Crystal growth and superconductivity of large single crystals $La_{1.875}Ba_{0.125}CuO_4$

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Abstract

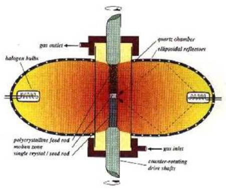
The origin of high temperature superconductivity in cuprate materials is one of the biggest puzzles in material science. Since the discovery of the significant anomalous suppression of superconductivity in high temperature superconducting oxide La2-xBaxCuO4 (x=1/8), the so-called 1/8 anomaly has been a subject of considerable research attention. The stripe order of holes and spins in the CuO plane has been discovered in La1.6-xNd0.4SrxCuO4 (x~1/8). Many attempts to grow the single crystals have been made, but no single crystal La2-xBaxCuO4 (x=1/8) has been successfully grown. In this work, the effects of the growth condition and the compositions of a feed rod on the crystal growth of La2-xBaxCuO4 has been studied by an infrared image floating zone method. The experimental result shows that a planar solid-liquid growing interface tends to break down into a cellular interface when the growth velocity is more than 1 mm/h. When the planar solid-liquid growing interface break down into a cellular interface, the single crystal size decreases abruptly and the as-grown rod is not single phase. The large single crystals of La2-xBaxCuO4 (x=1/8) has been successfully grown. The single crystals of La2-xBaxCuO4 (x=1/8) up to 8 mm diameter and 55 mm length have been cut from the as-grown bars. The neutron measurement show that the single crystals are high quality. The superconductivity transition temperature Tc of as-grown single crystals is 2.5 K. The static stripe order in the large single crystals has been studied by neutron scattering method.

Aim:

* To study the crystal growth mechanism of La-Ba-Cu-O system.
* To grow the large size single crystals of LBCO-214 for neutron study.
* To study a number of physical properties of the as-grown single crystals.

Equipment:

(a)



Advantages of an IR furnace:
* Uniform illumination and temperature profile.
* Non metallic materials can be grown.
* Floating Zone and Traveling Solvent Floating Zone methods can be used.
* No crucibles, and no contamination.
* Uniform well defined doping levels.

(b)

Fig. 1 Photograph (a) and Schematic (b) of our NEC SCI-MDH-20020-S image floating zone furnace system.

Result:

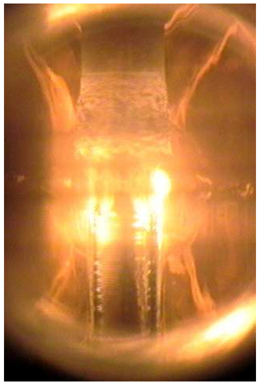


Fig. 2 one single crystal growth image of $La_{1.875}Ba_{0.125}CuO_4$

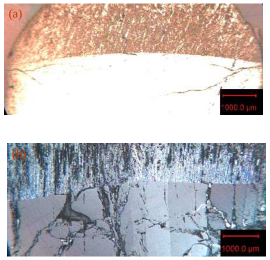
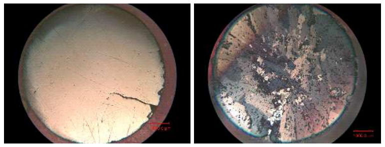


Fig. 3 The microstructure on the solid-liquid interface at the crystal growth front of as-grown rods $La_{1.875}Ba_{0.125}CuO_4$. (a) a planar growth interface at a velocity of 1 mm/h (single crystal growth rod), (b) a cellular growth interface at a velocity of 2 mm/h (multi-crystal growth rod).



(a) (b)

Fig. 4 The microstructure of the cross sections of as-grown rods of $La_{1.875}Ba_{0.125}CuO_4$ (a) a velocity of 1 mm/h (single crystal rod), (2) a velocity of 2 mm/h (multi-crystal rod).

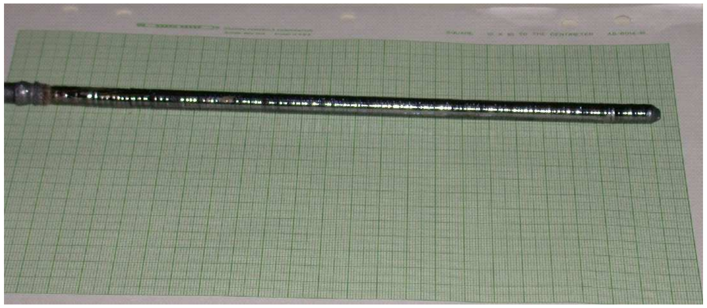


Fig. 5 one as-grown rods (La0.9375Ba0.0625)2CuO4+ä with a velocity of 1 mm/hr under 11 bars oxygen.

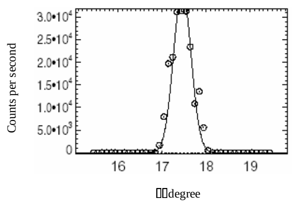


Fig. 6 Neutron scattering rocking curve of (002) of one single crystal $La_{1.875}Ba_{0.125}CuO_4$, a full-width at half-maximum is 0.47 degree.

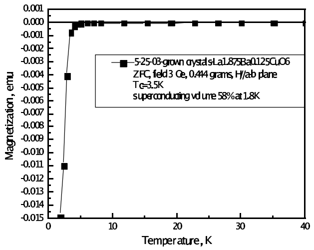


Fig. 7 SQUID measurement of single crystal of $La_{1.875}Ba_{0.125}CuO_4$.

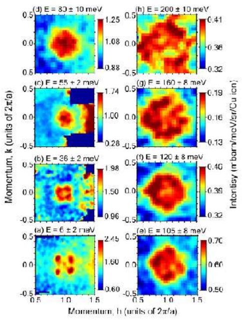


Figure 8 Experimental results: constant-energy slices through the magnetic scattering of La1.875Ba0.125CuO4 measured at 12 K (> Tc). Intensity is plotted in false color within a single antiferromagnetic zone [c.f. Fig. 1(m),(n)]. Energy has been integrated over the ranges indicated by the error bars, and Q dependence has been convolved with a Gaussian to reduce scatter. Panels (a)-(c) measured with an incident neutron energy Ei – 80 meV, (d) and (e) with Ei – 240 meV, and (f) with Ei = 500 meV. J. M. Tranquada et al, **NATURE**, 429(2004)534.

Achievement:

- Understood the crystal growth mechanism of LaBaCuO-214.
- Grown the large single crystals with a size of 10 cm³ of LBCO-214 which is available for various experimental measurements.
- A number of physical measurements on the single crystals are carrying by a number of research groups around world.

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