High-Pressure XANES study of rhenium in (Hg,Re)-1223

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INTRODUCTION

X-ray Absorption Near Edge (XANES) measurements on the L_{III} rhenium edge under different external pressure were performed using a DAC pressure cell. The rhenium present in $Hg_{0.8}Re_{0.2}Ba_2Ca_2Cu_3O_{8+\delta}$ superconductor is located in the charge reservoir layer and is connected with CuO_2 superconductor sheet by the apical oxygen. This rhenium was used as local probe to investigate the changes on the split of E_g and T_{2g} energy level induced by pressure on the crystalline field. The rhenium present in $Hg_{0.8}Re_{0.2}Ba_2Ca_2Cu_3O_{8+\delta}$ superconductor is located in the charge reservoir layer and is connected with CuO_2 superconductor sheet by the apical oxygen. The pressure induces change in the energy split, which is associated with the intrinsic term (dT_c^i/dP) described in the pressure induced charge transfer model. Considering the condensed energy and the T_c for the case of hight-T_c superconductors [**?**], we propose an explicit expression to the intrinsic term, which is associated with the crystalline field changes.

EXPERIMENT

As a high-T_c superconductor probe, it was investigated the effect of hydrostatic pressure under $Hg_{0.82}Re_{0.18}Ba_2Ca_2Cu_3O_{8+\delta}$, labeled here as (Hg,Re)-1223. First of all, to describe the effect of hydrostatic pressure, it was assumed that the volume compressibility of (Hg,Re)-1223 is the same one determined for $Hg_1Ba_2Ca_2Cu_3O_{8+\delta}$ compound (labeled as Hg-1223), which is close to 1%/GPa [2]. For (Hg,Re)-1223, when the hydrostatic pressure is closer to 0.9GPa, the crystal unitary cell volume is reduced down to -0.8%. The variation of hydrostatic pressure up to 1.2 GPa on (Hg,Re)-1223, with different δ causes different T_c changes [1].

The energy dispersive X-ray absorption spectroscopy beamline (D06B DXAS) of LNLS is installed after a dipole source and the optics combines a vertical focusing mirror and a Bragg dispersive geometry which altogether focus the polychromatic beam to a spot of dimensions $0.3x10^{-3}$m x $0.3x10^{-3}$m. The whole bandwidth is focused in the horizontal plane down to $150x10^{-6}$m. The vertical focusing is provided by a 60nm thick Rh coat mirror working at a grazing angle of 3.8 mrad, which focused the beam on the bending 111 silicon crystal. The polychromator uses $1.8x10^{-3}$m thick Si(111) rectangular crystal, mounted in a mechanical set up, which bends the crystal to a curvature radius varying from 3 to 10 meters causing a displacement of approximately $2.3x10^{-3}$m at the actuator position. In a 9.75:1 focusing ratio and Si(111) working at 10.500keV the curvature radius R is 9.158 m, Lo/R is 21.22 mrad, and the bend angle 0.113 mrad [4].

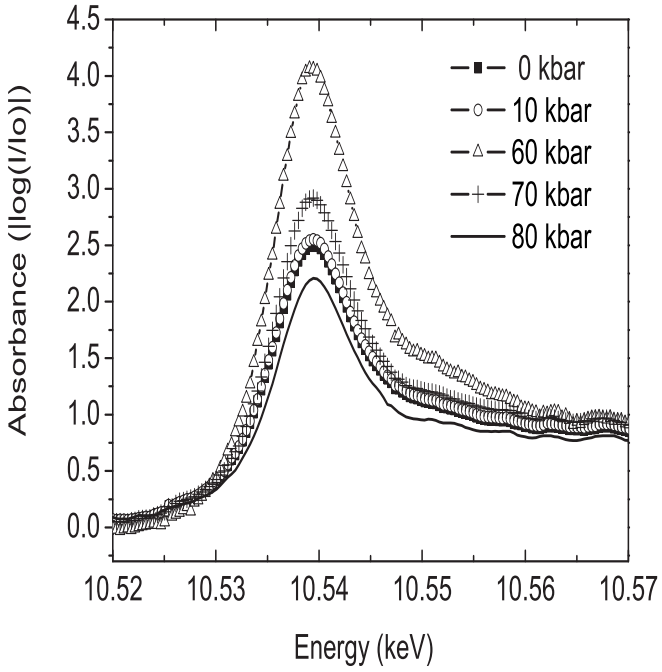

Figure 1 - XANES measuremens as external pressure function. Is was used a DAC pressure cell

RESULTS AND DISCUSSION

The XANES and X-ray diffraction analysis of the (Hg,Re)-1223, with optimally oxygen content has indicated a tendency of *O-Cu-O* bond angle being closest 180^o [3]. The effect of increase the external pressure is to change this *O-Cu-O* bond angle to 180^o. In our point of view, α coefficient is related with the convolution of CuO_2 local symmetry and crystal symmetry. As consequence, α value is reduced as comparing with the initial value (ambient pressure), when the pressure is increase.

CONCLUSION

The Casimir energy was related with the superconducting condensation energy [5–8], taken into account the density of states in the case of a Fermi gas in two dimensions. As consequence, the transition temperature T_c was predicted as function of $m^{3/4}$, $n^{1/4}$, and $d^{-5/4}$. Within this scenario, the α coefficient in $m = 2 * \alpha * m_e$ was interpreted as the effective carrier mass factor from the dispersion relation, taken into account the convolution between local symmetry of CuO_2 (Ex. Octahedral, pyramidal or plane) and the crystal symmetry. The values found by T_c expression is in agreement with the experimental T_c values found in the principal superconductors described in the literature and (Hg,Re)-1223 measured in our laboratory. The T_c's behavior under external hydrostatic pressure (described by PICTM) shows an intrinsic term, which is identified here with the variation of Casimir energy. This intrinsic term's pressure dependence presents an explicit expression proportional to the compressibility coefficient of c axis and the effective mass of carrier charge. For the best of our knowledge, the $\partial T_c^i/\partial P$ has not presented an explicit expression before. Our propose describe the dependence of intrinsic term with pressure in agreement with the values found in the literature.

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