Surface Science 603 (2009) 3410–3413

Contents lists available at ScienceDirect

Surface Science

journal homepage: www.elsevier.com/locate/susc

Ag induced restructuring of the oxygen precovered Cu(110) surface

T. Brandstetter, Th. Wagner, M. Oehzelt, P. Zeppenfeld *

Institute of Experimental Physics, Johannes Kepler University Linz, Altenbergerstr. 69, A-4040 Linz, Austria

A R T I C L E I N F O

Article history:
Received 11 August 2009
Accepted for publication 6 October 2009
Available online 14 October 2009

Keywords:
Copper
Silver
Oxygen
STM
PEEM

A B S T R A C T

The interplay between chemisorbed oxygen and deposited Ag on the Cu(110) surface has been studied by scanning tunneling microscopy (STM) and photoelectron emission microscopy (PEEM). The Cu–CuO stripe phase formed on the clean Cu(110) surface upon oxygen chemisorption at 660 K is partly dissolved by Ag deposition at 300 K. Upon annealing, however, a phase separation is observed, where the Cu–O compounds agglomerate into large CuO islands and the Ag is located in between. Also a strong preference for the Ag to attach to step bunches is observed. Especially on the fully (2×1)O reconstructed Cu(110) surface, all the deposited Ag is found at the step bunches giving rise to a contrast in PEEM.

1. Introduction

Oxygen chemisorption as well as the deposition of Ag on the Cu(110) surface have been subject to numerous studies in the last decades.

On the one hand, it is well known that molecular oxygen chemisorbs dissociatively from the gas phase onto the Cu(110) surface and combines with mobile Cu adatoms. Due to strong attractive interactions, these Cu–O compounds agglomerate to Cu–O chains oriented along the [001] direction [1,2]. Upon further oxygen chemisorption these Cu–O chains assemble into islands of a reconstructed (2×1)O added row structure. At temperatures above 600 K, these islands arrange themselves in regular stripes oriented along the [001] direction and separated by bare Cu areas, forming a one-dimensional periodic grating [3], the Cu–CuO stripe phase. Finally the CuO islands coalesce and a complete (2×1)O superstructure is formed [4–6].

On the other hand, it has been found, that the deposition of Ag on the clean Cu(110) surface leads to the formation of a surface alloy [7] or a quasi hexagonal wetting layer [8], depending on the Ag coverage.

In the present study we combine the two systems by depositing Ag on the oxygen precovered Cu(110) surface and even though the Cu–CuO stripe phase does not persist upon Ag deposition, a new type of ordered structure can be created. This restructuring is based on a phase separation between Cu–O compounds and Ag and can serve as an interesting template for selective adsorption or growth. For example, the fact that the growth of Ag nanowires on such a template is confined to the Ag rich phase enables us to tune their length [9].

2. Experimental

The experiments were performed in an ultrahigh vacuum (UHV) system with a base pressure around 5×10^{-10} mbar. The vacuum chamber is equipped with an argon ion gun for sample preparation, an evaporator for Ag deposition, an STM system (Omicron VT XA) and a photoelectron emission microscope (Focus IS-PEEM) with a spatial resolution of about 50 nm. All STM data presented in this paper were taken at room temperature. Sample cleanliness was checked by low energy electron diffraction (LEED) and Auger electron spectroscopy (AES) using a four grid LEED/AES system. Also the calibration of the evaporator was done with AES. To this end, the AES signal of Ag was measured as a function of evaporation time and the first kink in the signal was defined as the completion of the Ag monolayer [8]. As substrate we used a polished Cu(110) surface with a nominal miscut below 0.1°. The sample temperature was measured via a thermocouple attached to the manipulator in the vicinity of the sample transfer plate on which the crystal was mounted. The sample can be heated up to ~1000 K via resistive heating on the manipulator. The Cu(110) surface was prepared by argon ion sputtering with an ion energy of 900 eV and subsequent annealing at 900 K for 5 min.

