Preface

The phenomenon of photoelectron emission was found more than a century ago and yielded the concept of photons. The relation between the photon energies and the kinetic energies of photoelectrons was soon clarified. The usefulness of photoelectron spectroscopy (PES) for materials sciences was widely recognized in the last century. Electronic structures of gases and solids were mostly studied at low photon energies and chemical analyses were mainly performed in the X-ray region. Besides the development of high performance electron analyzers, light sources have in parallel been intensively improved till date. The use of synchrotron radiation has promoted the photoelectron spectroscopy since ~1975 due to the tunability of photon energies. The development of undulator light sources enabled the high energy resolution photoelectron spectroscopy even in the regions of soft and hard X-rays. Now, synchrotron radiation can provide photons with energy ($h\nu$) resolutions less than a few meV below 10 eV, 40 meV around 800 eV, and less than 300 μeV at 14 keV by use of good monochromators. Meanwhile, the resolution ≤ 1 meV can be achieved in laboratories by use of very low energy (~7 eV) quasi-CW, high-repetition lasers as well as high resolution rare gas (Xe, Kr, Ar) lamps.

By utilizing the angle resolving power of the electron energy analyzer, the angle resolved photoelectron spectroscopy (ARPES) became very popular to probe the band dispersions of solids as well as the fermi surface topology in metals. In strongly correlated electron systems, where the surface electronic structures as well as surface band dispersions are often noticeably different from those of the bulk electronic structures, the high energy photoelectron spectroscopy with high bulk sensitivity and enough energy and momentum resolutions is now extensively performed. Since the inelastic mean free path of photoelectrons becomes again increased in some materials below the kinetic energies of a few eV, extremely high resolution photoelectron spectroscopy is under development below $h\nu \sim 10$ eV. For a complete understanding of electronic structures of strongly correlated electron systems, studies in wide photon energies in the range of 10 keV down to a few eV will be highly desired. By utilizing the high brilliance of the synchrotron radiation, studies of micro- and nano-materials are progressing rapidly. The scanning photoelectron microscopy and the photoelectron emission microscopy are such examples. In addition, spin polarized measurements are widely used to study the spin states.

Complementary techniques to probe materials electronic structures are also under intensive development. For example, absorption and reflectivity spectroscopy as well as the resonance inelastic X-ray scattering are very powerful techniques with high bulk sensitivity. Inverse photoemission spectroscopy is a useful tool to probe the unoccupied electronic states. On the other hand, photoelectron diffraction can provide the structural information down to sub nm range. The scanning tunneling spectroscopy by use of scanning tunneling microscope can also probe the occupied and unoccupied electronic states with extremely high spatial resolution down to the atomic resolution. By means of the Fourier transform, the information in the momentum space can also be obtained. Thus we intended to include up-to-date achievements in photoelectron spectroscopy and frontiers of some typical complementary techniques in this book.

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