

SIMS analysis of a oxide thin film with continuous composition gradient

Joseph Scola¹, François Jomard¹, Jérôme Wolfman², Beatrice Negulescu², Marie-Amandine Pinault-Thaury¹

¹Université Paris-Saclay, UVSQ, CNRS, GEMaC, 78000 Versailles, France

²Laboratoire GREMAN, UMR 7347 CNRS, Université de Tours, Tours, France

Due to their high dielectric permittivity, low dielectric loss and obvious dielectric tunability, dielectric materials are promising for applications in microwave and multifunctional devices. $\text{Ba}_{1-x}\text{Sr}_x\text{TiO}_3$ is one of the most famous dielectrics since the Sr fraction can be varied, thus tailoring its dielectric properties. So far, attention has been paid to its fabrication with different Ba/Sr ratios. Among the methods developed for thin film growth, combinatorial pulsed laser deposition (PLD) provides a unique chance to prepare continuous composition spread library on a single substrate at the same time [1, 2]. Then, the comparison of the properties of the various compounds solely depends on the local chemical composition of the sample, contrary to a batch of samples influenced from run-to-run fabrication parameters modulation that cannot be ruled out.

In this work, we report SIMS analysis performed on our CAMECA IMS7f to investigate the matrix effects in a thin film (~250 nm) of $\text{Ba}_{1-x}\text{Sr}_x\text{TiO}_3$ grown by combinatorial PLD on a $\text{LaNiSrO}_4/\text{SrTiO}_3$ stack (see fig 1) [3, 4]. Even if the Ti content is constant into $\text{Ba}_{1-x}\text{Sr}_x\text{TiO}_3$, its signal exhibits an increasing trend with the variation of Ba and Sr. Such phenomenon can be explained by the variation of the neighbouring atoms electronegativity induced by the Ba-to-Sr substitution.

In addition to the continuously varying composition along the width, the oxide multilayer sample features sharp interfaces. Therefore, we also took a look on the in-depth resolution under our analysing conditions. We performed atomic force microscopy in the bottom of the craters to measure its roughness and electron dispersive spectroscopy to evaluate the interdiffusion length between layers. Using the mixing-roughness-information depth model [5], we estimate the contribution of the atomic mixing to the broadening of the interface crossing profiles as low as 5 nm. Such value paves the way to SIMS analyses of thin oxides.

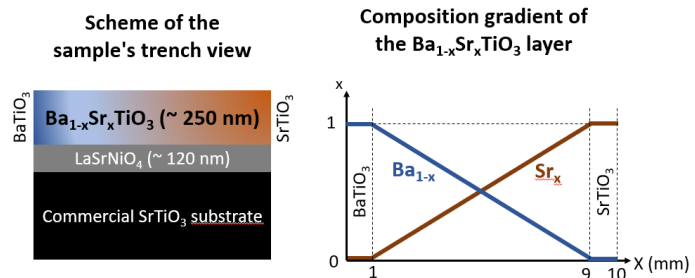


Figure 1. Scheme of the studied sample and composition gradient of the continuous variation of Ba and Sr compositions along the width.

References

- [1] X.D. Xiang et al. Science 268 (1995) 1738.
- [2] X.Y. Sun et al. ACS Comb. Sci. 16 (2014) 640–646.
- [3] J. Qiu et al., Ceramics International 42, 6408–6412 (2016)
- [4] S. Sandeep, et al., Nanomaterials 11, 3131 (2021)
- [5] S. Hoffmann, Surf. Interface Anal. 27, 825–834 (1999)