The Effect of Deposition Pressure on Adsorbate Structure and Coverage: Oxygen on W(110)*

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The oxidation and corrosion of metal surfaces has long been an important topic for surface physicists, and the system of oxygen adsorbed onto W(110) has been an archetype in the study of metal oxides. Three adsorbate structures have previously been observed to form, including the (2x1), (2x2), and (1x1) structures, and were also seen here. In this study, however, a fourth structure was also observed and characterized using both low energy electron diffraction (LEED) and scanning tunneling microscopy (STM). In addition, the effects of dosing pressure on structure type and total surface coverage has been observed for low dosing pressures and suggests a profound new interpretation of the oxygen on tungsten absorption system.

In most prior surface science studies, it has been assumed that total exposure, rather than both pressure and time as independent variables, controls the types of adsorption structures formed. However, the potential importance of deposition pressure as a variable has recently been suggested in a study of the kinetics of the low pressure adsorption of oxygen on W(110) using time- and chemical-state-resolved photoelectron spectroscopy and diffraction.[1] As a more quantitative measure of such effects, we have used a homebuilt ultrahigh vacuum STM to explore the adsorbate structures and the coverage dependence of oxygen on W(110) as a function of the deposition pressure and for room temperature exposures. For the same total adsorbate exposure in Langmuirs (L), our study shows that changes in deposition pressure of as little as a factor of 3 cause significant changes in the apparent structures, domain sizes (e.g., of (1x2)O), and the actual resulting coverages of the adsorbate layer in monolayers. Total coverages derived from STM data using a software thresholding technique indicates that a critical dosing pressure exists for both the (2x1) and (2x2) structures, below which coverage does not increase with increasing exposure time. New data on the temperature dependence of this pressure effect will be presented.

The inability to form complete monolayers of (2x1) and (2x2) structures at dosing pressures of 1×10^{-9} torr and 3×10^{-9} torr respectively indicates that an equilibrium condition has been reached, from which surface free energies for both of these structures can be derived.[2]

Based on the LEED pattern, the new fourth structure for oxygen on W(110) was determined to be $\begin{pmatrix} 3 & -1 \\ 0 & 5 \end{pmatrix}$ in matrix notation relative to the W(110) substrate.[3] The structure formed for oxygen exposure of 3 to 6 L and has been observed to coexist with the (2x1) structure. The primitive unit cell for this structure is a perfect rectangle, 7.74 Å x 13.68 Å, and includes 15 tungsten atoms. A high resolution STM image shows 6 oxygen atoms per unit cell, yielding a coverage of 0.40 ML.

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References

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