Technology Offer

TT-Ref. 2015-102

Fast online detection by induction spectrometry

Invention

Ultrafast photo-electron and photo-ion spectroscopy utilize detectors based on different electron multipliers. These detectors have some important limitations such as fast-signal distortion (low-pass filtering), mutually exclusive positive or negative modes, dead times, requirement of triggering and more. A new high-pass induction detector, based on a hollow-cored toroidal coil, was developed that overcomes the above-mentioned limitations.

Background

Ultrafast charged particle spectrometry allows real-time study of chemical reactions. State-of-the-art detectors used in charged particle spectroscopy are based on different electron multipliers such as microchannel plates or single-channel electron multipliers. A known drawback of ordinary detectors is related to distortion of fast signals, due to low-pass operation (Bode diagram). The high-frequency component of a signal bandwidth is important for preserving a steep leading edge. If the readout setup cannot "read" the high-frequency components, the output signal typically has a smeared-out profile. This can limit the time-resolution as well as enhance interferences and cross-talk.

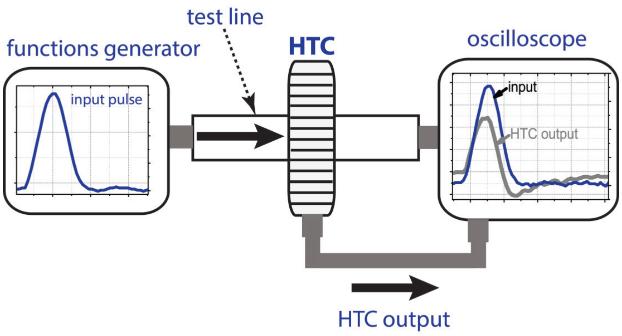
Ordinary detectors do also require a reliable and jitter-free triggering system, in order to 'snap' the important information of an analytical signal. The related instrumentation required to deal with such issues adds to the complexity and cost of the analytical instrumentation, especially when coincidence photoelectron – photoion spectroscopies are carried out. Another drawback is that physical detectors along the beam path stop the incident beam to be measured, e.g. electrons are hitting the sensors and are lost in the measurement process. This restricts the possibility of on-line monitoring, which can be advantageous in applications such as nano-fabrication and nano-structuring using focused beams, or to study correlated electron/photon bunches, such as in Auger electron versus fluorescence spectroscopy. Also, in time-of-flight measurements, state-of-the-art detectors impose the limitation of the duty cycle to 10−20% because of risk of bunch overlapping or detector overload. This restricts the possibility of higher sensitivity or improved precision. Saturation at high electron count rates is also another constraint of operation.

Advantages

A hollow-cored toroidal coil detector (HTC) with high-pass response for ultrafast spectroscopy, addressing the above-mentioned issues was developed. Charged particles, regardless whether electrons (negative mode) or ions (positive or negative mode), cross the HCT and produce an induction signal. Such signal, independent of phase, is stronger, the faster the transition (high pass operation), which permits to preserve ultrafast transient pulses structure and suppress low-frequency background beam, without need for modulation. The HCT is "self triggered" and has response characteristics optimized by geometrical and electrical design. The HCT measures, but does not 'kill' the particle pulse along its path, becoming ideal for on-line monitoring. The HCT has virtually unlimited resolution, because induction spectrometry is performed in the Fourier domain.

Applications

The HCT will find immediate application in photoemission spectrometry and/or mass spectrometry, as classical "charge particle" analytical fields. Its character of preserving the pulse while measuring, makes it suitable for implementation as online current characterization in beam-processing facilities.



Ownership

Empa, Swiss Federal Laboratories for Materials Testing and Research, Überlandstrasse 129, CH-8600 Dübendorf; Patent pending

References

Y. Arbelo, D. Bleiner "Frequency-dispersive induction spectrometry using a ultrafast hollow-cored toroidal-coil (HCT) detector" *submitted* to Rev. Sci. Instrum. on 25 September 2016

Keywords

Detector, spectrometry, coincidence spectroscopy, frequency-domain, XUV, ns-time resolution, high-pass band-width, induction, electron bunch, ion bunch, fast pulses

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