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# Channeling at 3.05 MeV: Oxygen Stoichiometry of a Cubic Metastable Phase and Oxygen Diffusion Induced Disordering in YBCO Films

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It has been recognized that methods for accurately determining oxygen stoichoimetry are essential in gaining an understanding of superconducting mechanism. Helium ions at 3.05 MeV offer a significantly enhanced sensitivity for detecting and profiling oxygen concentration in superconductor films [1]. The high $Z$ elements in the matrix (e.g. Y,Ba and Cu) strongly influence the sensitivity of the oxygen detection. In this study, we report an improvement in sensitivity over the traditional RBS technique for oxygen detection. For the YBCO films grown on MgO substrates, the backscattering energy of Mg signal can be shifted to low energy direction and oxygen resonance peak is separated from the Mg background by choosing a range of film thickness of YBCO film or tilting the sample with a large tilt angle. Without the influence of the background yield, the accuracy of oxygen detection can be greatly enhanced. Oxygen stoichoimetry in a YBCO film (600 nm) with a cubic metastable phase has been measured by oxygen resonance. A composition Y:Ba:Cu:O=1.2:1.9:3.1:7.0 was determined using this technique (see Fig.1). This cubic phase is an excellent candidate for use in heteroepitaxial structures with the family of rare earth-alkaline earth- cuprate superconductors [2].

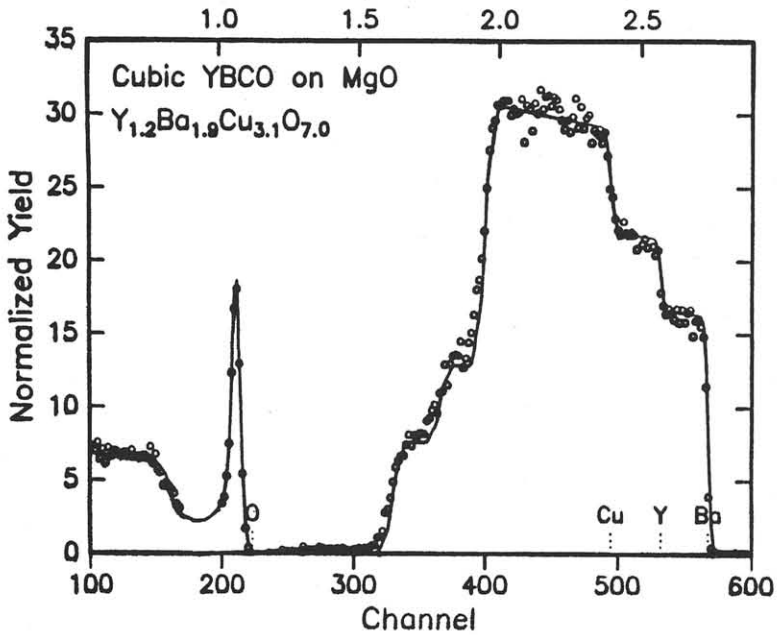


Figure 1. RBS spectrum with modified RUMP (solid line) showing the oxygen stoichoimetry in a cubic YBCO film.

Channeling at oxygen resonance energy can provide more information on the oxygen disordering in high $T_c$ superconductors. The value of $\chi_{min}$ based on the enhanced oxygen peaks at 3.05 MeV can reflect the nature of the oxygen sublattices after subtracting the thermal vibration factor. Figure 2 shows the random and [001]-aligned backscattering spectra from the YBCO film on (100) MgO at 3.055 MeV. It is known that oxygen diffusion in high $T_c$ films during processing can induce the variation of the superconducting properties. In this study, we investigate the correlation between the epi- quality and superconducting properties after

oxygen out- and in- diffusion in YBCO films formed by laser ablation on (100) MgO substrates [3].

