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Interdependence between Pb content and annealing conditions in the preparation of BPSCCO superconducting films grown by spray pyrolysis technique

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Abstract – Bi-Pb-Sr-Ca-Cu-O (BPSCCO) thin films were grown on MgO substrates by spray pyrolysis technique from a solution containing $Bi(NO_3)_3$, $Pb(NO_3)_2$, $Sr(NO_3)_2$, $Ca(NO_3)_2$ and $Cu(NO_3)_2$, followed by a solid state reaction for growing the Bi-based superconducting phases. Annealed films were characterized by X-Ray Diffraction, Atomic Absorption Spectroscopy and resistance measurements. Interdependence between Pb content, annealing time and temperature, in the formation of superconducting phases was studied applying a fractional factorial design 3_{III}^{4-2}. Interrelation among Pb content, t_a and T_a exists. The presence of Pb is necessary to stabilize the high-T_c phase but its content depends on the annealing conditions.

The discovery of high-T_c superconductors has attracted much attention for their technological applications as bulk material as well as thin films, as for example, electronic devices, conductor tapes, and superconducting quantum interference devices. For the preparation of thin films, several physical and chemical techniques have been used: pulsed laser deposition, r. f. sputtering, magnetron sputtering, atomically layered epitaxy, chemical vapor deposition and spray pyrolysis [1]. Most of them are high vacuum deposition techniques that produce superconductor thin films by sequential layer-by-layer deposition of the constituent elements. The precursor films obtained by means of this sequential deposition needs oxidation of the deposited layer with complete evaporation of the volatile gases present. The spray pyrolysis technique does not need subsequent oxidation because the complete thermal decomposition and oxidation of the deposited layers can be controlled. On the other hand, Bi-based films are already used in low current as well as power applications. Among the high-T_c ceramic superconductors, the Bi-based system has been extensively studied because of its high critical temperature. However, it has not been reported the interdependence between Pb content, annealing temperature and annealing time on growing the high-T_c superconducting Bi-phases. Studies of Pb-substituted $Bi_2Sr_2Ca_2Cu_3O_{8+\delta}$ single crystals indicate a reduction in T_c values of the overdoped samples. When growing the Bi-based films, many technological parameters are involved in such process that influences the final properties of the synthesized films. In our previous studies we observed a loss of Pb during the annealing treatment [2]. This Pb-loss leads to the transformation of the high-T_c (2212 and 2223) phases to the low-T_c (2201) phase or others no superconductor phases. In the present work, we report on the deposition of Bi-Pb-Sr-Ca-Cu-O films using the spray pyrolysis technique and the interdependence between Pb content, annealing temperature, annealing time and covering material. The last one to prevent Pb-loss by exposition of the precursor annealed in an air ambient into which Pb evaporates. The results indicated that an interrelation among Pb content, t_a and T_a exists. Therefore, the electrical behavior and the X-ray diffraction patterns of the films 6 and 7 verify the interdependence between Pb content, annealing time and annealing temperature. This means that the presence of Pb is necessary to stabilize the high-T_c Bi-phases but its content depends on the annealing conditions.

Table 1: Growth conditions, where t_a = annealing time, T_a = annealing temperature x = nominal lead content, 1 = superconducting pellet, 2= precursor film, 3=MgO substrate.

Sample No	Material used to cover the precursor film	t_a [h]	T_a [°C]	x [mole]
1	1	1	840	0.7
2	1	15	850	1.4
3	1	29	860	2.1
4	2	1	850	2.1
5	2	15	860	0.7
6	2	29	840	1.4
7	3	1	860	1.4
8	3	15	840	2.1
9	3	29	850	0.7

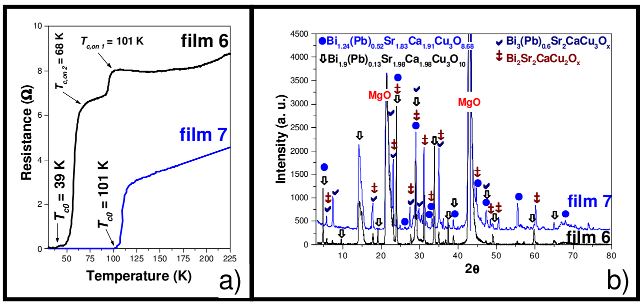

Figure 1: a) Electrical behavior of the films 6 and 7. **b)** X-Ray diffraction patterns from $Bi_{1.4}Pb_{1.4}Sr_2Ca_2Cu_3O_\delta$/MgO films prepared following the experimental conditions of samples 6 and 7.

References

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[2] E. Díaz. C. Mejía, J. L. López and M. Jergel, J. Mater Sci: Mater Electron 18 (2007) 1167.