Study of free-electron-like plasmon excitations by hard-X-ray photoemission

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Photoelectron lines of solid free-electron-like materials are usually accompanied by strong plasmon satellites. These collective electronic excitations originate from both intrinsic processes due to the sudden creation of the local core hole and from extrinsic processes during the transport of the photoelectron through the solid. In addition, both surface and bulk excitations contribute to the spectra. Plasmon excitations were intensively studied experimentally and theoretically in the early days of photoelectron spectroscopy. Renewed interest in these phenomena is reflected by a number of recent publications where the emphasis is on a more quantitative description of the different processes in order to model the complete excitation spectrum.

A number of studies have been performed to quantify the relative contribution of intrinsic and extrinsic excitations as well as the influence of the surface. The corresponding results differ considerably. Most experiments so far used traditional X-ray excitation with laboratory sources producing rather slow electrons where surfaces effects are significant and complex scattering paths for multiple excitations are not in favor of a quantitative analysis.

We have studied the plasmon excitation accompanying the 1s and 2s lines of free-electron-like materials such as Si, Ge, Al with hard X-rays both for bulk samples and overlayer systems. At these high energies surface effects are generally small and interference effects between extrinsic and intrinsic channels, which lead to the same final state, are also expected to be small. Also, preferential forward scattering simplifies the analysis of multiple excitations. The experimental data are interpreted using a semi-classical dielectric response model.