

Piezoelectric $\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{-PbTiO}_3$ films processed by the diol sol-gel route

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Piezoelectric rhombohedral $\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{-PbTiO}_3$ (PMN-PT) thin films are of interest for microelectromechanical systems due to their high piezoelectric coefficient and electric field induced strain along the $\langle 001 \rangle$ direction. Among the thin film deposition techniques, sol-gel is widely used for the preparation of ferroelectric films. Major problems of the sol-gel routes are toxicity and sensitivity to moisture of the chemicals used in the process. To minimize these problems, we have developed a PMN-PT sol synthesis method based on the diol route¹ and that, previously, has been successfully applied to the synthesis of solutions containing Ta(V)². Nb(V), like Ta(V), are elements of the group Vb, and thus, they have very similar chemical properties. Based on this, an air-stable and precipitate-free sol of PMN was synthesised using 1,3-propanediol, $\text{HO}(\text{CH}_2)\text{OH}$, as solvent and niobium ethoxide, $\text{Nb}(\text{OC}_2\text{H}_5)_5$, magnesium ethoxide, $\text{Mg}(\text{OC}_2\text{H}_5)_2$, and titanium di-isopropoxide bis-acetylacetonate, $\text{Ti}(\text{OC}_3\text{H}_7)_2(\text{CH}_3\text{COCHCOCH}_3)_2$, as reagents. A PT sol was also synthesised by the diol route, as reported elsewhere¹. PMN and PT sols were mixed in a molar ratio of 0.7/0.3 of PMN/PT and refluxed in air. The resulting 0.7PMN-0.3PT sol was diluted with ethanol, $\text{C}_2\text{H}_5\text{OH}$, and deposited by spin-coating onto silicon substrates electroded with platinum. Crystallisation of the films was carried out by Rapid Thermal Processing (RTP), at temperatures between 500°C and 800°C. At low temperatures, coexistence of a second pyrochlore phase and perovskite is detected by X-ray diffraction (XRD). Electrical characterisation was accomplished by impedance spectroscopy as a function of temperature and frequency, and by ferroelectric hysteresis loops.

1. N.J.Phillips, M.L.Calzada and S.J.Milne. *J.Non-Cryst.Solids*, **1992**, 147&148, 285.
2. M.L.Calzada, R.Jiménez, A.González and J.Mendiola. *Chem.Mater.*, **2001**, 13, 3.

This work has been funded by Spanish project CM 07/0084/2002. M.Algueró acknowledge the support of the Ramón&Cajal Spanish MCyT program.