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Surfaces

The surface region of a solid can be thought of as a new phase of matter; its chemical composition often differs from that of the bulk. Atomic arrangements at or near the surface and electronic structures also differ from those in the solid. New and improved methods of observing inorganic surfaces are leading to findings that are important to fundamental science. The precise behavior of atoms at the surface is crucial in many practical applications, including catalysis, corrosion, adhesion, and lubrication. With further reduction in dimensions of microelectronic devices and increased use of epitaxial layers, surface effects will take on enhanced importance. This issue samples some of the activities of surface scientists.

The scanning tunneling microscope has been modified by Tromp, Hamers, and Demuth to permit simultaneous study of the electronic and geometric structure of Si(111) and Si(001) surfaces. They report observations on the electronic structure of single atoms on silicon surfaces. Silicon atoms are bound covalently in crystals, and it has been known that the discontinuity at the surface leads to a rearrangement (reconstruction) of surface atoms to minimize the number of dangling bonds. The new results correlate atomic position with electronic quantum states. The authors project broad usefulness for their type of equipment in further studies. Examples are crucial defect states in electronic devices and the role of adsorbed foreign elements in catalysis.

Unlike semiconductors, the surfaces of most pure metals are not reconstructed. However, Noonan and Davis note that the distance between the layer at the surface and the second layer is in general reduced—in one example, 8.5 percent. The surface composition of alloy samples is often drastically different from the bulk. For example, in a $Pt_{78}Ni_{22}$ alloy, the surface layer was enriched to about 99 percent platinum, whereas the second layer was only 30 percent platinum.

Engel has constructed a helium atomic beam apparatus for observing scattering from surfaces. The helium beam has an effective wavelength comparable to atomic spacings in surfaces, and the apparatus has features that give it great flexibility. It can be particularly sensitive to vacancies or kinks on surfaces and to adsorbed molecules. Most of our present understanding of hydrogen adlayers on various metal surfaces has come from atom beam diffraction experiments.

Madey has reviewed studies of electron and photon desorption of adsorbed gases from surfaces. These studies have shown that desorbed ions do not generally come off in an isotropic manner but in directions that are determined by the orientation of the surface molecular bonds. It is known that when CO is bound to Ni(111) the atom bonded to nickel is carbon, and the CO stands upright. Electron-induced desorption leads to escape of O^+ in the direction of the surface normal. Thus measurements of the electron-stimulated desorption ion-angular patterns yield direct information about the geometrical structure of molecules in surface layers. Experiments show that CO stands up on Ru(001), that CO lies down on Cr(110), and that CO is tilted on surfaces such as Pd(210).

Celotta and Pierce are part of a group that has developed instrumentation for polarizing electrons to study magnetic surfaces. Earlier they showed that they could obtain a good source of polarized electrons by shining circularly polarized light on GaAs. Recently, they have developed a small and simple polarization detector that will doubtless find a large number of applications in surface studies. One example of a relation between surface electronic structure and magnetism is the change induced by chemisorption of CO on Ni(110) surface. It was found that the adsorption of one CO molecule eliminated the equivalent of two nickel surface atom magnetic moments.

If microelectronics devices are to be reliable, the behavior of surface materials must be understood and the agents that can cause corrosion and other failure must be identified. Comizzoli and co-workers report on the many kinds of chemical and physical effects that must be minimized.—PHILIP H. ABELSON