Study on the Development of Surface Science

Yueyun Fang[1, a], Hao Cui[2]

[1]Guangdong University of Science & Technology, Dongguan, 523083, China

[2]China Nuclear Industry Huaxing Construction Co. Ltd, Nanjing, 210000, China.

[a]996987541@qq.com

Abstract

Surface physics and surface chemistry take the polyphase system as the object, and discuss the change process of composition, structure, properties and adsorptive properties of various surfaces and interfaces between two phases on the atomic or molecular scale, and study the law of interface properties changing with the nature of materials.

Keywords

Surface science, Surface physics, Surface chemistry.

1. Introduction to the development of surface science

There are at least two phases with different properties in the space of heterogeneous system. The interface between the two phases is not a geometric plane but a physical interface, that is, it is a quasi-three-dimensional region with an infinite width and a thickness of approximately a number of molecular lineaments. You can think of an interface as a transition region from one phase to another. In fact, there is no distinct boundary between two phases, so the interface region is often treated as another phase, called the interface phase or interface region. The two homogeneous phases adjacent to the interface area are the main phase, and the change of any phase will affect the properties of the interface. So a surface is really just an interface between two phases, unless the object is in a vacuum. Traditionally, gas-solid and gas-liquid boundaries are often referred to as the surface, and the transition region between solid-liquid, liquid-liquid and solid-solid is referred to as the interface.

It was not until the 18th century that scientists began to notice that the interface region had many unique properties that the ontological phase did not have, and that much of the behavior of the heterogeneous system depended on changes in the interface properties. These findings have attracted the attention of many scientists and focused on the study of interfacial phenomena. For example, the surface tension of liquid and the adsorption amount on solid surface have been measured and applied to the study of surface (labeling) phenomena[1].

In 1875 ~ 1878, Gibbs, a famous scientist, summarized and developed the previous research work. He used the method of mathematical reasoning and pointed out that the concentration of substances in the interface area was generally different from that in each body (labeling), thus laying the theoretical foundation of surface physical chemistry. Many of the scientists on the adhesion, friction, lubrication, adsorption surface phenomenon, such as a lot of research work, especially the American scientists lundgren Samuel (Langmuir), from 1913 to 1943, he has an important discovery in the field of surface physical chemistry with outstanding inventions, especially for evaporation, condensation, adsorption, surface phenomena such as single molecule film studies (4, 5). For this reason, he was awarded the Nobel Prize in 1932 and was regarded as a pioneer of surface physics and chemistry and a pioneer of new fields.

In the early 40 years of this century, surface physical chemistry has developed rapidly, and a large number of research results have been widely used in various production sectors, such as food, paper, paint, rubber, building materials, metallurgy, energy industry and soil chemistry, material chemistry, heterogeneous catalytic chemistry. Famous physicists and chemists Polany, Langmuir, Rideal, Taylar, and Eminett et al., have made many pioneering studies on surface adsorption and surface element reaction mechanisms, including some surface analysis techniques. Based on the fracture hypothesis, Griffith proposed the Griffith equation for fracture of ideal brittle materials in 1921, which relates the strength of materials with surface energy and fracture size. Nevertheless, as far as the subject field is concerned, it was not independent of surface physical chemistry at that time, but only as part of the colloidal chemistry branch (labeled) in the field of physical chemistry[2].

In the early 1960s, the slow progress of surface science in the 1960s was broken by the development of the electronics industry and aerospace technology. Developments in the electronics industry and aerospace technology required that all components be made as small as possible in order to increase the surface-to-volume ratio, and that the surface properties of materials to some extent dominated developments in semiconductor technology and aerospace. Therefore, it is urgent to study the surface phenomena by means of microscopic testing, so as to continuously improve the ultra-high vacuum equipment, whose vacuum degree is as high as 10-6 Pa. In addition, the continuous introduction of electronic computers and new surface testing technologies led to the emergence of low-energy electron difftometer, auger electron spectrometer, X-ray photoelectron spectrometer, etc., which can be tested on a small surface area (generally l cm2) and can obtain identifiable signals. Therefore, it promoted the formation of a new situation of surface physical chemistry research (labeling).

By the 1970s, scientists were using newly developed high-resolution electron energy loss spectra (HREELS) to study surface adsorption species and surface reaction mechanisms. Yates, Somorjai, Ertl and other scientists extended the molecular beam technology to the surface research, thus combining the theory with the applied research, resulting in a great step forward in the research of surface adsorption and surface reaction dynamics. From the late 1960s to the early 1970s, surface science has entered the stage of studying surface phenomena from the micro level, and has achieved rapid development. Surface science has finally been recognized as an independent discipline[3].

2. Introduction to the development of surface physics

Surface physics, as a branch of science, flourished after the 1960s. In daily life and traditional technology (such as architecture or machine tools), the surface is usually only associated with the artistic performance (whether beautiful or not), does not affect its basic (label) function. In this sense, the surface does not matter much, nor does it require the study of scientists. With the development of technology, however, surfaces, even surface layers as thin as one or two atoms, play a decisive role on many important issues. Among these problems, the most studied are two kinds, one is related to the motion of electrons on or through the surface, and the other is related to the decomposition, binding or chemical reaction of atoms or molecules on the surface. In recent years, in microelectronics, materials, friction and wear, corrosion and oxidation of catalyst, the development and utilization of solar energy, film technology, materials and device failure analysis, a lot of problems in the research of biofilm in areas such as are associated with surface physics, so the surface physics has grown into direct contact with high technology a very active basic discipline.

