ESRF	**Experiment title:** Superconducting superalattices: XAS and RIXS investigation of CuO_2 plane hole doping	**Experiment number**: HE-1735
Beamline: ID08	**Date of experiment**: from: 16/02/05 to: 22/02/05	**Date of report**: 17/03/05
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Report:

In this experiment we aimed to study the local electronic structure and in particular the symmetry properties of the $[BaCuO_{2+x}]_2/[CaCuO_2]_n$ superlattices (briefly *2* x *n*) at the Cu sites. To that purpose we used both X-ray Absorption Spectroscopy (XAS) and high resolution Resonant Inelastic X-Ray Scattering (RIXS) measured at the $L_{2,3}$ Cu edges (930-950 eV)

It is known that in this special family of artificially layered cuprates an accurate control of doping level in the CuO_2 superconducting planes can be achieved without changing the local crystalline structure at the Cu sites. Namely, by maintaining fixed the "doping power" of the charge reservoir block (i.e. the 2 $BaCuO_{2+x}$ layers in the *2* x *n* supercell), it is possible to finely tune the density of holes in the CuO_2 superconducting planes by increasing the number *n* of $CaCuO_2$ layers (infinite layers, IL).

We recorded XAS and RIXS spectra on a variety of superlattices and on the IL-like compounds $BaCuO_{2+x}$ and $CaCuO_2$. In detail, absorption measurements were performed on three different series of artificial $[BaCuO_{2+x}]_2/[CaCuO_2]_n$ superlattices, with *n* ranging from 2 up to 13. Furthermore, the $BaCuO_{2+x}$ phase and two $CaCuO_2$ Infinite Layer grown on different subtrates have been investigated. In order to enhance either the *in-plane* or the *out-of-plane* contributions, we recorded absorption spectra at different incidence angles, both with vertical (V) and horizontal (H) linear polarization. The absorption spectra concerning a series of five samples are reported in figure 1. From a preliminary analysis, it can be deduced the relatively strong differences in the apical oxygen content, between the metallic $BaCuO_{2+x}$ phase, and the insulating $CaCuO_2$ Infinite Layer structure. The spectra of (*2* x *n*) superlattices show mixed features coming from the Ba-based charge reservoir block and from the Ca-based Infinite Layer block. A trend is clearly evident, starting from the optimally doped (*2* x 2) supercell (having a superconducting zero resistance temperature around 75 K) toward the strongly underdoped and semiconducting *2* x 12 structure.

This trend seems to be confirmed by RIXS measurements, performed on three superlattices (*2* x *n*, with *n*=2,6,13) and on the IL-like constituents compounds across the copper $L_{2,3}$ edges, in 20° grazing incidence geometry, with vertical polarization [GI,V] and horizontal polarization [GI,H]. In fig. 2 the RIXS spectra of these five samples, recorded at the Cu L_3 peak are shown. Both the *dd* and the charge-transfer excitations are present in the spectra, so that a systematic comparison of the charge doping effect is possible. Even before the necessary accurate analysis of the spectra we can see from the raw data that the main *dd* excitation energies are not influenced by the doping level. On the other hand the incident energy dependence of the RIXS spectra depends on the average doping of the CuO planes (one example for the 2 x 2 sample is shown in figure 3 for excitations energies above the main L_3 peak, which is labelled as F; every letter indicates a 1 eV step in the excitation energy).

Furthermore for some of the samples a series of RIXS spectra across the copper L_3 edge have been recorded at the liquid Helium temperature (i.e. in the superconducting state for the 2 x 2 sample).

