STUDIES OF SUPERCONDUCTIVITY OF Y-Ba-Ca-Cu-O AND Y-Ce-Ba-Cu-O SYSTEMS

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ABSTRACT

Systems of Y Ba_{2-x} Ca_x Cu_3 O_{9-y} (where x = 0 to 2) and Y_{1-x} Ce_x Ba_2 Cu_3 O_{9-y} (where x = 0 to 0.75) were studied. The effect of changing composition as well as the constituents on superconducting transition temperature is reported.

Compounds of Y-Ba-Cu-O system attracted the attention as they show superconductivity in liquid nitrogen temperature range[1-5]. Under this programme we have studied several compounds of Y-Ba-Cu-O and also Sr, Ca, Ce, Sn and Pb substituted compounds. In this communication, we report results of systematic studies of substitution of Ca in the place of Ba and also Ce in place of Y. All the samples were prepared by direct oxide mixing technique described elsewhere[5]. Different samples of Y Ba_{2-x} Ca_x Cu_3 O_{9-y} with x = 0 to 2 were studied and their resistance behaviour with temperature is depicted in figure 1. The starting composition Y Ba_2 Cu_3 O_{9-y} shows an onset T_c of 91 K with zero resistance at 83 K. As may be seen the calcium-substituted samples show the coexistence of two superconducting phases with onset at 100 K and 80 K. The 100 K phase becomes more prominent as

