Physical properties of Nd_1.85Ce_0.15CuO_4-y at high pressure and with different oxygen contents

Autor(en): **Bucher, B. / Rusiecki, S. / Wachter, P.**

Objekttyp: **Article**

Zeitschrift: **Helvetica Physica Acta**

Band (Jahr): **62 (1989)**

Heft 6-7

PDF erstellt am: **20.09.2024**

Persistenter Link: https://doi.org/10.5169/seals-116144

Nutzungsbedingungen

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.
Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.
Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Ein Dienst der *ETH-Bibliothek*
ETH Zürich, Rämistrasse 101, 8092 Zürich, Schweiz, www.library.ethz.ch

http://www.e-periodica.ch

PHYSICAL PROPERTIES OF $Nd_{1.85}Ce_{0.15}CuO_{4-y}$ AT HIGH PRESSURE AND WITH DIFFERENT OXYGEN CONTENTS

B.BUCHER, S.RUSIECKI and P.WACHTER,
Laboratorium für Festkörperphysik,ETH–Hönggerberg, CH–8093 Zürich

We have measured initial susceptibility on $Nd_{1.85}Ce_{0.15}CuO_{4-y}$ with y varing from 0.02 to 0.32. T_c was quite insensitive to the different oxygen contents. The pressure dependence dT_c/dp for a compound with y = 0.03 was determined to be – 0.04 K/kbar.

Introduction

Since the discovery of electron–doped superconductivity in high–T_c cuprates [1], each model on high–T_c superconductivity has had to suffer a checking whether it is symmetric upon doping of either holes or electrons. A single – band model can be thought of to accomplish this symmetry. The theories based on holes with spin $S = {}^1/_2$ fail to explain superconductivity with spin–holes on the Cu^{1+} ions. However, from the beginning Wachter and Degiorgi [2] and de Jongh [3] have proposed a polaronic model in which they postulated a singlet state of the Cu^{3+} ion. The $S = 0$ state of Cu^{3+} had been an issue but now from the NdCeCuO–compounds it turns out anambigiously that it is a spin–hole responsible for superconductivity.

Experiment, Results

We have prepared the NdCeCuO compound by mixing appropriate amounts of CeO_2, Nd_2O_3 and CuO to achieve a composititon of $Nd_{1.85}Ce_{0.15}CuO_4$. The mixed oxides were calcined in air at 950° C for 10 hours, pressed into pellets and sintered in air at 1150° C for 12 hours. The samples were quenched in air to room temperature. The as prepared material was not superconducting. Then the samples were placed into a Perkin–Elmer thermo–analyzer and quantitative amounts of oxygen were removed by heating up to 1140° C in an atmosphere of pure argon gas for different times. When the sampels had reached the desired oxygen content they were quenched with a cooling rate of 10° C/min. Beginning from an oxygen deficiency of y = 0.02 per formula unit superconductivity was observed with T_c near 23 K. Up to y = 0.22 the samples were single phase with a T_c not changing appreciably. Typical curves of the ac–susceptibility are shown in Fig. 1. The sample with y = 0.32 was investigated by X–ray diffraction to have two phases. Probably one of them (nonsuperconducting) is responsible for the magnetic response at 8 K. The lattice parameters of a specific superconducting compound with y = 0.04 were a = 3.947(± 0.001)Å and c = 12.08(± 0.002)Å.

Further we have measured the pressure dependence of T_c up to 15 kbar as described in a previous paper [4]. There was only a weak pressure dependence of dT_c/dp = – 0.04 K/kbar (see inset of Fig.1).

Discussion

It is amazing that the variation of the oxygen content does not influence the transition temperatur. A too large loos of oxygen (y > 0.22) results in a transformation to a red–brown phase. We believe that the outgoing oxygen comes from the (Nd,Ce)O–planes between the superconducting CuO_2 sheets. As Ce can exist in two valence states the charge balance can be achieved by the transition $Ce^{4+} \rightarrow Ce^{3+}$. Thus, the CuO_2 plane is stable and even more two–dimensional than in other superconducting cuprates.

Let us look at the pressure dependence. Assuming a band model, pressure causes a broadening of the bandwidth. However, all cuprates have more or less the same superconducting CuO_2–planes and thus a similar band structure. Therefore, upon applying pressure, they should behave in a similar way. But the pressure dependence dT_c/dp of the superconducting cuprates differs within the large range of – 0.05 to 0.6 K/kbar which is not very consistent with the band–picture.

