X-ray Standing Wave Atomic Images of Pt Nano-Crystals Supported on $SrTiO_3$ (001)

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Introduction

Fundamental research on the platinum/strontium titanate interface impacts many major fields including catalysis, microelectroncis and thin films [1-2]. The chemical termination of the $SrTiO_3$ (001) may be controled to produce either the TiO_2 or SrO stoichiometery at the surface [2,3]. For TiO_2 terminated $SrTiO_3$, 20 nm platinum films were shown to grow with a (001) cube on cube epitaxy [2]. DFT calclations support these experiments [4]. The minimal epitaxial strain (Pt *a*: 3.923Å; SrTiO3 *a*: 3.905Å) reduces this study to one largely of the chemical interface. A well defined interface begins with the surface preparation. Hence, we selected the surface preparation resulting in the formation of a (2x1) surface reconstruction [5].

Methods and Materials

$SrTiO_3$ (001) (OKEN, Japan) was treated with NH4F:HF buffer solution for ~30 s, then annealed at 1050ºC in flowing O_2, followed by an annealing at 950ºC in UHV for 30 minutes. LEED confirmed the formation of a (2x1) two domain reconstructed surface. Platinum was evaporated onto the surface in the UHV chamber while heating the substrate at 400ºC. Two different Pt coverages (0.17 ML Pt and 0.60 ML) were produced for analysis.

Without removing the samples from the UHV chamber, X-ray standing wave (XSW) data was collected for the (002) $SrTiO_3$ Bragg reflections after a series of anneals. The samples were then removed from vacuum for XSW scans for the (001), (002), (022), and (111) Bragg reflections. Grazing incidence X-ray scattering (GISAXS) and AFM measurements followed.

Results

Annealing the substrates leads to a general increase in coherent fraction, f_{002}, of the XSW measurment. For both coverages, the coherent position, P_{002}, of Pt undergoes a large modulation between 800-900ºC. Removal of samples to ambient shows a signficant decrease in f_{002} for the 0.17 ML Pt coverage. Summation of the Pt Fourier components measured by the open air XSW scans allows for the creation of a direct space atomic density map [6]. For both coverages an fcc-like Pt structure results. See *Fig. 1*. AFM and GISAXS measurements indicate the formation of Pt nanoparticles on the surface.

Discussion

The fcc-like structure observed in the XSW atomic density maps is consistent with the findings of the 20 nm films where cube on cube (001) epitaxy on TiO_2 terminated $SrTiO_3$ (001) was observed [2]. This would indicate that Pt sturcture on TiO_2 terminated $SrTiO_3$ (001) forms early in the growth process at submonolayer coverage. Furthermore, AFM results from ref. [2] show the films to consist (001) oriented Pt grains. Combining this with the current results from AFM and GISAXS suggests that Pt will form small nanocrystals that grow into grains of a film as Pt is deposited.

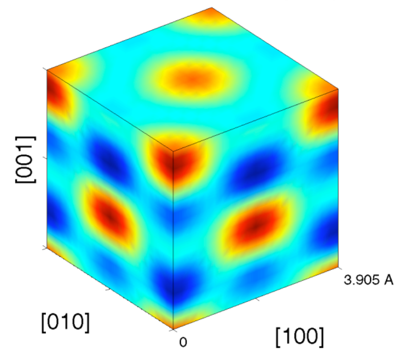

Fig. 1. Pt atomic density maps: 0.60 ML Pt.

This work was supported by the U.S. Department of Energy (DOE) Institute for Enviromental Catalysis under Grant Number DE-FG02-03ER15457. X-ray measurements were conducted at the BESSRC (Sector 12) beamline of the Advanced Photon Source under DOE Office of Basic Energy Sciences contract W-31-109-ENG-38.

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