The subject of surface physics is generally the few outer atomic layers of a solid and the atoms, molecules and their overlays adsorbed to it. This is an extremely thin surface, only a few angstroms to a shallow range of 20-30 angstroms. The surface is immediately contaminated in the atmosphere, and even in a vacuum of 10-6 liters, within seconds a layer of residual gas molecules is absorbed onto the surface, masking the real surface. Moreover, the surface is attached to the atomic layer in the body, and is surrounded by a variety of chemical environment, the signal from the surface is very weak. Some traditional methods, such as electron probes, X-ray diffraction, and nuclear magnetic resonance (NMR), are often not suitable for studying surfaces because they are destructive to surfaces or because they are too deep. With the development of ultra-high vacuum technology and weak signal detection technology, dozens of highly sensitive and high resolution surface (labeling) measurement technologies have emerged. Most of them take electron, photon, ion, proton and other particle beam as probe or increase the high electric field to measure the emission, scattering and vacuum tunnel spectrum of various types and give the microscopic information of the surface. At the same time, the development of surface experiments promotes the development of surface theoretical work, and the theory and experiment complement each other, and the research on surface is increasingly deepened.

The development of surface physics has been completely beyond the original meaning and category, now people often called surface science. Its research involves vacuum physics, metal physics, electrochemical catalysis, material science and semiconductor physics. At present, the surface physical research metals, semiconductors, insulators, etc all kinds of solid surface and chemical composition of the interface, the geometric structure of atoms in the surface layer and interface layer, surface and interfacial lattice vibration, surface diffusion and phase transition, electron spin and the distribution in space and the energy state, the surface phonon state, foreign particles (electrons, ions, atoms and molecules and photons, etc.) and the interaction of a solid surface, surface yuan excited state information, and other surface mechanical and chemical properties.

3. Introduction to the development of surface chemistry

Surface chemistry is a science that studies the chemical reaction process on the surface, and the main research objects are surface formation, surface composition and structure, adsorption, diffusion and the ability of chemical reaction on the surface, etc. In the field of surface science, surface physics and surface chemistry are like a pair of twin sisters, they have a very close relationship, but in the research content and research means and so on, they have obvious differences. In addition to studying the atomic structure and electronic properties of solid surfaces, surface chemistry focuses on the interaction between exotic species (adsorbents) and solid surfaces. From the perspective of contents and methods, the current research on surface chemistry can be roughly divided into four aspects: (1) the study of surface composition, (2) the study of surface structure, (2) the study of surface chemical reactions, (4) the study of heterogeneous catalysis.

Human understanding of the surface has gone through a long period from the shallow to the deep. In the 19th century, it was discovered that the surface phase had many unique properties that the bulk phase did not have, and could accurately measure the surface tension, the adsorption capacity of gases on porous solids and the evaporation capacity of solids, and many surface thermodynamic parameters were obtained from these experiments. Gibbs summarized and developed the work of predecessors, and laid the foundation of surface thermodynamics that we still use today. Due to the 1950 s and '60 s, the development of semiconductor technology has changed (label) the development of vacuum technology, there have been some research in high vacuum conditions on the surface of the new method, can make people from microscopic level to study surface phenomena, the basis of surface chemistry has become an independent discipline, and attracted a number of characteristics of solid state physics, physical chemistry, chemical engineering knowledge background of scientists, from the surface chemical get rapid development, a lot of research achievements have been widely used in the industries of paint, building materials, metallurgy, energy and other.

Since 1960s, various surface analysis techniques have emerged continuously. In recent decades, the experimental technology of detecting surface properties has made a breakthrough. The surface composition, structure, electronic properties and magnetic properties can all be characterized from the extremely microscopic level, which provides a very convenient experimental means for deep study of surface reaction process. Commonly used experimental method with X-ray photoelectron spectroscopy, ultraviolet photoelectron spectroscopy, auger electron spectroscopy, electron energy loss spectrum, low energy electron diffraction, temperature programmed stripping technology etc., among them, especially for benny (Gerd Binning) and Rohrer (Heinrich Rohrer) in the 1980 s after the invention of scanning tunneling microscope (STM) and developed by the guests, such as atomic force microscopy (AFM), will be the development of surface analysis techniques on top. These various surface analysis techniques and methods have become powerful weapons for people to explore the surface, bringing people into the fascinating world of atoms and molecules, realizing people's dream of "seeing" and manipulating atoms and molecules, and bringing endless vigor and vitality to the development of surface chemistry.

4. Conclusion

At present, some achievements have been made in the research of surface physics and surface chemistry at home and abroad. Therefore, with the further research on the surface and interface of materials, various materials will be more widely used.

References

[1] J. R. Chelikowsky, M. Y. Chou, Phys. Rev. B 1988, 38, 7966.

[2] T. Kraft, P. M. Marcus, M. Methfessel, M. Scheffler, Phys. Rev. B 1993, 48, 5886.

[3] R. J. Randler, D. M. Kolb, B. M. Ocko, I. K. Robinson, Surf. Sci. 2000, 447, 187.