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Technology Offer

Parallel-imaging time-of-flight momentum microscope

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The state of an electron is completely defined by its momentum and spin. In processes like electron diffraction or photoemission electron ensembles are generated which have a characteristic 3D distribution of momentum and spin. To examine such events the three components of the momentum vector have to be measured. Up to now, the momentum distribution of an ensemble of charged particles was typically measured using energy-dispersive spectrometers based on sequential approaches (sequentially changing angles of sample and/or spectrometer as well as observed energies) which resulted in time-consuming measurement processes.

Keywords

Measuring momentum/spin of charged particles, energy-dispersive spectrometer, photoelectron emission microscopy (PEEM)

Technology

Scientists at the Max Planck Institute of Microstructure Physics developed a parallel-imaging time-of-flight momentum microscope to measure the momentum distribution of charged particles. This novel approach (which, e. g., can be used to examine the electronic structure of surfaces) is based on the cathode-lens technique known from PEEM (photoelectron emission microscopy). All three components of the momentum vector are measured simultaneously with very high precession.
The measurement of two momentum components k_x, k_y is achieved by using an electron-optical column. The third component k_z is determined via a drift tube (time-of-flight approach). All three components can therefore be measured simultaneously, drastically increasing the measurement efficiency in comparison to traditional methods. This is especially important when examining radiation-sensitive samples or observing dynamic processes. Furthermore, processes where two electrons with different energies are generated at the same time can be examined. Spin-dependent measurements can also be made possible by adding an imaging spin filter crystal, which allows for determining one component of the spin-polarization vector. In contrast to an energy-dispersive spectrometer (≈ 1 m^3) such an instrument is also relatively small (150 mm, length 1 m).

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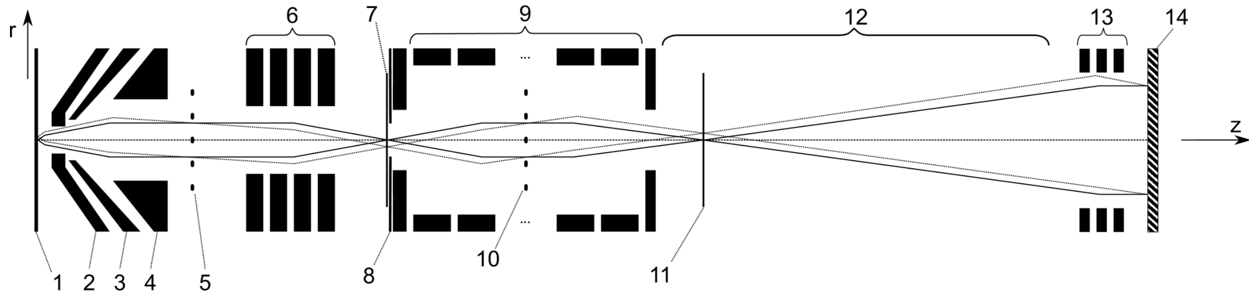

Fig. 1: Schematic view of a simple implementation of a time-of-flight momentum microscope. 1: sample, 2, 3: electrodes, 4 electron-optical column, 5, 9: reciprocal images, 6, 9, 13: transfer lenses, 7, 11: intermediate images, 8: aperture, 12: drift tube, 14: imaging detector.

Advantages

- Allows parallel measurement of all components of momentum vector with very high precision.
- Simultaneous measurement drastically increases measurement efficiency in comparison to other methods (reduced radiation exposure, fast dynamic processes can be examined).
- Processes where two electrons with different energy are generated at the same time can be examined.
- Spin-dependent measurements possible.
- Relatively small: diameter 150 mm, length 1 m (energy-dispersive spectrometer: ≈ 1 m^3).

Patent Information

- DE patent application filed March 2013.

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