Title

MODULATED STRUCTURE OF SUPERCONDUCTING BI[SUB]2 CASR[SUB]E CU[SUB]2 O[SUB]8+DELTA

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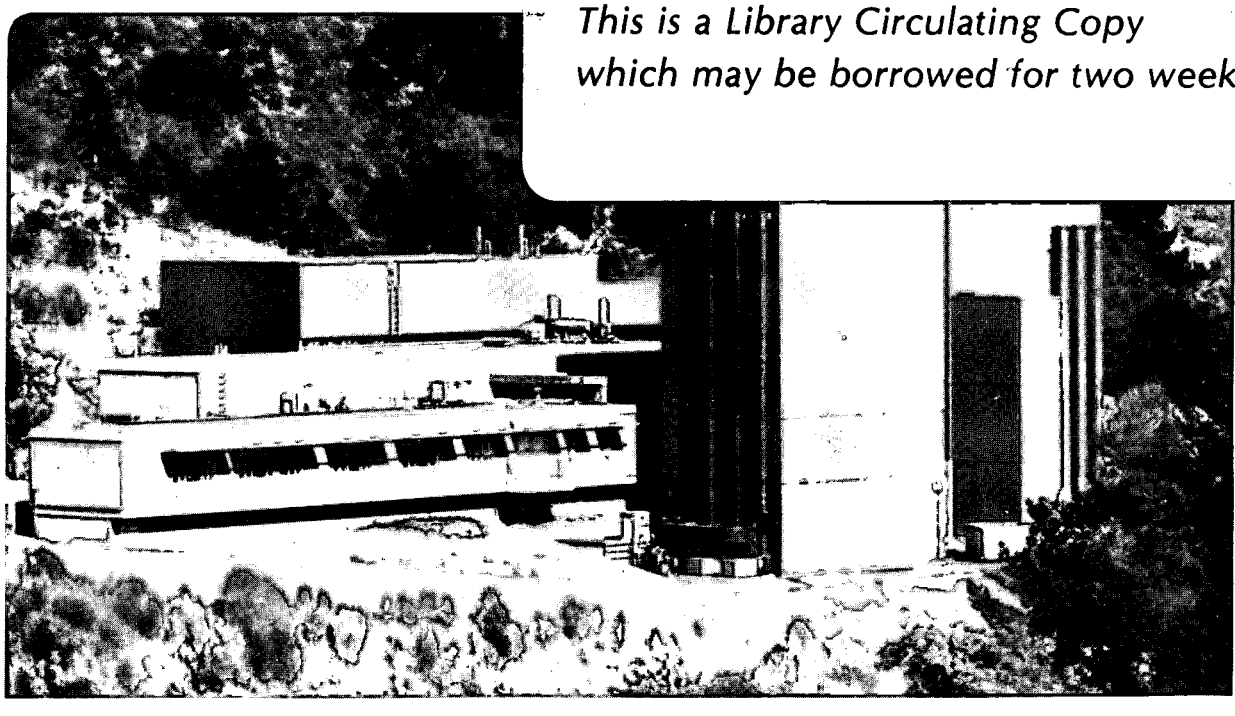

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DISCLAIMER

MODULATED STRUCTURE OF SUPERCONDUCTING $Bi_2CaSr_2Cu_2O_{8+\delta}$

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In the continuing search for new oxide superconductors, attention has recently been drawn to the Bi-Sr-Cu-O system by Michel *et al*[1] who achieved a resistance drop onset at 22K for an ultrapure compound with composition $Bi_2Sr_2Cu_2O_{7+\delta}$. Independent pursuits by the groups in Japan[2] and Houston[3] led to their simultaneous announcements of a new material with consistently high transition temperatures in the 100K range. This new compound is believed to have nominal composition $Bi_2CaSr_2Cu_2O_{8+\delta}$ and orthorhombic unit cell dimensions of **a** = 5.44Å, **b** = 27.2Å, and **c** = 30.78Å. Subsequent electron microscopy investigations of the material identified both an incommensurate structure,[4] and a two phase mixture[5], related structurally to the original $Bi_2CaSr_2Cu_2O_{8+\delta}$ phase. This investigation seeks further understanding of the microstructure of the new compound by a transmission electron microscopy study of single crystals (T_c = 85K) grown at the University of Houston.

Specimens were prepared by crushing to a fine powder in an agate mortar, dispersing the powder in 200 proof ethanol, and suspending the particles on a holey carbon grid. Because of a strong tendency for the crystal to cleave along (001) planes, most of the particles exhibited a preferred [001] orientation. Electron microscopy for this portion of the study was conducted on a Philips EM 301 operated at 100 kV.

Figure 1 is a multibeam bright field image of a crystallite in [001] orientation showing a pronounced fringe contrast along four well-defined directions (appearing in regions labeled A-D). Reference to the electron diffraction pattern (Figure 3) reveals that the fringe contrast lies parallel to the principal {100} and {110} crystallographic planes of the structure, and the fringe spacing corresponds to the spacing of the satellite reflections along the pertinent reciprocal lattice directions. This contrast is concluded to arise from a modulation of the structure with a repeat distance of roughly 30Å. The dark field image in Figure 2 confirms that the periodic modulation along the [100] direction extends over more of the crystallite than the multibeam image suggests. Nevertheless, the spatial extent of the domains of one-dimensional modulation always appears to be less than 2000Å across.

