

Structural Studies on Electrodeposited Pt Ultra-thin Layers on Au(111) Surface by Resonance Surface X-ray Scattering

Toshihiro KONDO^{*1}, Masayo SHIBATA¹, Naoko HAYASHI¹, Takara SAKURAI¹, Hitoshi FUKUMITSU², Takuya MASUDA², Kohei UOSAKI^{2,3}

¹Ochanomizu University, Ohtsuka, Bunkyo-ku, Tokyo 112-8610, Japan

²Hokkaido University, Sapporo 060-0810, Japan

³MANA, National Institute of Materials Science, Namiki, Tsukuba, Ibaraki 305-0044, Japan

Introduction

Ultra-thin films on foreign metal substrates have been attracting interests because of their unique physical and chemical properties, particularly their electro-catalytic activities. Such high electro-activities are caused by the geometric and electronic structures of the interfacial layers different from those of the bulk [1], and therefore, it is very important to know the interfacial structures with atomic dimensions.

Pt ultra-thin films on foreign metal substrates are expected to be a good electro-catalyst in many areas. Previously, structural studies of electrochemically deposited Pt ultra-thin layers on a Au(111) single crystal electrode surface have been carried out by several groups [2-4] by scanning tunneling microscopy (STM), but the results were different from each other. While Naohara et al. reported that Pt grows on an atomically flat Au(111) surface in the layer-by-layer mode [2], Waibel et al. [3] and Strbac et al. [4] reported that Pt grows on the Au(111) surface in the islanding mode. In order to make clear this difference, here, we investigated the structures of the electrochemically deposited Pt ultra-thin layers, which were prepared by two kinds of the procedures as same as them, using surface X-ray scattering (SXS) technique.

The SXS technique is ideal to determine the structure of the metal deposit with atomic precision, but since the atomic number and, therefore, the scattering parameters of Pt are too close to those of Au, the interfacial structure of the Pt layer on the Au substrate cannot be precisely determined from the (00) rod data obtained using the incident energy of 11.271 keV, which is usually used in our SXS studies [5-8]. Thus, we have now demonstrated that the resonance SXS (RSXS) method, in which the incident X-ray energy close to the Pt L_{III} absorption edge (11.55 keV) is used so that the anomalous scattering parameter effect is utilized [9-12], is very useful to precisely determine the interfacial structure of the Pt layers on a Au(111) surface prepared under two extreme conditions as already reported; one to form a rough Pt layer [3,4] and the other to form an atomically flat Pt layer [2].

Experimentals

The RSXS measurements of the Pt ultra-thin layers deposited on the Au(111) using two kinds of the

preparation methods were carried out at the BL4C beamline at the PF. Detailed experimental conditions including the preparation methods of the samples and set-up conditions of the RSXS measurements are described in the reference [13].

Results and Discussion

Based on the analyses of the (00) and (01) rods and the energy dependence of the scattered X-ray intensity at a certain scattering point of (a) Pt/Au(111)_1 and (b) Pt/Au(111)_2, which are expected to be rough and atomically flat, respectively, according to the previous reports [2-4], it was confirmed that a rough Pt multi-layer and an atomically flat Pt monolayer, respectively, were formed on the Au(111)-(1×1) surface. The Pt atoms of the atomically flat monolayer were found to be situated at the threefold hollow closest packing (ccp) sites of the Au(111)-(1×1) surface, namely Pt monolayer maintains the fcc stacking sequence of the Au(111) substrate. This behavior is the same as those in the case of the electrochemical deposition of Pd [6] and Ag [7,8] on the Au(111) surface.

References

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* kondo.toshihiro@ocha.ac.jp