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EXAFS analysis of Pt doped SnO_2 Catalyst for Micro gas sensor

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1 Introduction

SnO_2 has been widely utilized as gas sensors due to its conductivity which changes according to partial pressure of oxygen or reducing gases. For the sensors used especially in house, cordless type models are required since these days social needs to utilize town gas safely rises high to achieve safe and secure life. To realize sensors which have 5 years of lifetime, high reliability and low electricity consumption are required. In addition, high selectivity for methane, which is a main ingredient in natural gas, is required. Recently a thin film of a catalyst supporting Pt on SnO_2 is paid attention to realize battery-powered sensors with low electricity consumption. Clear understanding device material is of great importance to make sensors fit for practical use.

Recently, addition of Pt increases the SnO_2 sensor sensitivity for methane. Metallic Pt is a good catalyst for many reactions including the CO and hydrocarbon oxidation reaction. In the catalysts, Pt metal clusters are speculated as an active structure. Pt clusters deposited on the SnO_2 was often assumed and the spill-over reaction created from Pt cluster to SnO_2 might play important role. In this work we carried out the local structure analysis of Pt on the SnO_2 film by EXAFS to elucidate the reaction mechanism. What we found was quite unexpected, i.e., Pt was atomically dispersed in SnO_2 thin layer.

2 Experimental

Pt and SnO_2 targets were both sputtered on a Si wafer. Pt and SnO_2 ratio was controlled by the loading ratio in the targets and finally the concentration of Pt in the film was determined by the ICP by dissolving the film using hydrochloric acid.

3 Results and Discussion

Figure 1 shows Pt L_{III}-edge EXAFS oscillations (χ(k)) and their Fourier transform of Pt-SnO_2 samples together with reference samples. Pt L_{III}-edge EXAFS of Pt-SnO_2 was quite different from those of Pt foil and PtO_2. The peaks corresponding to the Pt-O and Pt-Sn appeared at 1-2 Å and 2.5-4 Å The peak shape at 2.5-4 Å was similar to that of SnO_2, indicating the Pt was incorporated in the SnO_2 lattice.

Figure 2 shows the Sn K-edge EXAFS oscillations and their Fourier transforms. The SnO_2 structures were maintained in Pt-SnO_2. The first peak was corresponding to Sn-O while characteristic double peak appeared in Sn-Sn interactions in rutile SnO_2.

Moreover, XRD patterns of Pt-SnO_2 thin film on Si substrate gave a rutile structure.

No Pt clusters were observed during the reaction.

We concluded that the active site structure was not Pt clusters but Pt placed at the SnO_2 lattice. This result was quite surprising but it is informative to lead to a rational design of the high-performance gas sensor system.

Acknowledgement

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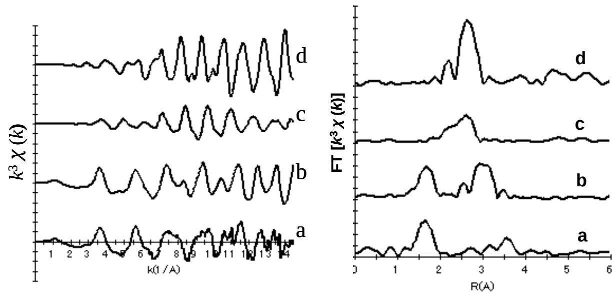

Figure 1: EXAFS oscillation by Pt L_{III}-edge (left figure) and Fourier Transform (Right figure) of Pt-SnO2
a:Pt-SnO2 **b:**PtO2 **c:**PtSn alloy **d:**Pt-foil

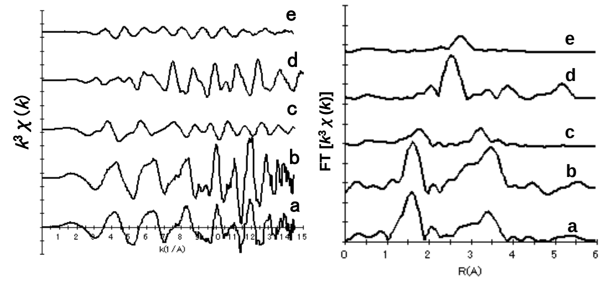

Figure 2: EXAFS oscillation by Sn K-edge (left figure) and FOURIER Transform (Right figure) of Pt-SnO2
a:Pt-SnO2 **b:**SnO2 **c:**SnO **d:**PtSn alloy **e:**Sn-foil

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