The origin of the modulation is linked to an incommensuration in the structure associated with the required lateral displacement across the double BiO layers[5]. Although the discommensurations have not been imaged in the present case, their origin is suggested in the structural model of Figure 4. Here the offset of the orthorhombic subcell across the double BiO layer is shown to have three possible directions that satisfy the local bonding requirements. Any one of the directions are candidate discommensuration directions in the $Bi_2CaSr_2Cu_2O_{8+\delta}$ crystal. The present results suggest that all three directions are simultaneously modulated in a mosaic domain configuration.[6]

References

1 C. Michel, M. Hervieu, M.M. Borel, A. Grandin, F. Deslandes, J. Provost and B. Raveau, *Z. Phys.* B 68, 412 (1987).

2 A.H. Maeda, Y. Tanaka, N. Fukutomi, and T. Asano, (submitted for publication).

3 C.W. Chu, J. Bechtold, L. Gao, P.H. Hor, Z.J. Huang, R.-L. Meng, Y.Y. Sun, Y.Q. Wang, and Y.Y. Xue, Phys. Rev. Lett., (in press).

4 T.M. Shaw, S.A. Shivashankar, S.J. La Placa, J.J. Cuomo, T.R. McGuire, R.A. Roy, K.H. Kelleher and D.S. Yee, (submitted for publication).

5 H.W. Zandbergen, Y.K. Huang, M.J.V. Menken, J.N. Kadowski, A.A. Menovsky, G. van Tendeloo, and S. Amelinckx (submitted to *Nature*).

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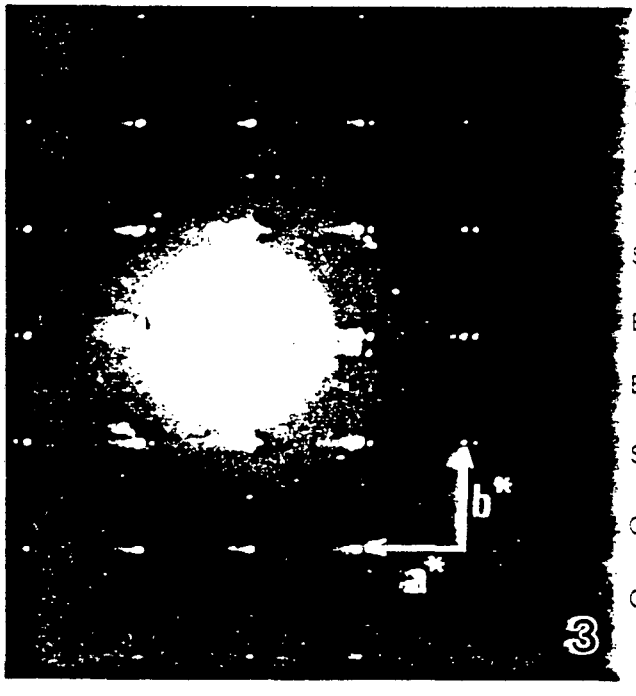

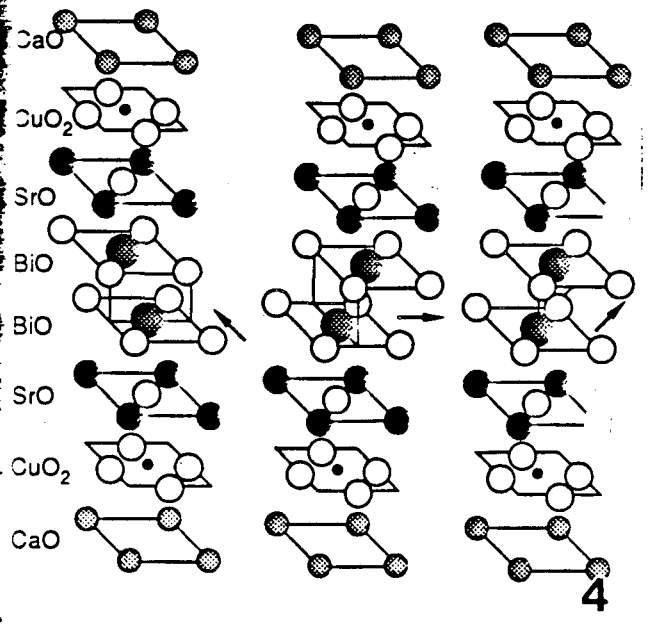

FIG. 1--Multibeam bright field image of small crystallite of $Bi_2CaSr_2Cu_2O_{8+\delta}$ showing four orientations (A,B,C, and D) of modulated substructure.

FIG. 2--Dark field image of same particle using a 100 reflection with scattering direction indicated by arrow. The modulation fringes are perpindicular to **g**, and are confined to domains of a single orientation.

FIG. 3--Diffraction pattern showing satellite reflections from the modulated structure.

FIG. 4--Structural models of the "2122" phase depicting three possible directions of relative displacement across the BiO layers: [100], [010], and [110], which are candidate directions for the required discommensurations in the modulated structure.

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