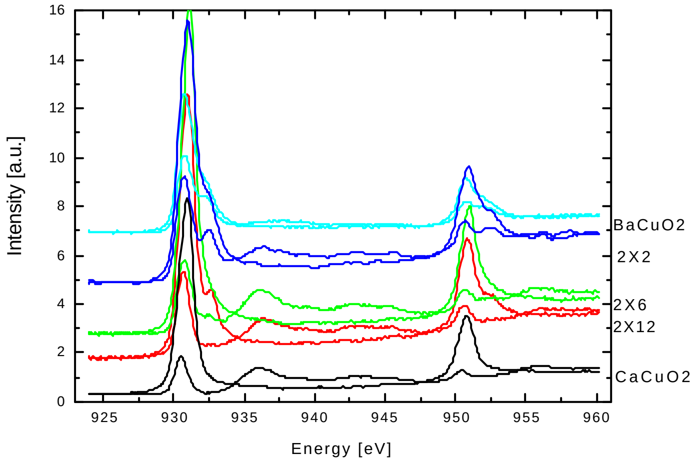
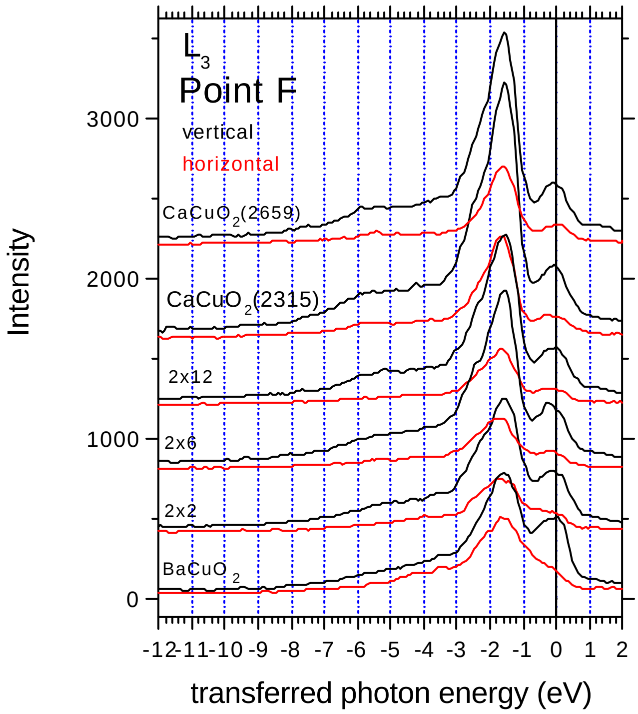


Fig.1



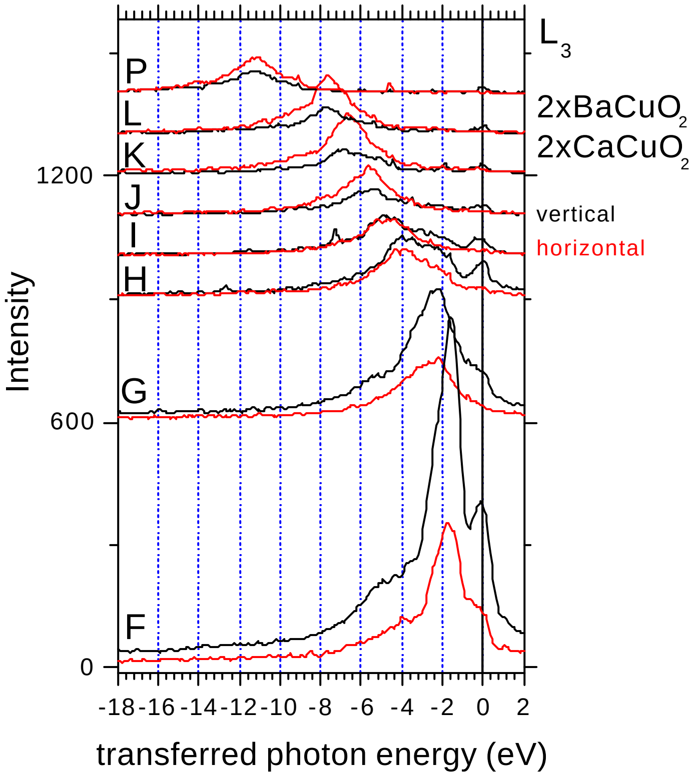


Fig. 2

Fig. 3