XVII School on Synchrotron Radiation
"Gilberto Vlaic":
Fundamentals, Methods and Applications
Muggia (Trieste), Italy / 16-26 September 2024

Ambient pressure x-ray photoemission and absorption spectroscopies

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Decades of surface science in ultra high vacuum (UHV) has shown the power of XPS and XAS spectroscopies. Their unique property is the extremely short elastic mean free path of electrons as they travel through condensed matter, of the order of a few atomic distances, in the energy range from a few eV to a few thousand eV. As a consequence of this, the information obtained by analysing electrons emitted or scattered from a surface refers to the top first few atomic layers, which is what surface science is all about. This property combined to the wealth of information about the chemical state of the analysed atoms that can be obtained from XPS and XAS have made both fundamental tools in the understanding of the surface chemistry and catalysis.

Despite the incredible success of those spectroscopies (Kai Siegbahn was awarded the Nobel Prize in 1981 for having developed the XPS starting from 1957) XPS has always suffered of a great limitation: the measurements can be conducted only in vacuum conditions. The same problem affected the XAS spectroscopy operated in the soft x ray range (soft-XAS). The result of this limitation was that the chemical processes cannot be studied while happening (given that the great majority of the relevant chemical reaction happen at atmospheric pressure or higher) and thus only "pictures" of the surface chemical states before or after the reactions was obtainable with XPS and soft-XAS. This problem has become known in the surface science community as the "pressure gap" and the techniques that was permitting to investigate the chemical state of surfaces during reaction was called "operando" spectroscopies.

During the last 25 years the scientific community has worked hard to overcome the "pressure gap" and to develop instruments capable of performing both XPS and soft-XAS at relatively high pressure: XPS is now routinely performed at few millibars and can be pushed up to 1 Bar in some cases while soft-XAS is routinely performed at 1 Bar and can be pushed up to about 5 bars. During the lecture I will briefly introduce the basic principles of XPS and XAS, their main applications moving then to the result achieved in the development of NAP-XPS and AP soft-XAS. The two techniques will be presented starting from the instrumental point of view moving then toward their main applications and future perspectives.