3. Results and discussion

3.1. Dissolution of the Cu–CuO stripe phase upon Ag deposition at 300 K

An STM image of the Cu–CuO stripe phase is shown in Fig. 1a. It was prepared by exposing the Cu(110) surface to 1 L of oxygen at 660 K. The main periodicity along the $[1\bar{1}0]$ direction is around

---

* Corresponding author. Tel.: +43 732 2468 8510; fax: +43 732 2468 8509.
E-mail address: peter.zeppenfeld@jku.at (P. Zeppenfeld).

0039-6028/$ - see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.susc.2009.10.003

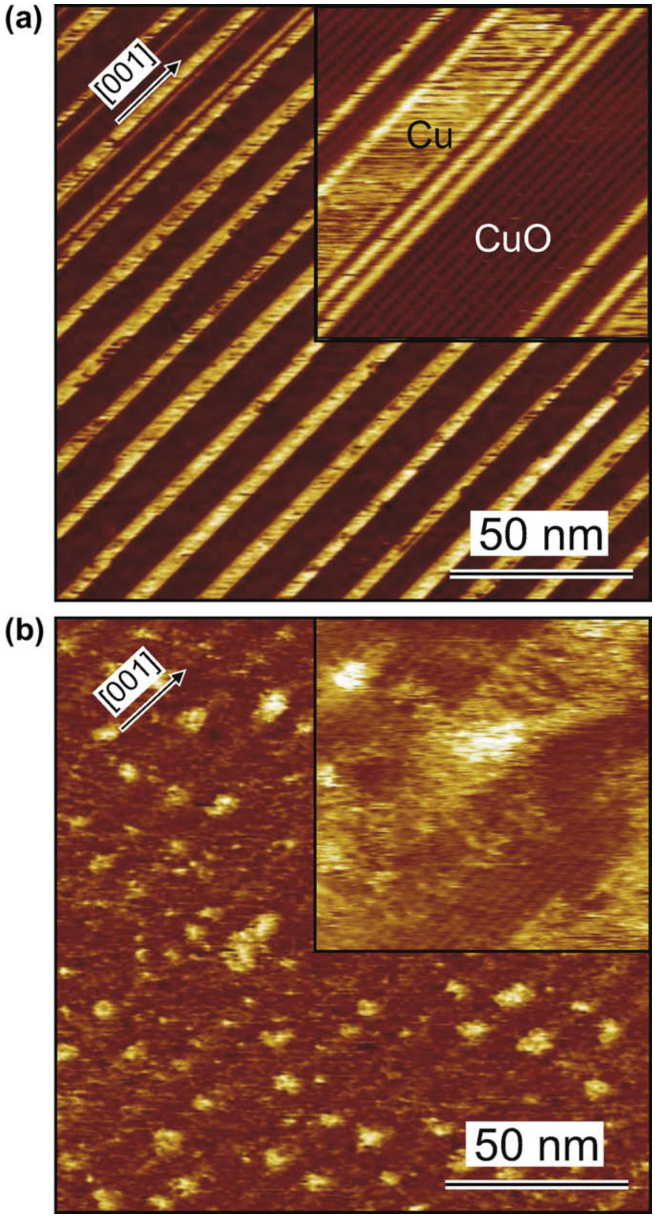

Fig. 1. STM images of a 160 × 160 nm^2 area of the Cu(1 1 0) surface after exposure to 1 L of oxygen at 660 K (a) and subsequent deposition of 0.025 ML of Ag at 300 K (b). The insets show 16 × 16 nm^2 details.

