Electron-reflectivity measurement of mobile surface-species concentrations

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The rates of many surface processes like diffusion are determined by the concentration of mobile adsorbed species. For metal on metal diffusion, the diffusing species typically are simple adatoms. In thermal equilibrium or even during crystal growth, the adatoms are usually present at low densities because of their high formation energies. Directly determining adatom concentrations over a wide temperature range by proximal probe microscopies such as STM is difficult because of the high adatom mobilities. Only a few methods, namely work-function and helium-scattering measurements, are known to be sensitive to thermal concentrations of adatoms. However, these techniques are not spatially resolved. Motivated by this limitation, we are investigating measuring adsorbate concentrations using a technique based on electron reflectivity. When performed in a low-energy electron microscopy (LEEM), the approach offers the powerful ability to determine the local adsorbate concentrations on heterogeneous surfaces.

We are investigating two model systems, Ag on W(110) and C on Ru(0001). When Ag adatoms are vapor deposited onto the surface, the intensity of reflected low-energy electrons decreases linearly with the adatom concentration. Using this simple relationship, the adatom concentrations are easily determined from electron-reflectivity changes. The intensity change is usefully large – a Ag adatom density at least as small as 10^{-3} ML can be measured in a μm size region at video rates. We use the technique's imaging basis to measure the adatom concentration in equilibrium with condensed-phase Ag islands as a function of temperature, finding good agreement with a previous work-function measurement [2], albeit with considerably better accuracy. The method also allows precise measurement of the adatom formation enthapy.

Using electron reflectivity, we measure the temperature-dependent concentration of C adatoms in equilibrium with C impurity atoms in bulk Ru. We are also studying the dynamics of C segregating from the bulk and condensing into single layers of graphitic C ("graphene"). The adatom supersaturation present before graphene island nucleation is easily observed and is surprisingly large. We will discuss the relationship between the graphene growth rate, bulk diffusion, and the time and spatial dependence of the C adatom concentration.

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[1] J. de la Figuera, N. C, Bartelt, and K. F, McCarty, Surf. Sci., in press (2006).
[2] J. Kolaczkiewicz and E. Bauer, Surf. Sci. **155** 700 (1985).