A SINGLE-SHOT NEXAFS SPECTROSCOPY USING LASER PLASMA DOUBLE STREAM GAS PUFF TARGET SXR SOURCE

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Summary

Thin organic samples and silicon nitride membrane were measured by means of a single-shot near edge X-ray fine structure spectroscopy, using a laboratory laser produced plasma soft X-ray source. High power nanosecond laser pulse from an Nd:YAG laser is interacting with a double stream gas puff target, forming krypton/xenon plasma. Efficient emission in the "water window" spectral region allows one to obtain simultaneously emission spectrum of the source and transmission spectrum of the investigated sample, using a specially designed grazing incidence SXR spectrometer. Calculated absorption spectrum is then independent of source energy fluctuations and mechanical instabilities. Fine structures near the carbon K- and of Kr source on the left side. Source and sample chamber Nd:YAG laser beam

Technical specifications:

- Nd:YAG laser Ekspla NL 129 with approximately 7 J energy in a pulse with duration 1 ns and repetition rate of 10 Hz
- Focusing lens with f = 100 mm
- 12 μm wide slit from 50 μm thick brass foil
- Reflective grating from Hitachi, model 001-0471 with 2400 l/mm
- BI CCD camera with 2048 × 2048 pixels from greateyes, model GE 20482048 BI

Advantages:

- debris-free
- high repeatability
- no maintenance required
- variety of working gases (Kr, Ar, He, N2, SF6)
- more in [1]

Figure 1: Technical scheme of an experimental system.

Experimental scheme

Source and sample chamber SXR spectrometer

Figure 2: Snapshot of the NEXAFS system.

Spectral resolution of homemade grazing incidence spectrometer was estimated to be E/ΔE = 940 at 280 eV

Source spectra

Figure 3: CCD picture of a single-shot spectrum on a 200 nm thick Si membrane (right side) and transmission spectrum of the Xe source on the left side.

Absorption coefficient

From intensities, absorption (attenuation) coefficient μ can be calculated using

\[
\mu(E) = \frac{1}{d} \ln \left( \frac{I_0(E)}{I(E)} \right),
\]

where d is thickness of the membrane, Is is intensity spectrum of the sample and I0 is reference emission spectrum of the source. Normalized attenuation coefficient in the vicinity of the edges of various samples are on the left.

The system has high shot-to-shot stability (SD for PET and 5 shots σ ≈ 6%, input pulse energies from 5 to 6 J). The spectral resolution is good enough for spectral deconvolution, when peak positions are a priori known, allowing for compositional analysis [1].

Figure 4: Emission spectra of various working gases used for spectrometer calibration and for measurements of the absorption coefficient.

Figure 5: Absorption coefficient of 200 nm thick membrane from silicon nitride.

Figure 6: Absorption coefficient of 1 μm thick PET foil from Lebow.

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