

Field Desorption Micro-Spectroscopy: direct access to binding energies of adatoms in coadsorption systems

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Modern nanotechnology and surface science applications require detailed knowledge about the binding energy of specific adatoms in increasingly complex multicomponent coadsorption systems. For example, the system alkali-oxygen-d-transition metal (e.g. Li-O-W(hkl)) is interesting both from a fundamental and practical point of view. Additional complexity arises from the necessity to obtain the binding energy data from locally modified nanosized surface regions such as steps, kinks, defects etc. Existing experimental methods, frequently based on thermodesorption, do not provide data with lateral resolution on the nanoscale.

At the same time, 3D chemical resolution on an atomic scale is available from atom probe techniques, utilizing time-of-flight (TOF) analysis of individual field-evaporated or field-desorbed atoms [1]. The energy analysis of corresponding field ions might yet provide valuable data about the binding energy of adatoms or even bulk substrate atoms. The concept of the Field Ion Appearance Energy (FIAE) [2, 3] appeared to be very useful in this sense because the experimentally measured values can be related (by means of a thermionic cycle) to the physically meaningful binding energy of adsorbed atoms [4] or molecules [5] and to the activation energy of field desorption (or field evaporation). This rather theoretical concept was first realized in a combination of the Lithium Field Desorption Microscope [6] with a retarding potential analyzer, used for measurements of the binding energy of Li adatoms field-desorbed from individual surface sites on W(111) [7]. In the experimental configuration, Li adatoms adsorbed on the surface of a W-nanotip were field-desorbed from its apex by an applied field and created a Li-FDM image on the screen (Fig.1). Those Li⁺ ions which were selected by probe-hole in the screen, were subsequently mass-to-charge separated in a magnetic sector field, and were finally energy-analyzed by a retarding potential analyzer. The FIAE values for Li⁺ ions were computed as $A_{Li^+} = n\phi_{ret} - e\delta^{on}$ and the binding energy of a neutral Li atom was obtained from the thermionic cycle [8] as $H_{Li} = A_{Li} - I + Q$, where I is ionization energy of Li and Q the activation energy of Li field desorption [7].

In the present contribution we extend this approach to the coadsorption system Li-O-W(hkl). We obtained the binding energy of Li adatoms field-desorbed from individual surface sites on Li-O-W(112), at submonolayer Li coverage and oxygen saturation coverage. The results are compared to data obtained independently for planar (single crystal) Li-O-W(100) and Li-O-W(112) by thermodesorption experiments. Both macroscopic (single crystal) and microscopic (nanotip) results are discussed in terms of a charge transfer and lateral interaction of Li- and O-adatoms on the tungsten surface.

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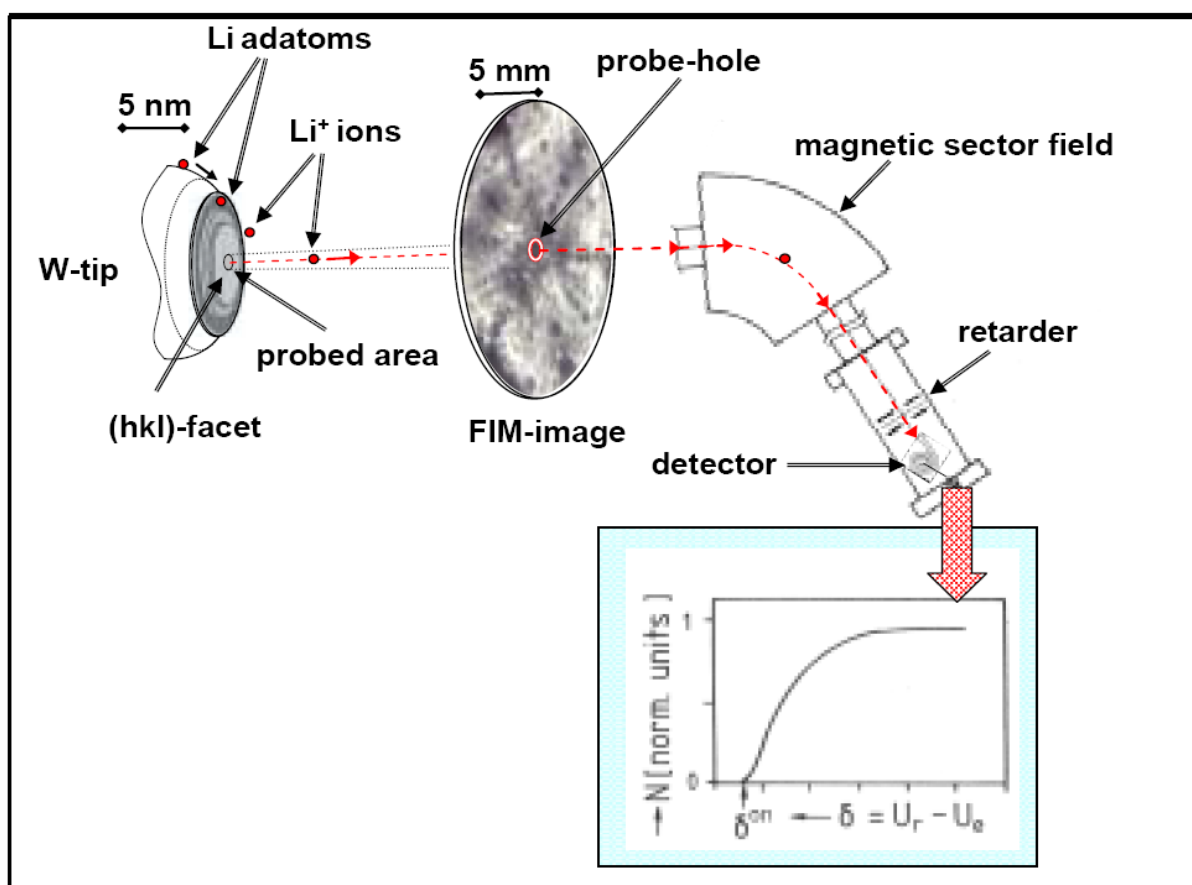


Figure 1. Principle of field-desorption micro-spectroscopy: Li⁺ ions field desorbed from the apex of a W nanotip create a magnified ($\sim 10^6\times$) image of the tip surface. Mass-to-charge resolved retarding potential analysis of Li⁺ ions, originating from surface sites selected by the probe-hole, provides the onset voltage δ^{on} which is used to compute FIAE-values.