We suggest a model of exchange coupled bipolarons as described by Wachter and Degiorgi [2]. In this model the concentration of polarons (i.e. the concentration of Cu^{3+} resp. Cu^{1+}) is crucial. At high pressure the apical oxygen ion is shifted towards the CuO_2–plane and can serve as a doping reservoir. The more apical O–ions available the more effective will be an applied pressure to adjust the optimal concentration. From this point of view it seems reasonable that the $(La,Ba)_2CuO_4$ family with two apical O–atoms and the $YBa_2Cu_4O_8$ and $YBa_2Cu_{3.5}O_7$ [5] compounds with two chains resp. alternativly two and one chain as intercalation exhibit a strong pressure dependence. The $YBa_2Cu_3O_7$ composition with only one apical oxygen is to show a lower dT_c/dp as is really the fact. For the NdCeCuO–compound with no apical oxygen above Cu(2), it is not surprising that we even have detected a negativ dT_c/dp.

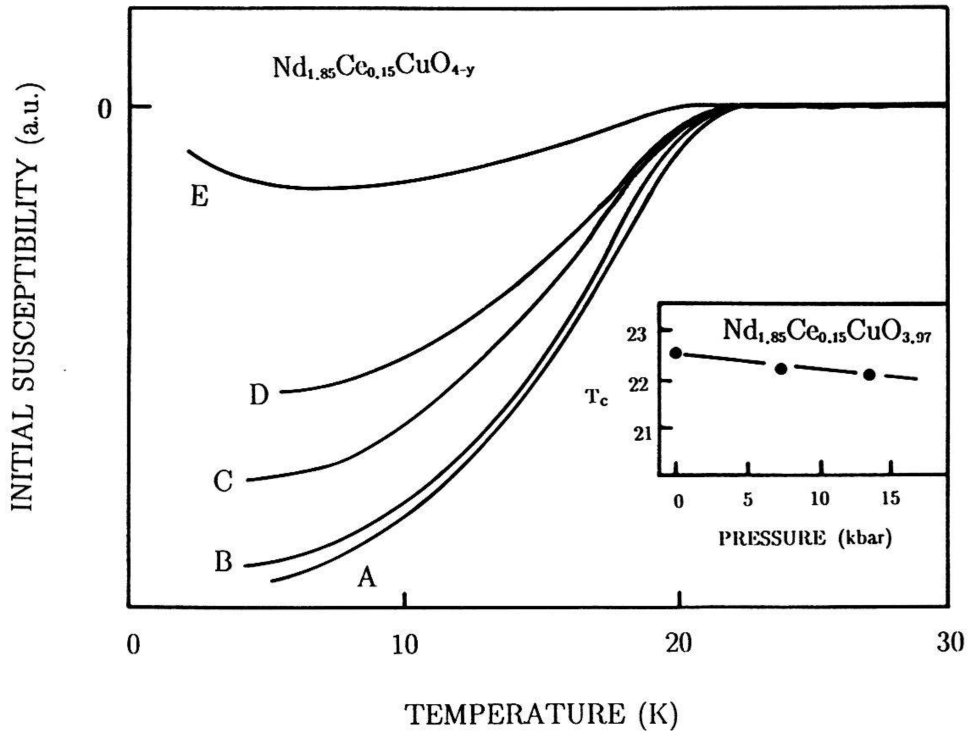

FIG.1 Initial susceptibility of $Nd_{1.85}Ce_{0.15}CuO_{4-y}$ with the different oxygen contents y : A: 0.03, B: 0.07, C: 0.02, D: 0.21, E: 0.32.
The inset shows the pressure dependence of T_c of $Nd_{1.85}Ce_{0.15}CuO_{3.97}$.

[1] Y.Tokura, H.Takagi and S.Uchida, Nature **337**, 3345 (1989)
[2] P.Wachter and L.Degiorgi, Solid State Commun. **66**, 211 (1988)
[3] L.T.de Jongh, Solid State Commun. **65**, 963 (1988)
[4] B.Bucher, J.Karpinski, E.Kaldis and P.Wachter, Physica C **157**, 478 (1989)
[5] The pressure dependence of $YBa_2Cu_{3.5}O_7$ was determined to be dT_c/dp = 0.45 K/kbar (to be published elsewhere)