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In-situ Observation of Nano-particulate Gold Catalysts under Reaction Gas and Non-reaction Gas Conditions

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Gold exhibits catalytic activity when it is in the form of fine particles having a size of less than 10 nm and is tightly supported on specific metal oxides such as TiO_2, etc [1]. To reveal its mechanism, dynamic observation of the sample structures during the reaction by the transmission electron microscope (TEM) is quite essential. “Environmental-cell (E-cell) TEM” technique [2], which enables gas introduction around specimens, is one of the most powerful methods for the purpose. The authors also have developed the closed-type E-cell TEM [3], and had revealed that the shape of catalytic gold nano-particles are changing during reaction [4]. In the paper, we report about difference of the shape change of gold nano-particles between under reaction gas and non-reaction gas conditions.

Our developed E-cell TEM system consists of “E-cell specimen holder” and “gas control unit” equipped with a conventional 200kV-TEM (H-8000, Hitachi). The E-cell specimen holder is so called closed-type; that separates the gas environment from the vacuum with ultra-thin carbon films (< 10nm thick). The films used are specially developed with high toughness and anti-oxidative property. The specimen observed was gold on TiO_2. The gas introduced were 1% CO in dry air as a reaction gas and dry N_2 as a non-reaction gas. Their pressure around the specimen was set at about 750 Pa.

Fig. 1 shows in-situ TEM images of a gold nano-particle picked up from among those recorded sequentially. In this case, the introduced gas was CO in dry air. Therefore, catalytic reaction happened on the catalyst surface; CO was oxidized into CO_2. As shown in these images, the shape of gold particle was dramatically changed. Various facets were appeared and disappeared. On the other hand, almost no change was observed in the case of non-reaction gas N_2 condition, as shown in Fig. 2. Although slight shape changes might occur due to electron beam irradiation in the case of Fig. 2, the difference of alterations of the particle shape can be clearly shown by comparing with Fig. 1. There results prove that the catalytic reaction causes the shape changes of the gold nano-particles.

References

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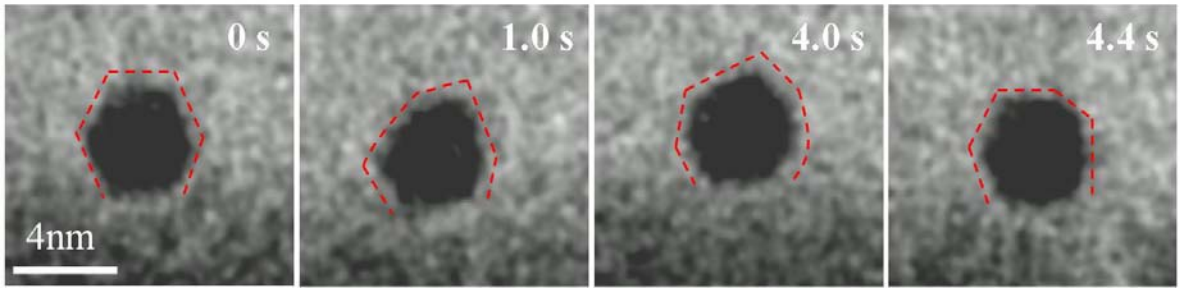

Fig. 1 In-situ TEM images of a catalytic gold nano-particle during CO oxidation (Reaction gas is CO with dry air; Pressure is about 750Pa)

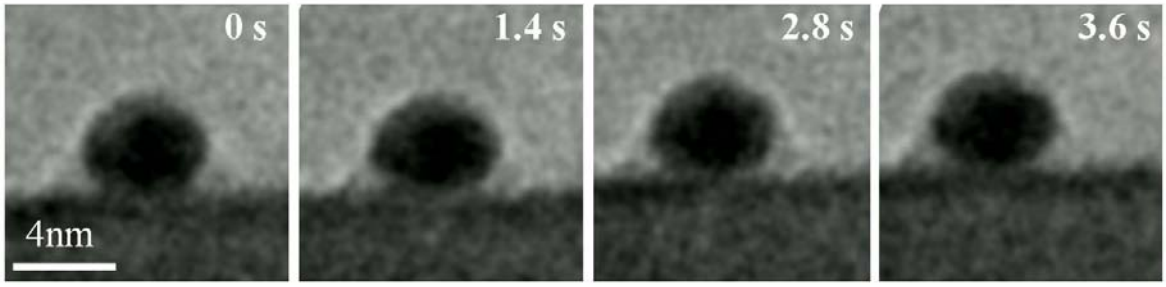

Fig. 2 In-situ TEM images of a catalytic gold nano-particle in the condition of non-reaction gas environment (Non-reaction gas is dry N_2; Pressure is about 750Pa)