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## Investigation of the Oxygen Adsorption on Iron Covered W(110) Surface by LEED and STM

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**Abstract**

Adsorption of oxygen on the epitaxial growth of iron thin film on tungsten (110) surface was intensively studied considering several Langmuir (L) exposure range. Typical surface characterization approaches were considered, such as low energy electron diffraction, and scanning tunneling microscopy (STM) to analyze the O/1 ML Fe/W(110) surface. Certain oxygen adsorption structures on one monolayer (ML) of Fe on W(110) surface is reported in this literature and compared with previous study. Previously reported the (3×2) structure of the oxygen on the iron monolayer (ML)/W(110) surface was recognized at less than 4L of oxygen exposure.

### 1. Introduction

The coverage of oxygen atoms on pseudomorphic monolayer of iron on tungsten surface is controversial since past and recent studies. Several research studies reported the oxygen coverage on Fe/W(110) surface is between 1/4 to 2/3 monolayer for (3 × 2) structure [1-6]. In general estimation, by increment of oxygen exposure corresponds to other ordered structure. Several literature review suggested (3×1), c (3×1) or split (3×1) structure appeared in large range of exposure (3L to 60L) [5,6].

This experiment will contribute to a new dimension in case of oxygen adsorption on 1 ML-Fe/W(110) surface. Unit cell of the (3×2) structure of the oxygen on 1 ML-Fe/W(110) surface determined by the LEED images. Unit cell length of the similar structure was also compared with the STM images. Surface morphology of the oxygen adsorbed on epitaxial ultra-thin iron film on tungsten surface was analyzed by STM images. The STM image shows that 1/3 ML of oxygen coverages corresponds to (3×2) structure of the oxygen on 1 ML-Fe/W(110) surface.

### 2. Experimental

The experiment was performed in an ultrahigh-vacuum (UHV) (base pressure $1\times10^{-9}$ Pa) chamber equipped with molecular beam epitaxy (MBE) deposition system, scanning tunneling microscopy (STM) and low energy electron diffraction (LEED). The epitaxial Fe film was grown on clean W(110) surface. Fe was deposited by MBE system. The Fe deposition rate was 0.2ML/min. Adsorption experiments were performed at room temperature using molecular oxygen with a precise leak valve. Depending on the total exposure, partial pressure was between $1\times10^{-7}$ Pa and $1\times10^{-6}$ Pa. Surface cleanness of W(110) and 1ML Fe/ W(110) was checked by LEED. The Fe coverage was estimated by STM (1 ML Fe is defined as the number of the surface atoms on W(110). The oxygen adsorption structure on 1 ML Fe/W(110) was thoroughly investigated by STM

### 3. Results & Discussions

#### 3.1 LEED Analysis

The clean surface of W(110) was prepared by several cycle of flash heating at 2050K temperature. The duration of the flash heating was 7s. The monolayer of Fe/W(110) shows the LEED pattern identical to (1 × 1) structure of W (110) surface [7]. Initial pressure of oxygen dosing was $1\times10^{-7}$ Pa. The (1×1) structure of 1 ML of Fe/W(110) surface was replaced with a new surface structure. New surface structure appeared after dosing of 0.8L of oxygen on 1 ML Fe/W(110) system (Fig. 2a). This structure existed up to an exposure of 0.8L-1.4L and was mostly intense at approximately 1.1L at RT in contrast Friendl. et. al reported this structure was the most intense at 4L [7]. Fig. 2b. shows the interpretation of LEED pattern spots corresponding to (3×2) structures arises from two mirror domains due to the two-fold symmetry spots from two rotational domains are shown by circles of different colors and sizes. The basis vectors for the reciprocal lattice of the substrate (black), for the adsorbate structure (yellow/red) and for the unit cell of the reciprocal centered rectangular lattices are shown (Fig 2b.).

Fig 1a. shows the different sites for oxygen adsorption on 1 ML-Fe/W(110) surface. Model-3 (fig. 1d) is a simple (3×2) structure of the oxygen on 1 ML-Fe/W (110) surface. In this model unit cell contains one oxygen atom, which corresponds to coverage of 1/6 ML.

