14.X–1 SURFACE STRUCTURE DIFFRACTION AND IMAGING.

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In transmission electron diffraction from perfect single crystals the diffraction intensities depend most sensitively on thickness for special conditions of incidence due to dynamical effects. Using such a diffracted beam - the zero beam included - for imaging in a transmission electron microscope (TEM) the local variation of thickness can be observed. In such a topography surface steps of atomic height are visible. The same atomic steps can be seen in reflection electron microscopy (REM) when using a Bragg-diffracted beam for imaging. REM requires ultrahigh vacuum (UHV) conditions or UHV-similar conditions, at least for the specimen area. Experimental conditions used by different authors for such investigations (as e.g. N. Osakabe et al., Surface Sci. 97 (1980) 393) will be described and their results will be compared with own observations. Diffraction conditions for microscopic imaging of the surface structure and especially the influence of surface resonance conditions on contrast in REM will be discussed.

The advantage of a combination of LEED and RHEED for surface structure analysis will be demonstrated by the detection of a vertical disorder of an electrochemically deposited submonolayer of copper on a (111)-gold surface.

14.X–2 SURFACE STRUCTURE ANALYSES BY LOW ENERGY SCANNING ELECTRON MICROSCOPE IN ULTRA HIGH VACUUM.

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In the microanalysis and imaging of solid surface, it is valuable to provide a high spatial resolution scanning electron microscope of ultra high vacuum (UHV-SEM) with the capacity for several electron spectroscopies and for electron diffraction. Moreover, the surface under investigation must be clean and well defined, necessitating preparation within the ultra high vacuum system.
From these aspects, a low energy UHV-SEM with a field emission gun in a vacuum of 2×10^{-10} Torr in the sample chamber, which is operated from 100eV to 30keV in the accelerating voltage E_p, was constructed. Auger electron image and dark field image of solid surfaces are observable by an incident electron current of 10^{-10} A and a probe diameter of 500Å-100Å using a data processing system for Auger electron signal and a two dimensional digital electron multiplier system for electron diffraction pattern. A reflection electron diffraction pattern in a selected area of a diameter of several hundred Å is observable on a cathode ray tube by an incident probe current of 10^{-10} A at E_p=200eV-2keV.
In situ observations of Si surfaces are demonstrated for processes on surface cleaning by flashing, epitaxial growth of metal deposited layers on Si surface, super structure formations of the Ni contaminated Si(110) surface by heat treatments and phase transitions of reconstructed structures for several planes.

14.X–3 STUDIES OF SURFACES BY ELECTRON ENERGY LOSS SPECTROSCOPY.

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Elastic scattering or diffraction of low energy electrons (LEED) is used to study the crystallography of surfaces. Inelastic scattering of slow electrons, or electron energy loss spectrosopy (EELS) as a complementary technique, has become a source of information about elementary excitations at the surface. These excitations comprise plasmons of free carriers in metals and semiconductors, interband transitions, electronic excitations of adsorbed molecules, and, with high resolution spectroscopy, vibrations and phonons of adsorbates and the substrate. During recent years EELS has proven to be the most powerful technique for vibrational spectroscopy of clean and adsorbate covered surfaces. Comparing the vibrational spectra of adsorbed species with gasphase spectra of similar compounds and exploiting different scattering mechanisms, which have different selection rules with respect to the symmetry elements of the adsorbate complexes, allows to identify adsorbed species and to estimate their adsorption geometry and adsorption sites on the surface. By combining the latter information for example with LEED-results one can fix the position of an observed unit mesh of an ordered adsorbate layer on the surface. Identification of adsorbed species made it possible to follow up decomposition reactions and in many cases new surface species have been found, which allows to describe possible reaction pathways in surface chemistry or catalysis.

Substrate atoms in the surface and adsorbed atoms or molecules in two-dimensionally ordered overlayers experience lateral interaction and therefore the frequency of their vibrations becomes a function of the wave vector parallel to the surface, i.e. the modes show dispersion. EELS is suitable to measure dispersion curves of substrate and adsorbate phonons. As first examples dispersion curves of the Rayleigh waves on the Ni(100) surface and of the vibrations of oxygen in the c(2x2) overlayer on Ni(100) have been measured throughout the Brillouin zone. From the dispersion curves one can suggest relaxation or contraction of the topmost surface atom layer compared to the bulk lattice constant; for the adsorbate system one can estimate the distance of the adsorbed atoms above the surface, i.e. to gain important data on the structure and dynamics of the surface. Surface phonons should be sensitive to phase transitions and to reconstruction of the surface. Measurements of surface phonon dispersion curves will become a new focus of interest in the application of EELS in surface physics.