Physics of metal/electrolyte interfaces

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Short introduction

Over the last four decades surface science of solid surfaces under ultrahigh vacuum conditions (UHV) has been extraordinarily successful. With a plethora of methods, properties and processes at solid/vacuum interfaces can not only be studied with highest possible spectroscopic and spatial resolution, but even controlled and manipulated on the atomic and submolecular level. This evolution was crowned with the Nobel-Prize 2007 for Gerhard Ertl for his outstanding achievements in surface chemistry.

This research has laid the basis for our fundamental understanding of properties and processes at solid/vacuum interfaces which may be coined in the statement *"Surfaces, a new state of matter".* This understanding nowadays is the basis for technologically and economically so important areas as catalysis (pollution control, drug and fine chemical production), material-science (thin film technology, corrosion, passivation, biocompatibility), micro- and nanotechnology (electronics, sensorics) etc. These technologies nowadays make a major fraction of the gross national product (GNP) of the industrialized countries.

Yet, both the research as well as the technological application under vacuum conditions are very demanding and expensive. The further scientific evolution calls for an extension to more realistic conditions, either solid/gas or solid/liquid interfaces. For instance, at the recent International Vacuum Congress (IVC) in Beijing, 23. – 27. August 2010, the Nobel-Prize Laureate, Heinrich Rohrer, inventor of the Scanning Tunneling Microscope in ultrahigh vacuum, publicly stated: "The future of surface and interface science is at the solid/liquid interface."

Research at solid/liquid interfaces is much more challenging, in that much less methods are available to study these (between two condensed phases) buried interfaces: All UHV-based methods using atom-, ion- and electron-beams are excluded, only photon- and probe-based methods can be applied. For the time being this is a severe restriction, and new methods are desperately required which eventually enable solid/liquid interfaces to be studied with the same precision we are used to from UHV-surface science.

Progress in this direction is highly important because processes at solid/liquid interfaces are more realistic, better to control (e.g. near electrochemical equilibrium), broadly applicable and more economic.

Probably, the most promising evolution is the symbiosis of organic chemistry and surface physics. Organic chemistry can synthesize (almost) every functional molecule desired, surface physics provides the methods and concepts to study and describe the interaction of these molecules at surfaces. However, more complex molecules are often no longer intact volatile under UHV-conditions, they must be deposited from liquid phase. Hence, solid/liquid interface science will become of utmost importance, again for vital technologies and disciplines like catalysis (fuel cells as alternative energy sources), molecular electronics (incl. displays), medicine (biocompatibility and drug delivery systems) etc.

This lecture will give an overview over the state-of-the-art contribution of surface/interface physics to this scientific exciting and technologically highly relevant research area.