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High-temperature superconductivity in bismuth-copper oxides of the type $Bi_mM_nCu_pO_x$ (M = Mg, Ca, Sr, Ba, Bi)†

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Abstract. Several oxides of the $Bi_mM_nCu_pO_x$ family ($m = 2, 3$; $n = 2, 3, 4$; $p = 1, 2, 3$ and M = alkaline earth or Bi), possessing structures similar to the Aurivillius family of oxides, show high T_c superconductivity.

Keywords. High-temperature superconductivity; $Bi_mM_nCu_pO_x$ (M = Mg, Ca, Sr, Ba, Bi).

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Superconductivity above liquid nitrogen temperature in the 123 oxides ($T_c \sim 90 \pm 5$ K) of the general formula $LnBa_2Cu_3O_7$ (Ln = Y or rare earth) has been the subject of much investigation in the last few months (Nelson *et al* 1987; Rao 1988a, b). In the last few weeks, an oxide system containing bismuth, alkaline earth metals (or Al) and copper has become the subject of intense activity, since there are indications that T_c s around 100 K or higher may be possible with these oxides (see High T_c update, Vol. 2, February 15, 1988). An oxide of the composition $Bi_2Sr_2Cu_2O_7$ was shown by Michel *et al* (1987) to become superconducting around 22 K. Maeda *et al* (1988) report onset of superconductivity around 105 K in $BiCaSrCu_2O_x$. Onset temperatures up to 120 K have been reported by Chu *et al* (1988) in Bi-Ca-Sr-Cu-O and Bi-Al-Ca-Sr-Cu-O systems. All these superconducting Bi-Cu oxides seem to be multiphasic and proper characterization of the phase responsible for high T_c behaviour is yet to be accomplished. In this laboratory, we have investigated a variety of bismuth oxides containing copper of the general formula, $Bi_mM_nCu_pO_x$ ($m = 2, 3$; $n = 2, 3, 4$; $p = 1, 2, 3$) where M = Mg, Ca, Sr, Ba, Bi or combinations of these elements, for superconductivity. These oxides bear resemblance to the $(Bi_2O_2)^{2+}$ $(A_{n-1}B_nO_{3n+1})^{2-}$ family of oxides described long ago by Aurivillius (1950), and investigated extensively by high resolution electron microscopy and other techniques in recent years (Hutchison *et al* 1977; Gopalakrishnan *et al* 1984; Rao 1985). In this communication, we report preliminary results of our studies on the structure and superconductivity of the $Bi_mM_nCu_pO_x$ oxides. Depending on the method of preparation, many of the oxides

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