ELECTRON DIFFRACTION AND THE PHYSICS OF SOLIDS

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During the last ten years our knowledge of the structure and properties of matter has greatly increased. One notes, however, that a large part of this information has to do with the gaseous or vapor state of matter. Studies of the solid state have lagged somewhat or at least have not been so amenable to interpretation in terms of forces and energy of the primary building units, whatever they may be. The introduction of X-ray analysis some twenty years ago resulted in a very complete knowledge of the arrangement of crystals and atoms in solids. The relation of many of the physical properties of a solid to its structure is not so well known.

The discovery that electrons are diffracted or selectively reflected by atoms in a crystal lattice has created a new tool for the study of the latter problem. Much of the theory developed for X-ray analysis can be carried over in electron diffraction studies. There are, however, certain advantages in each method. X-rays will penetrate a considerable thickness of a solid. Electron experiments must be confined to surface layers or thin films of the substance. The amplitude of the wavelets accompanying the electrons scattered by few atoms is so strong that diffraction effects can be obtained from exceedingly thin layers of material. In certain organic substances electron experiments yield patterns due to the carbon atoms in the molecule whereas the X-ray pattern is largely due to the molecular aggregate.

It is not my purpose to compare or contrast these two excellent aids in the study of solids. I wish to point out certain results which have been obtained and call attention to some problems yet to be tested by electron diffraction. In the recent theories of metals the question as to the number and energy of the free electrons arises. One is able, by means of diffraction experiments, to determine this energy commonly called the "inner potential".

The next field is in the investigation of orientations of crystal planes in thin films. This is of importance in photo electric work, in the transmission and reflection of light, in the resistance to oxidation or gas adsorption, polishing of surfaces, in short, any property which is specifically concerned with the surface of the solid.

It has been found that forming films by evaporation at certain temperatures will result in the selective orientation of crystal planes with respect to the backing surface. Silver on molybdenum deposited at 650° C prefers the 111 orientation while at 700° C there is little preference. Silvered optical mirrors when treated with aqua regia become better reflectors, and prefer to have the 110 plane of the oxide parallel to the surface.

The surface of a highly polished metal is revealed as a layer of molecular aggregates not unlike a super cooled liquid.

Questions having to do with curious and varying photo electric effects are no doubt related to the structure of the surface of the emitter. Different gases and varying pressures alter the structure of the surface of film deposited by sputtering or evaporation. The diffraction or reflection of electrons from such surfaces should throw some light on the processes involved. An examination of the rate of change of a collodial layer of a solid to a crystalline layer must in the end bear some relation to the forces existing in a solid. The catalytic action of such substances as platinum on asbestos is no doubt associated with the surface conditions.

In increasing our knowledge of the physics of solids it seems desirable to begin with the simple structures first. It is not likely that a structure more simple than the thin film and crystal is to be found in the solid state. For such studies electron diffraction methods are unusually adequate.