LEAD CONTAINING PEROVSKITE FILMS AND SUPERLATTICES GROWN BY MOCVD IN SELF-TUNING MODE

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Complex oxides with the perovskite structure demonstrate an impressive range of electrical and magnetic properties: superconductivity, colossal magnetoresistance, ferroelectricity, metallic conductivity, and others. The growth of the lead-containing oxide films is usually performed at temperatures of about 500-700°C to prevent the loss of highly volatile lead oxide from the film. High volatility of PbO is evidently the reason why there are not so much examples of the successful film growth of lead-containing complex oxides. On the other hand, volatility of lead oxide provides a very important advantage: under certain conditions the film adopts exactly as much lead, as it needs for the stoichiometrical formula, while the excessive lead oxide evaporates.

The self-tuning approach was already used by us for the MOCVD growth of high-quality epitaxial films of $La_{1-x}Pb_xMnO_3$ and $PbTiO_3$ on the perovskite substrates [1]. These experiments can be considered as a preliminary stage for the deposition of heterostructures possessing tunnel magnetoresistance. In the present work we have prepared the heterostructures containing magnetoresistive $La_{1-x}Pb_xMnO_3$ (LPMO) and insulating $Pb_{1-x}Sr_xTiO_3$ (PSTO) perovskite layers. It should be noted that it is the first example of successful PSTO deposition by MOCVD. The choice of $Pb_{1-x}Sr_xTiO_3$ as insulating material is owing to its transition to the cubic form at $x \geq 0.4$ which is advantageous in respect of tetragonal at room temperature $PbTiO_3$. Tetragonal splitting of XRD reflections decrease down to zero with the increase of Sr content in films (Fig. 1).

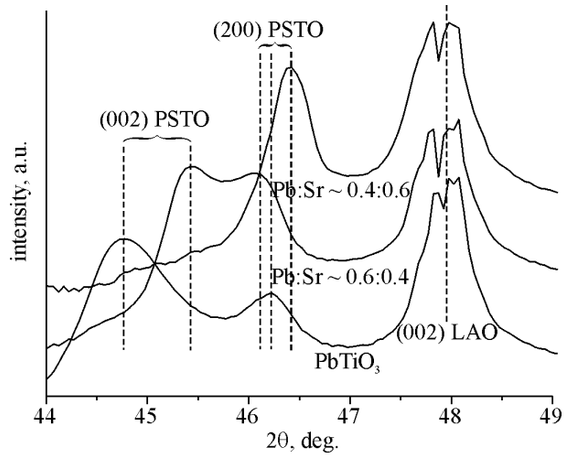

Fig. 1. XRD θ/2θ patterns for PSTO films with different composition

As long as both types of layers can be grown under the same conditions, it allows us to grow them in the continuous deposition; the alternate feeding is assured by the band flash evaporation [2] (Fig. 2). The secondary phases and extended defects are effectively suppressed in the conditions of self-tuning MOCVD [1].

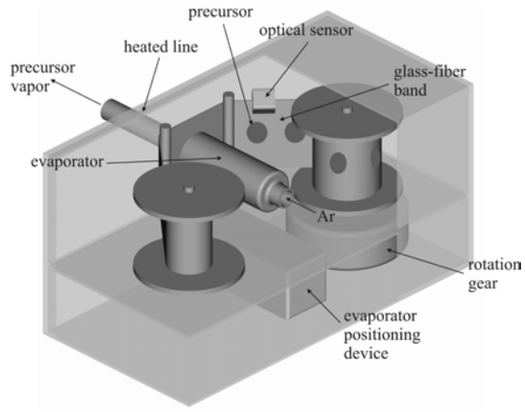

Fig. 2. The sketch of band-flash feeder

Optimizing PbO partial pressure allowed us to deposit various $[(La_{1-x}Pb_xMnO_3)_l/(Pb_{1-x}Sr_xTiO_3)_m]_k$ ($k = 6$, $l = 10\text{-}12$, $m = 5\text{-}8$) multilayers giving superstructural reflections in XRD patterns:

$$\frac{2\sin\theta_n}{\lambda} = \frac{1}{d} + \frac{n}{\Delta}.$$

Superlattice period Δ found from the satellites positions was of the order of 80 Å.

The HREM observations also demonstrated high degree of coherency of obtained structures (Fig. 3) and confirmed the superlattice period estimations performed using XRD.

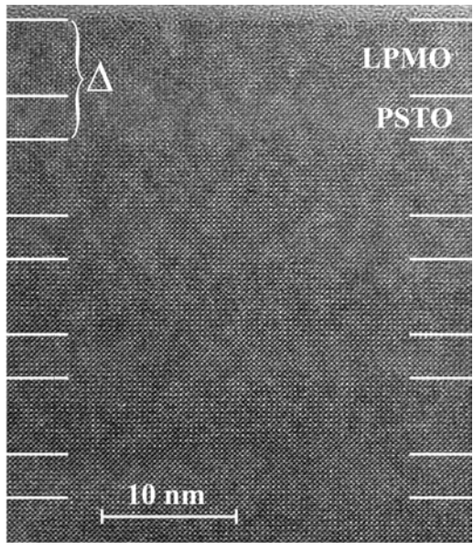

Fig. 3. HREM image of the upper part of LPMO/PSTO superlattice deposited on $SrTiO_3$: [100] zone

Nevertheless, the problem of layers interdiffusion is evidenced and this mixing is found to be strongly dependent on PbO partial pressure. The superlattice reflections were suppressed at high PbO pressure. At the same time, ferromagnetic resonance study showed the considerable increase of Curie temperature to 370 K which can be explained only by the strontium transfer into the A-sublattice of manganite layer. Strong contribution of the surface anisotropy to the magnetic properties is also demonstrated by the ferromagnetic resonance technique.

[1] A. A. Bosak, S. V. Samoilenkov, O. Yu. Gorbenko, I. E. Graboy, A. N. Botev, A. R. Kaul, H. W. Zandbergen, Chem. Mater. 13 (2001) 981

[2] A.R. Kaul, B.V. Seleznev, J. de Physique IV 3 (1993) C375

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