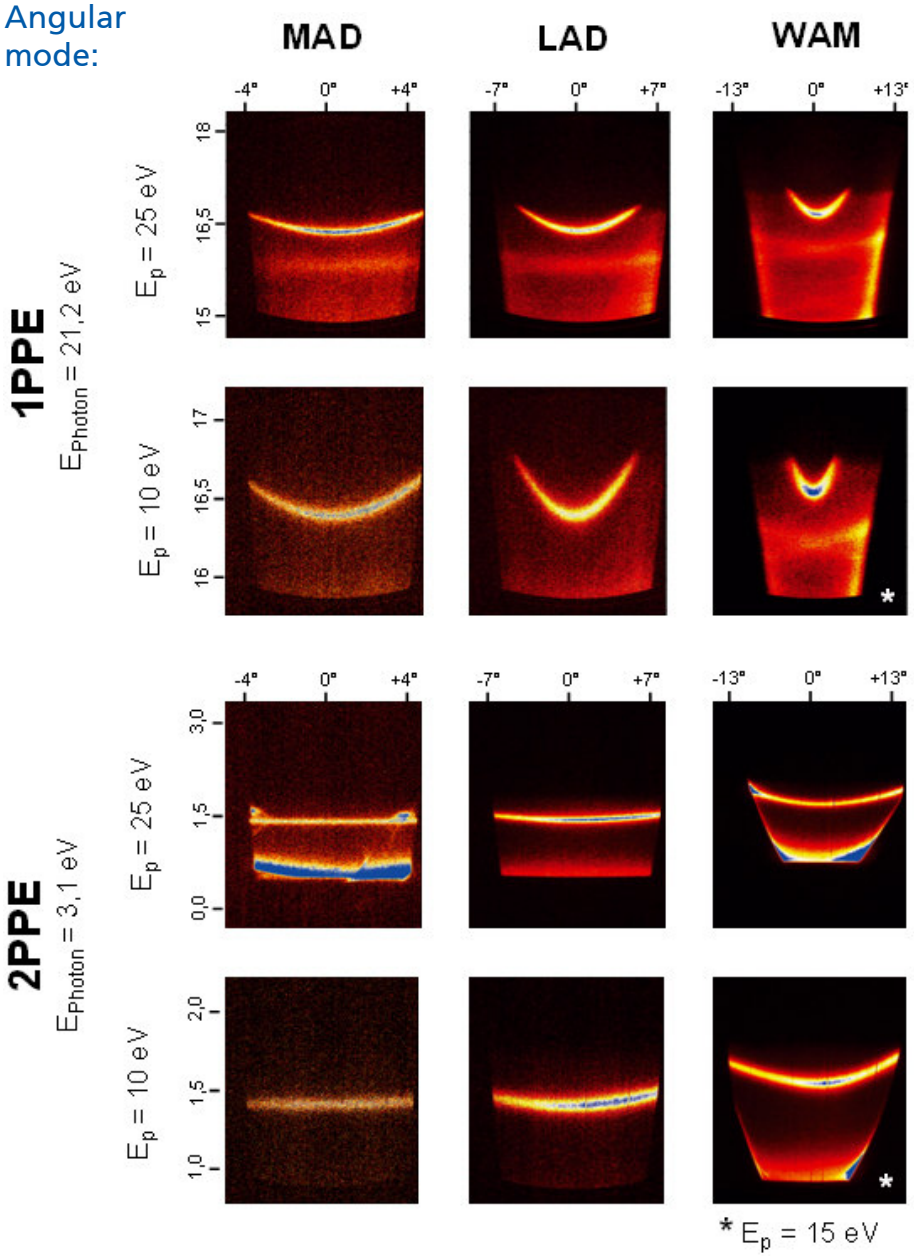
Two-Photon-Photoemission

Application Notes

Angular mode:



The images showing the one- and two-photon photoemission signal of the Cu(111) surface state at 300 K for the different angular resolved lens modes of the PHOIBOS analyzer at different pass energies E_p. The surface has been analyzed using a PHOIBOS 150 analyzer with the 2D CCD Detector. Data courtesy S. Mathias and M. Bauer (University Kaiserslautern, Germany).

Two-photon photoelectron emission (2PPE) is a version of **photoelectron spectroscopy** which allows one to investigate unoccupied electronic states located between the Fermi level and the vacuum level of a metal or semiconductor. Two-photon photoemission has been used most extensively for the spectroscopy of image-potential states at metal surfaces and for studies of electron dynamics of semiconductor surfaces. Recent applications using femtosecond laser pulses include the ultrafast relaxation of hot carriers in bulk metals and semiconductors, the spin dynamics of magnetic materials, lifetimes of adsorbate-induced or adsorbate-modified electronic states and real-time investigations of electron localization in thin molecular films.

A first (pump) laser pulse with photon energy hv_a populates the unoccupied state $|i>$, a second (probe) laser pulse with photon energy hn_b and a time delay photoemits the electron. With the incorporated pump and probe facility, the electron dynamics of the processes being studied can be observed on a femtosecond time scale.

The kinetic energy of the photoelectron

$$E_{kin} = hv_b - E_i$$

provides a straightforward means to determine the binding energy E_i of the unoccupied state with respect to the vacuum level. Typically the energy of these states is between 0.5 –5 eV above the Fermi level.

In an angular dispersive mode, the emission angle distribution is imaged instead of the real image. There is no lateral resolution, but the emission angle information is easily available. These modes are intended for UPS band mapping, Fermi surface mapping or similar experiments.

Mode	D	Accepetance Angle	Energy Range
High Angular Dispersion	3.2 mm/°	± 3°	Not yet available
Medium Angular Dispersion	2.2 mm/°	± 4°	Ep × [1 – 200]
Low Angular Dispersion	1.2 mm/°	± 7°	Ep × [0.05 – 30]
Wide Angle Mode	0.5 mm/°	± 13°	Ep × [0.1 – 3]

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