Nanosecond pump-probe soft X-ray NEXAFS spectroscopy using a laser-produced plasma source

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Near edge X-ray absorption fine structure spectroscopy (NEXAFS) is most widely performed at large scale facilities by utilizing tunable monochromatic radiation which is varied across an absorption edge of interest. An alternative method is to use a full X-ray spectrum and disperse the light which is transmitted through a thin sample with a highly resolving spectrometer. Such schemes allow for polychromatic excitation with laboratory sources employing for example laser-produced plasmas (LPP). LPP sources have the inherent possibility to perform perfectly synchronized optical pump X-ray-probe experiments if the laser pulse is split into two pulses. Additionally, due to the absence of background light between pulses and the possibility to monitor changes after each pulse, the radiation damage of the sample is kept to a minimum.
We have shown that using a ns LPP source and a highly resolving spectrometer based on reflection zone plates, efficient single shot NEXAFS spectroscopy is feasible [1]. In this contribution we will present our newly developed twin beam spectrometer. Sample and reference spectrum are collected with each shot on one CCD camera image, yielding a normalization possibility for each light pulse. The spectrometer covers the whole available energy range between 100 eV and 1200 eV with energetic resolving powers of $E/\Delta E \geq 1000$. With this, NEXAFS K edge spectroscopy of the main constituents of biological samples such as C, O and N is feasible as well as the investigation of the L edges of all transition metals.
We applied this spectrometer for first proof-of-principle pump-probe experiments at the C K edge. By using frequency doubled light from the same seed laser a perfect synchronization between the optical and the x-ray pulse is achieved. Transient changes in the C K edge NEXAFS spectra of organic molecules will be presented with and without optical pumping accompanied with UV/Vis spectroscopic investigations.
This work demonstrates the potential of time-resolved laboratory-based spectroscopy for the elucidation of dynamic processes in the ns range, enabling the investigation of organic molecules while keeping the radiation dose minimal.

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[1] I. Mantouvalou, K. Witte, W. Martyanov, A. Jonas, D. Grötzsch, C. Streeck, H. Löchel, I. Rudolph, A. Erko, H. Stiel, B. Kanngießer, Appl. Phys. Lett. 108, 201106 (2016).