Core-Level Photoelectron Spectroscopy with a new Hemispherical Analyzer on Mass-Selected Lead Clusters at FLASH

P. Oelßner[1], J. Bahn[1], M. Köther[1], C. Braun[2], B. von Issendorff [3], S. Palutke[4], M. Martins[4], J. Plenge[5] E. Rühl[5], J. Tiggesbäumker[1], V. Senz[1], K.-H. Meiwes-Broer[1]

[1]*Institut für Physik, Universität Rostock, Universitätsplatz 3, 18051 Rostock, Germany*
[2]*Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany*
[3]*Fakultät für Physik, Universität Freiburg, Stefan-Maier-Straße 19, 79104 Freiburg, Germany*
[4]*Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany*
[5]*Physikalische und Theoretische Chemie, Freie Universität Berlin, Takustraße 3, 14195 Berlin, Germany*

The high brilliance of the VUV-FEL FLASH enables core-level photoelectron spectroscopy of free mass-selected metal clusters [1]. In previous beam times, the experiments were performed by detecting the electron kinetic energy via time-of-flight analysis. With the development of FLASH, in particular the last update, increased photon energies and thus deeper core-levels became accessible. However, now additional decay channels open, i.e. Auger, shake-up and other secondary electron processes. To get hand at details of the dynamics, higher electron energy resolution is essential, which cannot be achieved by the time of flight setup. Thus, in the reporting period we implemented a hemispherical electron analyzer with fast detection [2], see Fig 1.

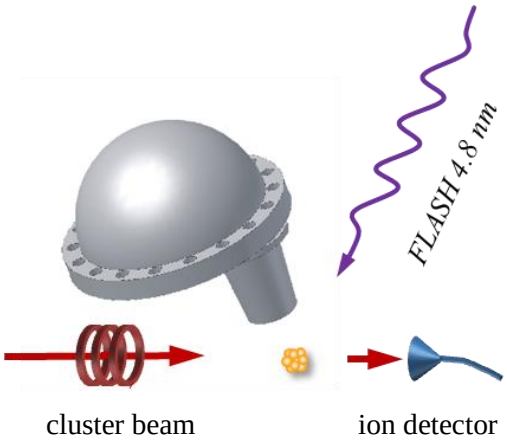

Fig. 1: Negatively charged mass-selected metal clusters generated in a vaporization source are exposed to the light of FLASH in the interaction region of a hemispherical spectrometer.

Compared to the standard design, our hemispherical analyzer is equipped with a two-dimensional delay-line detector which enables to simultaneously record photoemission from several clusters with selected size. The new spectrometer offers advantages for the measurements at FLASH:

- The energy resolution is substantially improved when compared to a time-of-flight system. We can demonstrate that the loss in the angular acceptance is compensated by the increase in sensitivity and reduced background signal.
- With each of the up to 200 micro-pulses per macro-pulse separate photoelectron spectra can be recorded. Therefore it becomes possible to sample the mass peaks in the spectrum with higher rate, see Fig 2.

We succeed in recording photoelectron spectra from mass-selected clusters. Fig. 3 displays as example selected traces in the Pb 4f range. Besides the appearance of the core level signatures, we find evidence for a cluster size dependence of secondary electron emission. In particular the low-energy shoulder evolves with size.

This finding may open a discussion concerning many-particle effects in electron emission from metal clusters. Similar size dependent secondary effects have also been seen with gold cluster [3].

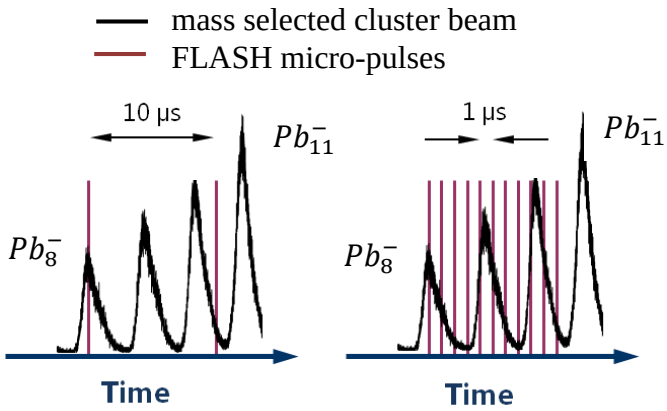

Fig. 2: Micro-pulses of FLASH (violet) overlap bunches of clusters with selected size (black). At 10 µs micro-pulse separation, only few peaks are scored (left). The new setup allows 1 µs separation which leads to a significantly enhanced sampling of the cluster size distribution (right).

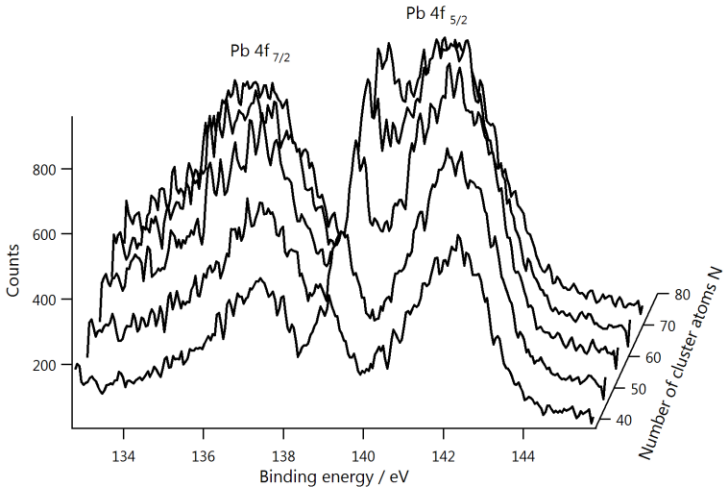

Fig. 3: Selected lead 4f photo-electron spectra from Pb_N^- in the size range from N=40 to 70 atoms. The data set shows contributions from secondary processes in electron emission which depend on the cluster size. Such many-particle effects will be subject to future investi-gations.

We gratefully acknowledge experimental support by the whole FLASH team. We like to thank A. Oelsner (Surface Concept GmbH) and Th. Kampen (SPECS GmbH) for the hemispherical analyzer and the detector. This work has been supported by the BMBF under the project number 05KS7HR2 and the Collaborative Research Center SFB 652 at the University of Rostock.

References

[1] V. Senz, T. Fischer, P. Oelßner, J. Tiggesbäumker, J. Stanzel, C. Bostedt, H. Thomas, M. Schöffler, L. Foucar, M. Martins, J. Neville, M. Neeb, T. Möller, W. Wurth, E. Rühl, R. Dörner, H. Schmidt-Böcking, W. Eberhardt, G. Ganteför, R. Treusch, P. Radcliffe, and K.-H. Meiwes-Broer, Phys. Rev. Lett. **101**, 138303 (2009).

[2] J. Bahn, P. Oelßner, M. Köther, Th. Kampen, A. Oelsner, V, Senz, and K.-H. Meiwes-Broer, Time-slicing 2D Photelectron Spectroscopy, Hasylab Annual Report 2009

[3] P. Oelßner, J. Bahn, A. Kickermann, M. Köther, M. Götz, S. Schorb, T. Möller, M. Martins, E. Rühl, J. Tiggesbäumker, V. Senz, K.-H. Meiwes-Broer, Correlation in Core-Level Photoelectron Emission from Mass-Selected Gold Clusters at FLASH, Hasylab Annual Report 2009