Synthesis and characterization of highly oriented $ZrTiO_4$ thin films by metal-organic chemical vapour deposition

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The growing diffusion of personal computers and satellite communications systems and the pressing demand for the miniaturization of more performing integrated circuits turned out into the intensive research activity focused on the synthesis and on the study of new materials for the realization of next generation micro-devices [1].

Metalorganic Chemical Vapour Deposition (MOCVD) appears one of the leading techniques for the preparation of a large variety of electroceramic materials, possessing high purity and desirable properties. In particular, MOCVD is expected to have some distinct advantages over other deposition techniques, such as the capability of creating films of widely varying stoichiometry, film thickness control, good deposition uniformity, the possibility of treating large-area substrates and an acceptable compatibility with silicon technology [2].

Zirconium Titanate (ZT) based materials have been used in a wide range of applications and, in the latest years, they appeared very promising as dielectrics for the integration in MIM (metal-insulator-metal) and MIS (metal-insulator-semiconductor) structures, owing to their great thermal stability (TCC= -20 ¸ + 20 ppm °C-1), their high dielectric constant (εr ~38-40) and their high quality factor (Q= 28000 - 60000) in the microwave range [3,4]. However, the dielectric properties of these materials still depend on their structural and chemical characteristics and require the development of a suitable synthesis methodology [5-10].

In this work we report on the deposition behaviour of highly oriented ZrTiO4 thin films prepared on p-type (100) Si and platinum coated Si substrates by the metal-organic chemical vapour deposition process. The ZT films were characterized by scanning electron microscopy (SEM), X-ray diffraction (XRD), atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS). C-V and I-V measurements were performed in the 100Hz-1MHz frequency range by a Precision LCR meter and a Semiconductor parameter analyser.

The chemical composition and the film thickness were controlled by simply adjusting the carrier gas flow rates and the deposition temperatures. We have investigated the influence of substrate temperature and the reactor pressure on the growth kinetic, on the crystallographic structure and on the microstructural and chemical properties. The substrate temperature plays an important role on deposition rate, on the orientation of the crystallographic phases and on the formation of a columnar structure. The modulation of the reactor pressure influences the deposition rate, the surfaces roughness and is important to obtain thin films characterized by an high dense, crack- and void-free columnar structure.

1. S. J. Fiedziuzsko, I. C. Hunter, T. Itoh, Y. kobayashi, T. Nishikawa, S. N. Stitzer and K. Wakino, IEEE Trans. Microwave. Teory Tech., **50**, 706 (2002)

2. M. de Keijser, G.J.M. Dormans and P.K. Larsen, in Ferroelectric thin films: synthesis and basic properties, C. Paz de Araujo, J.F. Scott, G.W. Taylor, Editors, pg. 485, Gordon and Breach Publisher, The Netherlands (1996)

3. A.E. McHale and R.S. Roth, J. Amer. Ceram. Soc., **69**, 827 (1986)

4. P.C. Osbond, R. W. Whatmore and F.W. Ainger, Proc. Br. Ceram. Soc., **36**, 418, (1985)

5. P. Victor, S.S.N. Bharadwaja, J. Nagaraju and S.B. Krupanidhi, Solid State Communications, **120**, 379 (2001)

6. E.S. Ramakrishnan, K. D. Cornett, G. H. Shapiro and W.Y. Howung, J. Electrochem. Soc, **145**, 358 (1998)

7. T.P. Alexander, D.R. Ulhmann, G.Teowee, F.McCarthy, K.McCarthy and T.J. Bukowsky, Integrated Ferroelectrics, **17**, 221 (1997)

8. C. L. Huang and C. S. Hsu, J. Vac. Sci. Technol. A, **18**, 2327 (2000)

9. T. Kim, J. Oh, B. Park and K. S. Hong, Jpn. J. Appl. Phys., **39**, 4153 (2000)

10. O. Nakagawara, H. Tabata, Y. Toyota, M. Kobayashi, Y. Yoshino, Y. Katayama and T.Kawai, J. Appl. Phys., **80**, 338 (1996)