TEM and STEM observation of Au/Fe_2O_3 catalysts

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Gold exhibits various catalytic properties when Au nano-particles are supported on the metal oxides [1,2]. The catalytic properties depending on the kind of the metal oxide supports are observed for various catalytic reactions. For example, high catalytic activity is observed in the water-gas-shift reaction at the low temperature when the CeO_2 is used as support [3], and high catalytic activity is shown in the low temperature CO oxidation when TiO_2 is used for support of Au nano-particles [2]. The origin of the catalytic properties of Au catalysts is not clear yet although it is suggested that the interface structure between the small Au particle and the metal oxide support act as active sites [4,5]. In order to clarify the relation between the fine structure and the catalytic properties at the Au-metal oxide interface, we have carried out the structure analysis on the small Au particle supported on TiO_2 and CeO_2 with a transmission electron microscopy (TEM) and high angle annular dark field scanning transmission electron microscopy (HAADF-STEM) [6,7]. In this experiment, the basic structure of Au nano-particles supported on Fe_2O_3 was observed in atomic scale by HRTEM and STEM.

The Au/Fe_2O_3 catalysts were prepared by solid grinding method using organogold complex [8] and γ -Fe_2O_3 fine particle (Nanophase Tech. Corp.). The catalyst was calcined at 573K for 4 hours in air. The model structure of Au particles on Fe_2O_3 was also prepared by vacuum deposition method by using poly-crystalline Fe_2O_3 substrate. The observations were carried out by using aberration corrected TEM/STEM (FEI Titan^3 G2 60-300). Accelerating voltage for the observation was 300kV.

Figure 1 shows typical HAADF-STEM images of Au/ γ -Fe_2O_3 catalyst prepared by solid grinding method. Small Au particles of approximately 2-10 nm in diameter are deposited on the γ -Fe_2O_3 support as indicated by arrows in the figure 1. The γ -Fe_2O_3 support crystal exhibit spherical shape with low index facets. Figure 2 shows profile-view HRTEM images of Au particles on γ -Fe_2O_3 (111) substrate. The incident electron beam direction was set along the γ -Fe_2O_3 [1-10] zone axis. Gold particles tend to be deposited on the γ -Fe_2O_3 surface with the preferential orientation relationships of (111)[1-10]Au//(111)[1-10] γ -Fe_2O_3 or (111)[-110]Au // (111)[1-10] γ -Fe_2O_3 for the γ -Fe_2O_3 (111) surface. The high resolution STEM observations were also carried out for the Au/ γ -Fe_2O_3 interface.

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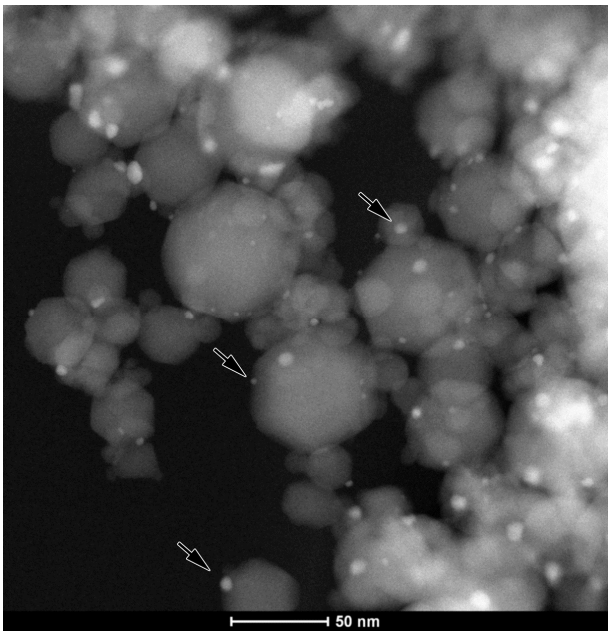

FIG. 1. Typical HAADF-STEM image of Au/ γ -Fe_2O_3 catalyst.

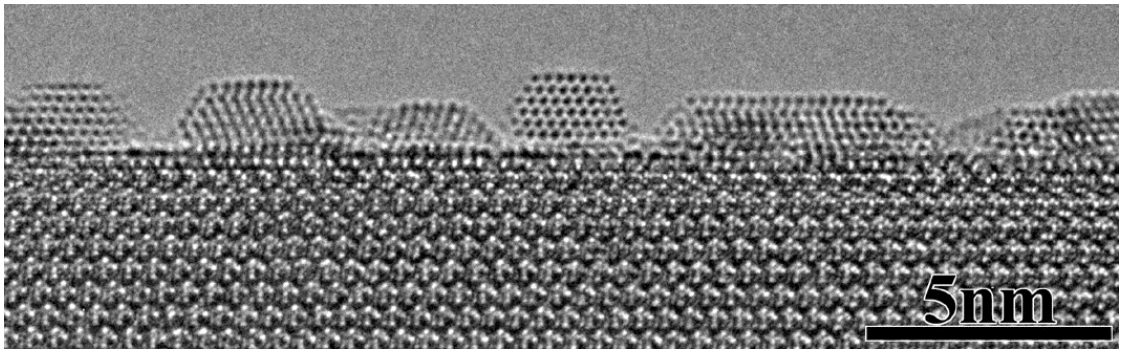

FIG. 2. HRTEM image of Au on γ -Fe_2O_3 substrate.