1st General Conference of the Balkan Physical Union
26-28 September 1991, Thessaloniki

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EPR, XRD AND MAGNETIC MEASUREMENTS OF THE CERAMICS $YbBa_2Cu_3O_{7-\delta}$ IN THE ORTHORHOMBIC AND TETRAGONAL PHASE

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Abstract. The Yb-Ba-Cu-O compound in the tetragonal (with large oxygen deficiency) and orthorhombic (without oxygen deficiency, with T(c) = 90 K) phase have been investigated. The EPR spectrum of Cu(2+) ions in the orthorhombic local symmetry have been observed at room temperature (RT) and a liquid nitrogen temperature (LN -77 K). For the orthorhombic sample at LN a very broad non-resonant obsorption line has been recorded. For the sample in tetragonal phase the EPR spectrum of trivalent ytterbium ions has been detected.

1. Introduction

Systematic EPR studies of the 123 superconductors with different rare earth ions have shown that the orthorhombic phase, which is the superconducting one, always exhibits an EPR signal due to divalent copper ions [1-3]. In the tetragonal phase this signal usually is not observed due probably to the large oxygen deficiency [4-6]. Yet, the oxygen content of these materials affects not only the valence state of copper ions but also the valency of rare earth ions. For some of the $ReBa_2Cu_3O_{7-\delta}$ compounds (Re = Pr, Nd and Gd) we have recorded the EPR spectrum of the trivalent rare earth ions [5-8].

The purpose of the present paper is to study in detail, using X-band electron paramagnetic resonance (EPR), the $YbBa_2Cu_3O_{7-\delta}$ material both in the orthorhombic and tetragonal phase.

2. Experimental results

The samples were prepared by the standard solid state reaction technique described elsewhere [6,7]. Powdered samples were used for characterization by XRD. The indexing was done on an orthorhombic unit cell for the oxygen annealed sample with lattice constants: a = 3.8040(3) Å, b = 3.8703(3) Å, c = 11.6566(9) Å and on a tetragonal unit cell for the oxygen reduced sample with: a = b = 3.8486(3) Å, c = 11.8077(9) Å. The magnetic measurements were performed on densily packed powder samples with a vibrating sample magnetometer operating between 4.2 to 100 K at 0.02 T. The obtaned Meissner signal, for orthorhombic sample, corresponds to an almost perfect diamagnetism and the transition temperature (T_c) is 90 K. From the FC (the field cooled mode) line and from the ratio L = (−4πM/H), the obtained percentage of the superconducting phase is about 23% (the magnetization correction has not been taken into account). Over 50 K, the sample in tetragonal phase has shown a characteristic paramagnetic behaviour. The number of Bohr magnetons (μ_B) determined from the temperature dependence of the reciprocal magnetic suceptibility is approximately 3.85 μ_B per formula unit. For the trivalent ytterbium ions must be 4.54 μ_B per formula unit. One of the cause, of the above difference may come from copper ions or crystal field interaction [9].

EPR spectra, at RT and LN, were obtained using a conventional type Varian E-4 spectrometer operating at X-band frequency (ν = 9.28 GHz) and a static magnetic field varying between 0.025 to 0.6 T. The measurements were performed on powder (30 mg) samples of cylindrical shape. The obtained spectra from a sample in

