrographs of examined SiC

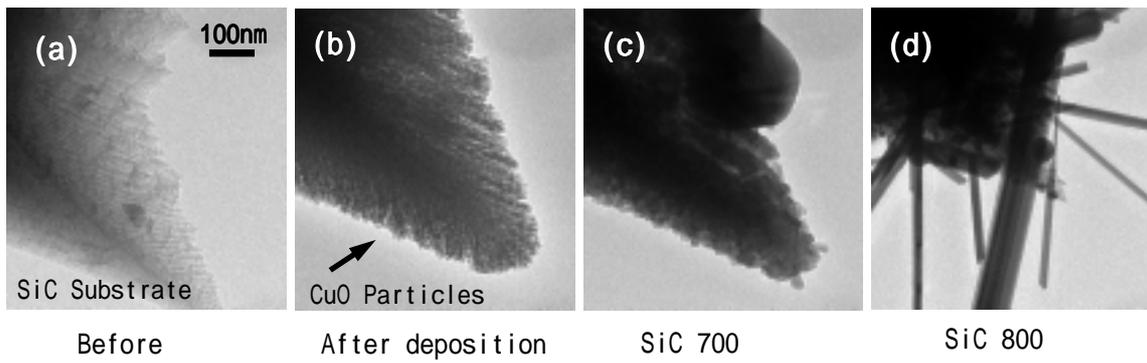


FIG. 3. Elemental mapping images of silicon oxide whisker

