Highly (100)-Oriented Metallic $LaNiO_3$ Grown by RF Magnetron Sputtering

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In recent years, metallic oxides have been investigated as promising alternatives to Pt-based electrodes for ferroelectric thin films. Oxide electrodes lead to an improved performance against fatigue [1], and in case they exhibit a perovskite structure, they may serve at the same time as seed layer for perovskite ferroelectrics. Among them, pseudo-cubic perovskite lanthanum nickel oxide $LaNiO_3$ (LNO) with a lattice parameter of 3.84 Å is a very good candidate. It exhibits a good metallic conductivity in a wide temperature range, and its composition is relatively simple to control [2]. The LNO film resistivity at room temperature is typically in the 0.3 to 2 mΩ cm range. It has been reported that properties of ferroelectric oxides are significantly improved with the use of lattice-matched LNO bottom electrodes [3], [4].

LNO films have been grown on many materials by various methods [1], [5]. RF sputtering has the advantage to produce low resistivity, dense films on large area substrates. Sputtering atmosphere and temperature are important parameters for the process. LNO films are almost amorphous when deposited below 150 °C. Above this temperature, the film grows in crystalline form, often with (100)-oriented or textured microstructure. A critical issue is Ni evaporation above 300 °C, leading to Nickel deficiency, and the formation of a parasitic phase of La_2NiO_4 [1], [2].

In this work, we prepared highly conductive (100)-textured LNO films on SiO_2/Si and Pt/Ti/SiO_2/Si substrates employing RF magnetron sputtering at a growth temperature of 300 °C. The 5×10-inch target consisted of stoichiometric $LaNiO_3$ ceramics with a purity of 99.9%. Sputtering was carried out at a power density of 4.6 W/cm^2 with a high purity gas composed of 100 sccm Ar and different levels of O_2. The latter compensates oxygen loss during the sputter process. The degree of (100)-texture was found to depend on the oxygen partial pressure. When the latter is low, or zero, the as-deposit film showed quite small Bragg peaks in X-ray diffraction, indicating weak crystallization. When the O_2 pressure becomes comparable to the Ar pressure, both (100) and (110) reflections were observed. Reduction of the O_2 pressure lead to a relative reduction of the (110) peak, thus to an increase of the (100)-texture index. LNO films deposited at 6.4 mTorr with Ar/O_2 flow ratio of 100/15 sccm showed the best (100) texture, and the lowest resistivity in the as-deposited state. Film stoichiometry was confirmed by compositional analysis using EDX spectroscopy. Characterization of a 240 nm thick LNO film revealed a smooth surface with a dense microstructure without cracks, and a good uniformity on the 100 mm wafer. After rapid thermal annealing at 600 °C for 1 minute in O_2, a resistivity of 0.41 mΩ cm was obtained, thus in the range of the best possible values, and showing that such a film serves well as a metallic contact.

LNO films were found to be quite similar when deposited on Pt(111)/TiO_x/SiO_2/Si. A thin film of $Pb(Zr_{0.52}Ti_{0.48})O_3$ (PZT) was subsequently grown by a sol-gel method on the LNO-coated substrates of both types. XRD patterns of the various samples proved that the crystallization of the so derived PZT films are significantly predetermined by the seeding function of the LNO films, in as much as the (110)/(100) texture ratio was passed from LNO to PZT by local epitaxy.

References:
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