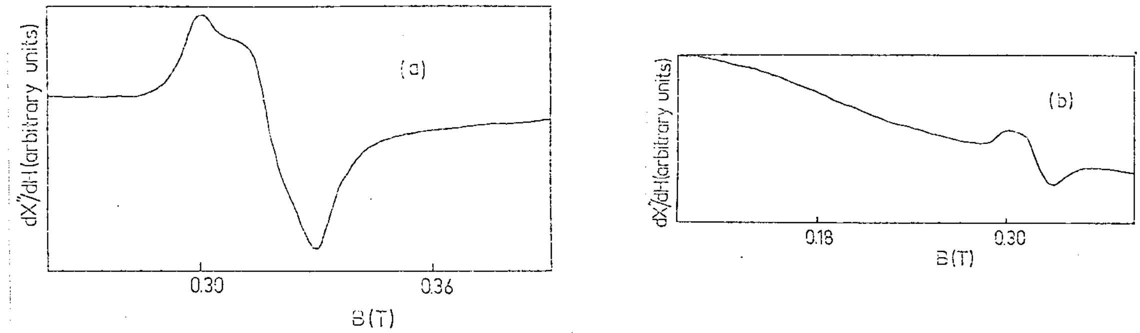

Fig.1 The EPR spectra of $YbBa_2Cu_3O_{7-\delta}$ compound in orthorhombic phase at RT (a) and LN (b).

orthorhombic phase at RT and at LN are shown in Fig.1a and Fig.1b respectively. In both cases the characteristic EPR spectrum of divalent copper ions has been observed as in the case of the $YBa_2Cu_3O_{7-\delta}$ compound reported previously [1]. At At LN a very broad non-resonant zero field absorption signal has been recorded. For the sample in tetragonal phase the EPR spectrum is composed of two lines, that arising from the divalent copper ions and another very broad one centered at g = 3.43(5) with linewidth ΔH = 0.16(2) T at RT (Fig.2a) and g = 3.01(5) with ΔH = 0.21(2) T at LN (fig.2b).

The ground state of Yb^{3+} in cubic sites is a $\Gamma(7)$ doublet. The wave function discribing the $\Gamma(7)$ doublet for J = 7/2 is 3/2 $\pm$5/2> − 1/2 $\mp$3/2> which yields an isotropic g-value of 24/7 = 3.429. Values of g as 3.443(2) and 3.426(1) have been previously reported [10,11]. This line was observable up to ~100 K [12], indicating a comparatively long spin-lattice relaxation time.

The observed EPR line in the sample with tetragonal phase could be attributed to the trivalent ytterbium ions. This signal has not been recorded in the orthorhombic phase either

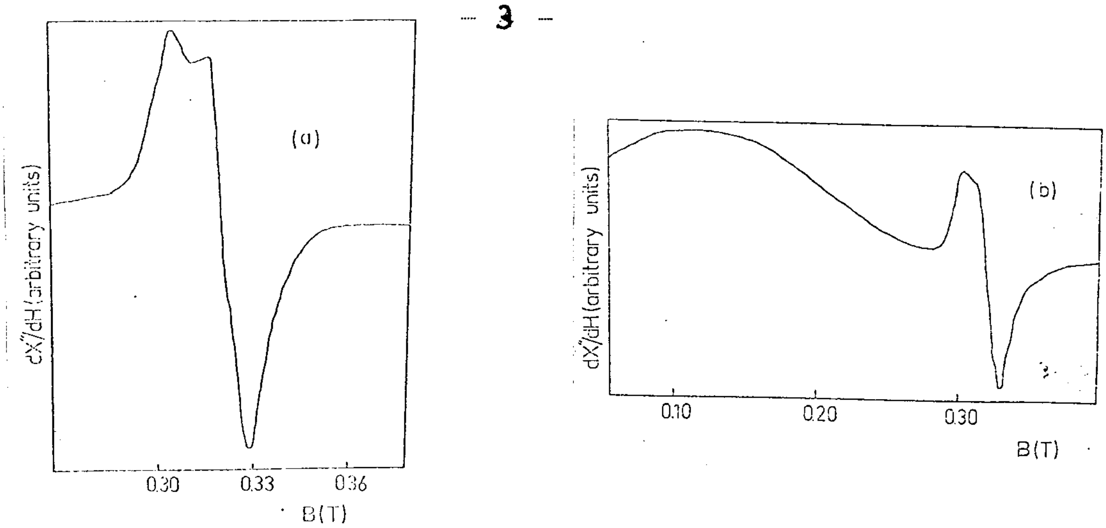

Fig.2 The EPR spectra of $YbBa_2Cu_3O_{7-6}$ compound in the tetragonal phase at RT (a) and LN (b).

because the ytterbium ions' valence has been changed or because the spin lattice relaxation time was much shorter than in tetragonal phase.

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