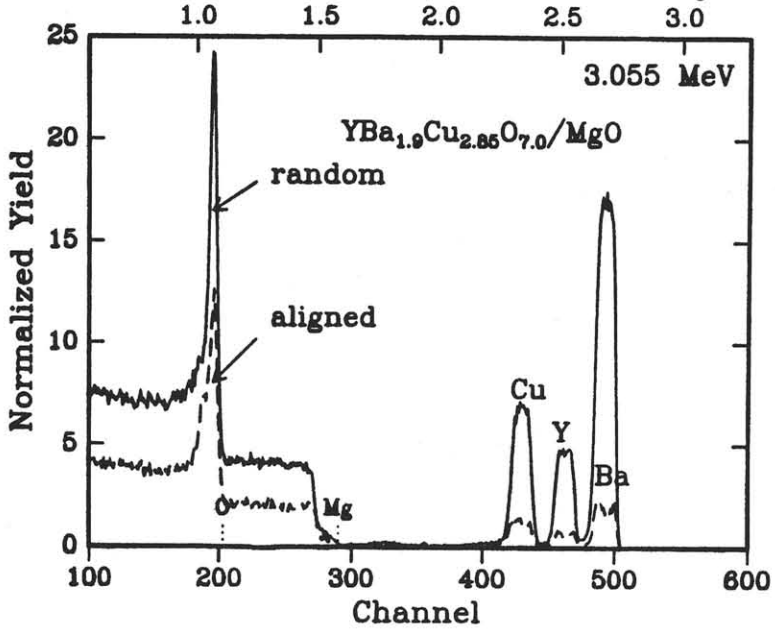


Figure 2. RBS spectra showing the random and aligned oxygen resonance peaks at 3.055 MeV.

YBCO films (300 nm) on MgO substrates were annealed in Ar and oxygen ambient at 450°C by rapid thermal annealing (RTA) for 20 seconds, inducing oxygen out- and in- diffusion, respectively. Channeling at 3.055 MeV has been performed at low current beam for short time acquirement to avoid beam heating and irradiation damage. The compositions near surface, values of $\chi_{min}$ based on Ba and oxygen peaks, and electrical properties (sheet resistance and $T_c$ (R=0)) are summarized in Table I.

| ... | compositions | $X_{min}$(Ba) | $X_{min}$(O) | R ($\Omega$) | $T_o$(K) |
|---|---|---|---|---|---|
| as-pre. | $YBa_{1.9}Cu_{2.85}O_{7.0}$ | 27% | 69% | 4.3 | 86 |
| 450°C, Ar | $YBa_{1.9}Cu_{2.85}O_{6.3}$ | 28% | 74% | 15 | 76 |
| 450°C, $O_2$ | $YBa_{1.9}Cu_{2.85}O_{6.7}$ | 29.5% | 86% | 12.5 | 87 |

It is found that RTA annealing in Ar can lead to the oxygen deficiency near the surface of YBCO films. After oxygen up-taking in oxygen ambient, oxygen concentration increases, but does not resume to that in the as-prepared sample. Compared to the values of $\chi_{min}$ (Ba), which remain constant, the values of $\chi_{min}$ based on the oxygen peaks increase after oxygen out- and in- diffusion. Correspondingly, the values of sheet resistance keep increasing. However, no significant change of $T_c$ (R=0) was found. During reduction and oxidation cycle at short time, the epi-quality of oxygen sublattices degradation near surface of YBCO films. It means that oxygen atoms can not completely resume their aligned positions after this cycle. Since RTA annealing at 20 seconds can only induce the oxygen atom migration near surface, the high $T_c$ properties (e.g.$T_c$) still remain in the bulk films.

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2. J. A. Agostinelli, S. Chen, and G. Braunstein, to be published in Phy.Rev. B, (1991).
3. B.H. Moeckly, S. E. Russek, D.K.Lathrop, R.A.Buhrman, Jian Li and J.W.Mayer, Appl. Phys. Lett. 57, 1687 (1990).