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Production of Co nanocrystals from a C-Co mixture amorphous film and Oriented Crystallization of Carbon

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Pt nanoparticles were used as a catalyst of a fuel cell. The catalyst consists of Pt nanoparticles put on onion-like carbon particles as a substrate. The Pt catalyst degraded by a growth of Pt nanoparticles and an alteration of the onion-like carbon structure. Because of a high price and poor resources, a low Pt catalyst by an additive of another metal or a new catalyst without Pt were studied. However, an effect of the additive materials on the degradation of the catalyst was not studied. In order to confirm the effect of degradation, we tried to grow several metal particles in an amorphous carbon film as a model experiment. In the case of Co nanocrystals, the structure of carbon changed with Co nanoparticles growth.

The C-Co mixture amorphous film was produced by co-evaporation of carbon and Co in vacuum. The film was heated in TEM from RT to 800oC by in-situ observation. TEM images and ED patterns of the film was taken every 200oC steps.

The co-evaporation film had uniform contrast and amorphous structure. On heating 400oC, black dots were deposited on the film and grew on rising their temperature. On heating 600oC, fcc-Co nanocrystals grew on the film like the black dots and diamond-like ring was appeared in the ED pattern. Above 600oC, the black dots began moving on the film and some contrasts like a wheel truck appeared on the film after the black dotes moving. The truck contrasts may produce by absorption of carbon atoms into the fcc-Co nanocrystal and diffused onto the surface again. When the absorbed carbon atoms diffused onto the surface, fcc-Co nanocrystals moved and microcrystallites of carbon with the truck like contrasts deposited on the film. In ED pattern, weak ring of (002) of the graphite appeared on heating 800oC.

To examine the diamond-like ring, ED pattern in a folded part of the film was observed after the heat treatment. The ring of graphite (002) perpendicular to the folded line of the film became strong in the ED pattern. The folded line of the film became white in a dark image from the strong ring. And graphite (002) lines were observed by HREM image of the folded part. Therefore, the origin of the diamond-like ring appeared in the ED pattern on heating 600oC was microcrystallites of oriented graphite of c-axis. The graphite may be crystallized on an interface of the fcc-Co particles and the amorphous film by diffusion of carbon atoms on heating 600oC.

Keywords: Nanoparticles, Crystallization, Co, Carbon, TEM, amorphous film