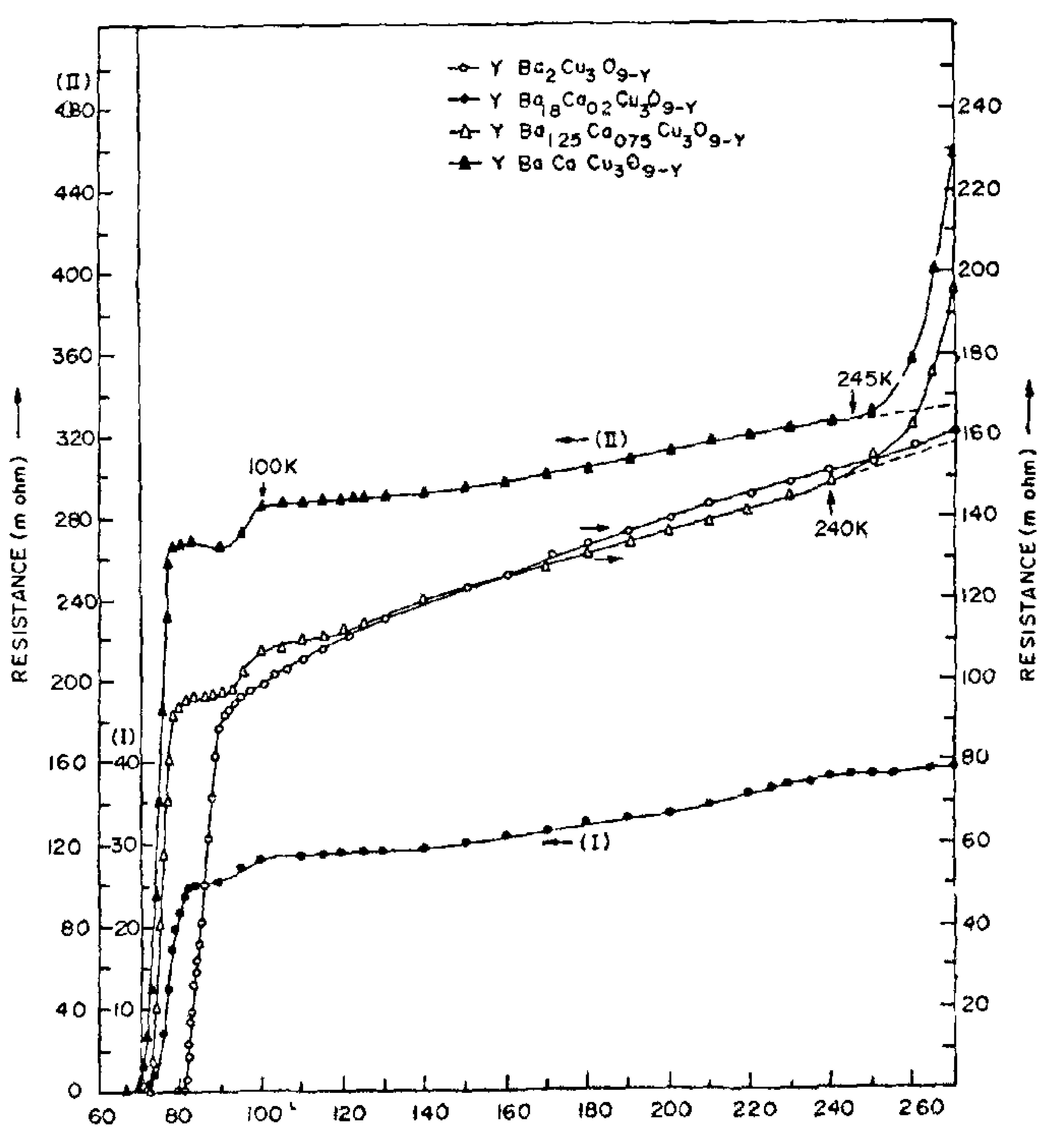

Figure 1. Resistance variation with temperature for different samples of Y-Ba-Ca-Cu-O of varying composition.

* For correspondence.

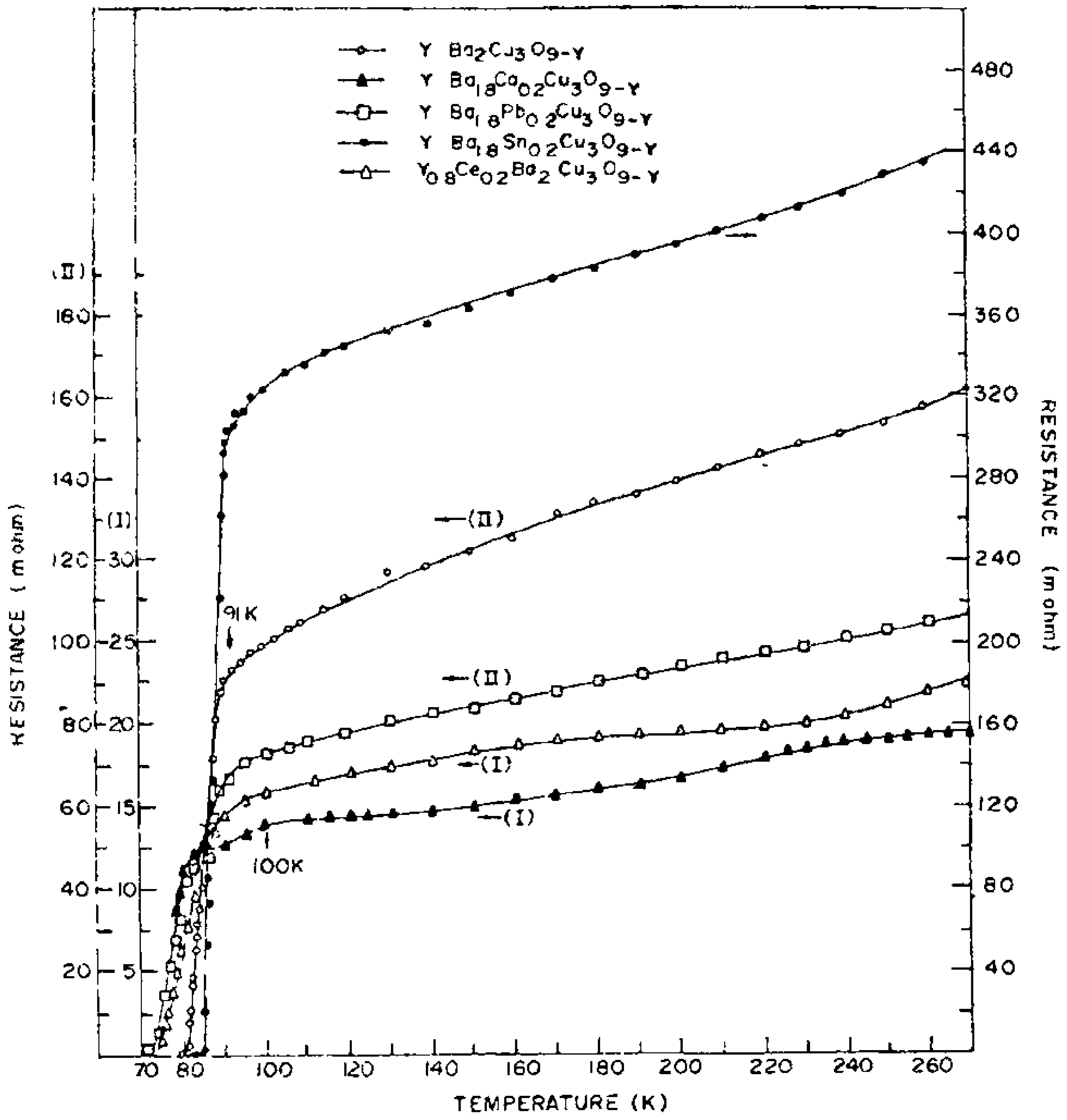

Figure 2. Resistance variation with temperature for different samples of Y-Ce-Ba-Cu-O of varying composition.