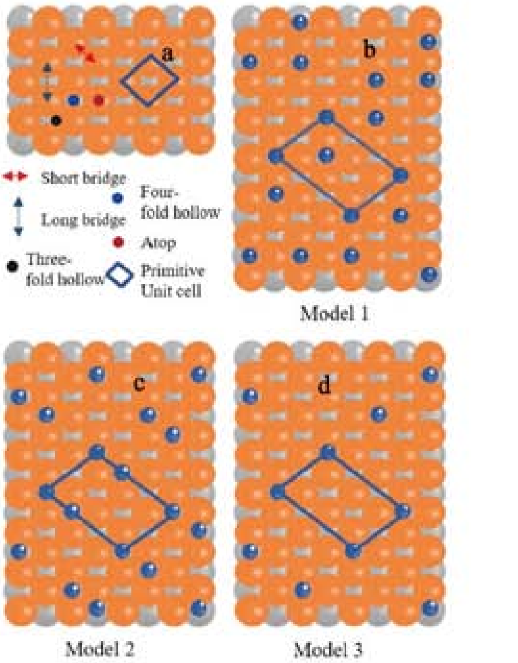


**Fig 1.** a) The (110) surface of BCC iron adsorption sites.b), c) and d) represents three simple models of the (3×2) O structure on the 1 ML-Fe/W(110) surface adsorbed at long bridge sites.

As previously reported oxygen coverage associated with this structure is in between 1/4 to 2/3 ML. Therefore, Model-III is not fitted with the (3×2) structure of the oxygen on 1 ML-Fe/W(110) surface [7]. In case of both Model-1 and Model-2 oxygen coverage are 1/3 ML with different atomic orientation [10]. Both of the Model-1 and Model-2 (fig 1c and 1d) has the possibility to fit with (3×2) structure of the Oxygen on 1 ML-Fe/W(110) surface.

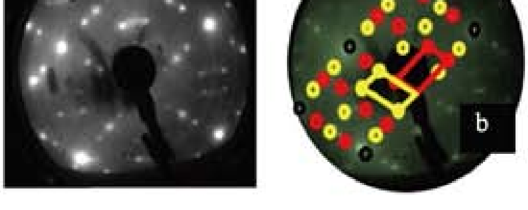


**Fig 2.** LEED pattern at an electron energy of 84 eV. a) LEED pattern of (3 × 2) structure of O on 1 ML Fe/W (110); b) Interpretation of the LEED pattern for the O (3 × 2)/ 1ML-Fe/W(110) surface.

3.2 STM Analysis

The STM image were taken at low temperature (80 K). Figure 3a. Shows the STM images of oxygen covered Fe film grown on W (110) surface at room temperature. In comparison with (3×2) structure by LEED, the unit cell length is almost similar to experimental STM image. Fig 3a. Shows the unit cell length of (3×2) structure of the oxygen on 1 ML-Fe/W(110) surface. This STM image (fig. 3a) suggests that the model-1 is fitted with the STM observation.

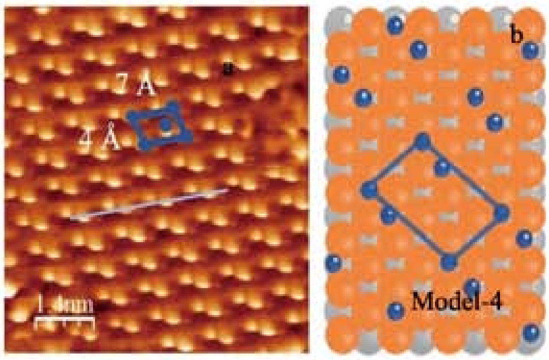


**Fig3.** Typical STM Image of (3×2)O on 1 ML-Fe/W(110)surface at 80 K. a) Atomically resolved STM image of (3×2) O structure on the 1 ML-Fe/W(110) surface (Scan size= 7nm); b) Proposed new model

However, the center atom of the model-1 is slightly shifted from its primitive position. A new model was proposed by this work where the middle atom (fig. 3b) is shifted from the long bridge site to 3-fold hollow site.

## 4. Conclusions

An in-situ STM and LEED investigation was done to identify the (3×2) structure of the oxygen on 1 ML-Fe/W(110) surface after exposing the oxygen dose of 1.1L. The atomically resolved STM image of the (3×2) structure reveals that the oxygen coverage is 1/3 ML and that a model for oxygen adsorption on pseudomorphic monolayer of Fe/W(110) surface has been proposed.

**References**

[1] G. Pirug, G. Broden, H.P. Bonzel, Surf. Sci. 94 (1980) 323.
[2] A. Hodgson, A. Wight, G. Worthy, Surf. Sci. 319 (1994) 119.
[3] J. Pignocco, G.E. Pellisser, Surf. Sci. 7 (1967) 261.
[4] Y. Sakisaka, T. Komeda, T. Miyano, Surf. Sci. 164 (1985) 220.
[5] K. Molière, F. Portele, in: G.A. Somorjai (Ed.), the Structure and Chemistry of Solid Surfaces, Wiley, New York, (1968), p. 69-1.
[6] T. Miyano, Y. Sakisaka, T. Komeda, Surf. Sci. 169 (1986) 197.
[7] K. Freindl, E. Partyka-Jankowska, W. Karaś, Surf. Sci. 617 (2013) 183-191.