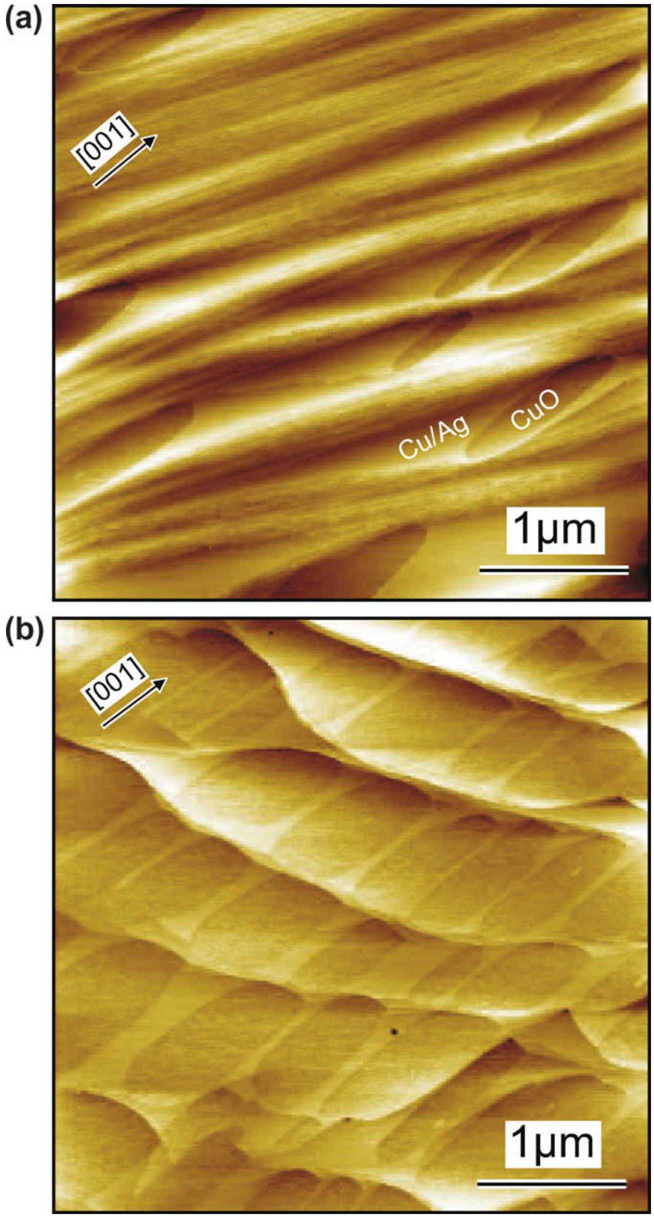

Fig. 2. STM images of a 4 × 4 µm^2 area of the Cu(1 1 0) surface after exposure to 0.15 L (a) and 1 L (b) of oxygen and subsequent deposition of 0.4 ML Ag at 660 K.

12 nm and in the inset, the (2 × 1) structure within the oxygen reconstructed CuO stripes is resolved. The CuO stripes cover around 2/3 of the surface and, due to chemical contrast, appear dark in the STM image. Deposition of Ag on such a surface at 300 K leads to a brakeup of the CuO stripes. Nevertheless, the persistence of (2 × 1)O reconstructed areas on part of the surface after Ag deposition (see inset in Fig. 1b) indicates the stability of the Cu–O compounds. This is in agreement with experiments by Matsumoto et al. [10,11], showing that the formation of Cu–O compounds is favored to Ag–O at room temperature for the inverted case, i.e. Cu deposited on the Ag(1 1 0) surface. Note, that the 12 nm periodicity is still visible after Ag deposition. The large bright spots seem to be located mainly between the original CuO stripes and are therefore ascribed to Ag on clean Cu(1 1 0) areas, whereas the smaller bright spots within the (2 × 1)O structure are interpreted as Ag on CuO. Since the original, strain induced, long range interaction between the stripes is very likely to be destroyed after Ag deposition, the remnants of the 12 nm periodicity are explained by the limited surface mobility at 300 K.

3.2. Ag deposition at 660 K

Annealing of a Cu(1 1 0) surface that carries a mixture of chemisorbed oxygen and Ag, as shown in Fig. 1b, leads to a phase separation where the Cu–O compounds agglomerate into large CuO islands. Due to chemical contrast, these islands are imaged at a slightly lower height than the surrounding terrace (see Fig. 2) and will be referred to as "ponds".

The same structures are formed when Ag is deposited on the Cu(1 1 0) surface at 660 K directly after oxygen exposure at the same temperature. Figs. 2 and 3a show typical examples for such structures. They were prepared by depositing 0.4 ML of Ag after exposure to 0.15 L (Fig. 2a), 0.33 L (Fig. 3a), and 1 L (Fig. 2b) of oxygen, respectively. The ponds are elongated along the [0 0 1] direction and are only confined by the terrace width. As oxygen