Ca concentration is increased up to $x = 1$. However, the compounds between Y $Ba_{0.5}$ $Ca_{1.5}$ Cu_3 O_{9-y} and Y Ca_2 Cu_3 O_{9-y} compositions showed insulating behaviour. A significant observation of the above study is the sharp resistance drop above 240 K in the samples with $x = 0.75$ and 1, indicating the possibility of high temperature superconducting phase above 240 K. Interestingly, a similar resistance drop has also been observed above 230 K in Y_2 Ba Sr Cu_3 O_{8-y} compounds earlier[5]

It is worth mentioning that in the compound Y $Ba_{1.8}$ $Pb_{0.2}$ Cu_3 O_{9-y} two transitions were observed at 95 K and at 85 K. Samples with $x = 0.75$ and 1, the substitution of Pb resulted in the insulating phase.

A systematic study of Y_{1-x} Ce_x Ba_2 Cu_3 O_{9-y} with $x = 0$ to 0.75 has also been made and their resistance behaviour as a function of temperature is shown in figure 2. The observations show that with increasing Ce concentration up to $x = 0.5$, T_c is depressed from 95 K to 80 K. The compound $Y_{0.25}$ $Ce_{0.75}$ Ba_2 Cu_3 O_{9-y} shows a semiconducting-like behaviour from 280 K below which a rapid resistance drop is observed. The zero resistance is not seen down to 63 K.

To sum up the above study a definite enhancement of onset T_c to 100 K occurs by substitution of Ca in place of Ba. This seems to corroborate a similar observation of onset T_c of 100 K observed in Sr-substituted samples studied earlier[5]. The samples with $x = 0.75$ and 1 of Ca show a rapid resistance drop above 240 K indicating the possible presence of high temperature superconductivity coexisting with 100 K and 80 K phases. The presence of superconductivity at such high temperatures has been substantiated in Y Ba_2 Cu_3 O_{9-y} samples through inverse Josephson effect studies[6].

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NEWS

MAJOR PROGRAMME OF RESEARCH INTO LOW-DIMENSIONAL STRUCTURES

The third research centre to join Britain's major programme of investigation into "low-dimensional structures" (LDS) has begun operating at the Cavendish Laboratory of Cambridge University.

Low-dimensional structures are formed by the precise deposition of flat, well-defined layers (typically only a few atoms thick) principally of crystalline semi-conductors, and by the formation of narrow channels using ion beam lithographic techniques. In such structures, which do not exist in nature, nearly all physical properties are changed from those of normal bulk solids. Entirely new phenomena appear when electrons in a solid are no longer free to move in three dimensions, and the research programme is therefore expected to lead to important developments in condensed matter physics and possibly a new generation of smaller, faster microchips.

Already the UK Science and Engineering Research Council (SERC) has committed some £9 million to the LDS programme, and a further £15.3 million is likely to be spent over the next four years.

The main elements in the scientific programme are "growth centres", which will provide the precise, complex semiconductor samples needed. Six have so far been approved. At the beginning of the LDS project in 1985, three major grants were approved for growth centres at Oxford, Nottingham and Cambridge Universities. The metallo-organic chemical vapour deposition equipment at Oxford began operating in February 1986, and the molecular beam epitaxy (MBE) equipment at Nottingham in April.

The centre at Cambridge is also based on MBE equipment manufactured in Britain. Its funding is partly supported by British Telecom Research Laboratories and the GEC Hurst Research Centre under the SERC's Co-operative Research Grants Scheme. Three further centres will be at Hull and Warwick Universities, and Imperial College, London, all employing molecular beam epitaxy.

Samples to be produced at the Cavendish Laboratory will consist primarily of layers of gallium arsenide and gallium aluminium a few atoms thick.

A special feature of the Cambridge work is the use of ultra-fine lithography to produce one-dimensional parts in the structures, such as arrays of lines within the layers. There are many interesting possibilities in designing such structues, some of which should exhibit novel electronic and optical properties. The lithography will eventually take place within the ultra-high vacuum of the MBE machine, which was designed and built with this in mind.

The UK electronics industry attaches great importance to LDS research in universities, and to date companies have provided well over £2 million in direct support. The variety of possible low-dimensional structures far exceeds that of conventional bulk solids. (Science Series, A Supplement to '*Spectrum* – British Science News' No. 204, 1986 British Information Services, British High Commission, New Delhi 110 021).