ESRF	**Experiment title:** **KMM Radiative Auger emission in low Z atoms following near threshold 1s photoexcitation**	**Experiment number**: HE-2201
Beamline: ID-21	**Date of experiment**: from: 5.7.2006 to: 10.7.2006	**Date of report**: 28.8.2007
Shifts: 18	**Local contact(s):** Remi TUCOULOU TACHERES	*Received at ESRF:*

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Introduction

Besides the radiative (fluorescence) and non-radiative Auger transition (electron emission) the radiative Auger process (RAE) presents an alternative decay mode of an inner-shell vacancy in which the filling of the inner-shell hole is accompanied by the simultaneous emission of a photon and the excitation of a second electron into a higher bound atomic state or continuum [1]. Since in the x-ray fluorescence spectrum the RAE decay channel contributes to the satellite structure on the low-energy tail of the corresponding main diagram line accurate and high energy-resolution measurements employing crystal spectrometers are thus needed to study RAE transitions experimentally. In our experiment the high resolution x-ray spectrometer has been used to measure the KMM RAE profiles induced in Ca and Ti targets by monoenergetic photon beams tuned around the threshold for the 1s photoexcitation of the target-atoms.

Experiment

The Kβ x-ray emission of Ca and Ti targets were measured with the high-resolution von Hamos bent crystal spectrometer of Fribourg [2] equipped for the present experiment with the LiF(200) crystal (2d = 4.028 Å), curved cylindrically to a radius of 25.4 cm. The diffracted photons were recorded by the back illuminated CCD camera which consisted of 1340 columns x 400 rows, with a pixel size 20x20 μm^2. The spectrometer was installed downstream from the STXM chamber to which it was connected through a 180 cm long evacuated pipe closed on the spectrometer side with a 50 μm thick kapton window. The x-ray beam delivered by the undulator was monochromatized with the Si(111) double crystal monochromator yielding energy resolution of appr. $2x10^{-4}$. A Ni mirror was used for the rejection of higher harmonics. The energy of the beam was calibrated by measuring K absorption edges of several standard materials (V, Cr, Ti).

In order to maximize the intensity and avoid the modification of the signal due to the inhomogeneous beamprofile seen on the target through the slit system of the spectrometer the 200 μm pinhole was inserted in the primary beam and the slits of the spectrometer completely opened. In such configuration the broadening due to finite energy resolution of the spectrometer is determined mainly by the size(width) of the beam on the target. The instrumental broadening, determined from the $K\alpha_{1,2}$ line measurement was less the 2 eV at the energy of the Ca Kα line (3.69 keV). For illustration a Kβ spectrum measured during excitation of Ca target with the 4047eV photon beam is presented in Figure 1. The KMM RAE structure on the low energy tail of the diagram line is shown enlarged in the inset.

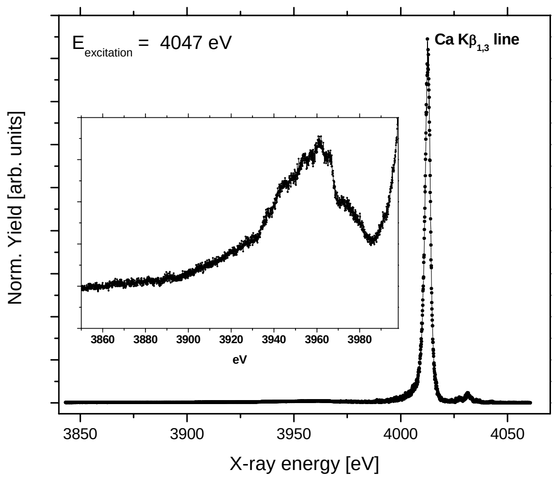

Figure 1: The Kβ fluorescence spectrum of the Ca target measured during the excitation with the 4047 eV photon beam. The broad structure on the low energy tail corresponds to the photons emitted in the KMM radiative Auger transition.

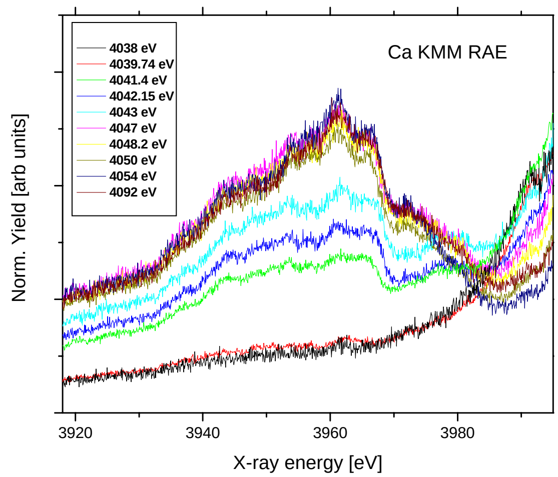

Figure 2: Evolution of the KMM RAE structure in Ca with the energy of excitation in the near 1s photoexcitation threshold region.

Data analysis

Data were taken at ten energies in the near 1s photoexcitation threshold region for Ca and Ti target. The spectra were normalized off line for the number of incident photons. The evolution of the KMM RAE measured profile is shown in Figure 2 for Ca target. No significant changes of the shape as a function of the excitation energy were observed and fast saturation of the KMM RAE intensity has been observed. More detailed analysis of the measured spectra is still in progress. A very good energy resolution of the present experiment will enable us to probe in details the results of the recent calculations [3]. The tunability of the photon beam used for excitation will give opportunity to study evolution of the RAE intensity from threshold to saturation and compare saturated values with existing results obtained with charged particles excitation with energies far above the 1s threshold [4] where excitation process and resulting decay of the inner-shell hole state can be treated separately.

References

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