doi: 10.1017/S1431927609095063
Microsc Microanal 15(Suppl 2), 2009

Microstructural Characterization of $Ba_{0.6}Sr_{0.4}TiO_3$ – MgO Composite Thin Films

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$Ba_{0.6}Sr_{0.4}TiO_3$ (BST-0.4) is one of the most interesting ferroelectric materials. It has a very large dielectric permittivity that makes it very attractive for electrically tunable microwave devices. These devices need large capacitance change ratio (tunability= $(C_{max} - C_{min})/C_{max}$) [1] accompanied with a small dielectric loss. However, the dielectric permittivity tends to be lower and the dielectric loss tends to be higher in the BST films compared to bulk BST, therefore limiting the potential benefits of BST-x thin films for device applications [2]. The misfit strain between the BST film and the substrate induces a drastic effect on the dielectric properties of BST thin-films [3, 4].

In this study, we were able to grow BST-MgO columns with a spontaneous phase assembly using Pulse Laser Deposition (PLD). A uniform mixture of Ba, Sr, Ti and Mg oxides has been used as the PLD target. The phases have been separated into BST and MgO columns spontaneously during the growth. This unique microstructure lowered the dielectric loss of the films significantly. We believe that the columnar structure modified strain in the BST films and therefore lowered the dielectric loss. To prove the columnar microstructure of the BST and MgO phases and their effect on the dielectric loss, detailed Transmission Electron Microscope (TEM) analyses have been carried out.

The microstructure of the PLD grown films have been examined using various analytical tools on the TEM. The samples have been prepared by using a FEI dual-beam Focused Ion Beam (FIB). Scanning TEM (STEM) with a High Angle Annular Dark Field (HAADF) detector has been used to image the columnar structure of the BST films (Fig 1). Energy Filtered TEM (EFTEM) and EDS Spectrum Imaging (EDS-SI) results revealed a very thin film of BST formation on top of the substrate right before the columnar structure, Fig 2. High Resolution TEM (HRTEM) and Selected Area Diffraction (SAD) have been used to investigate the epitaxy between the MgO and BST columns as well as the film and the substrate.

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Fig. 1. HAADF-STEM image of the BST-MgO thin film.

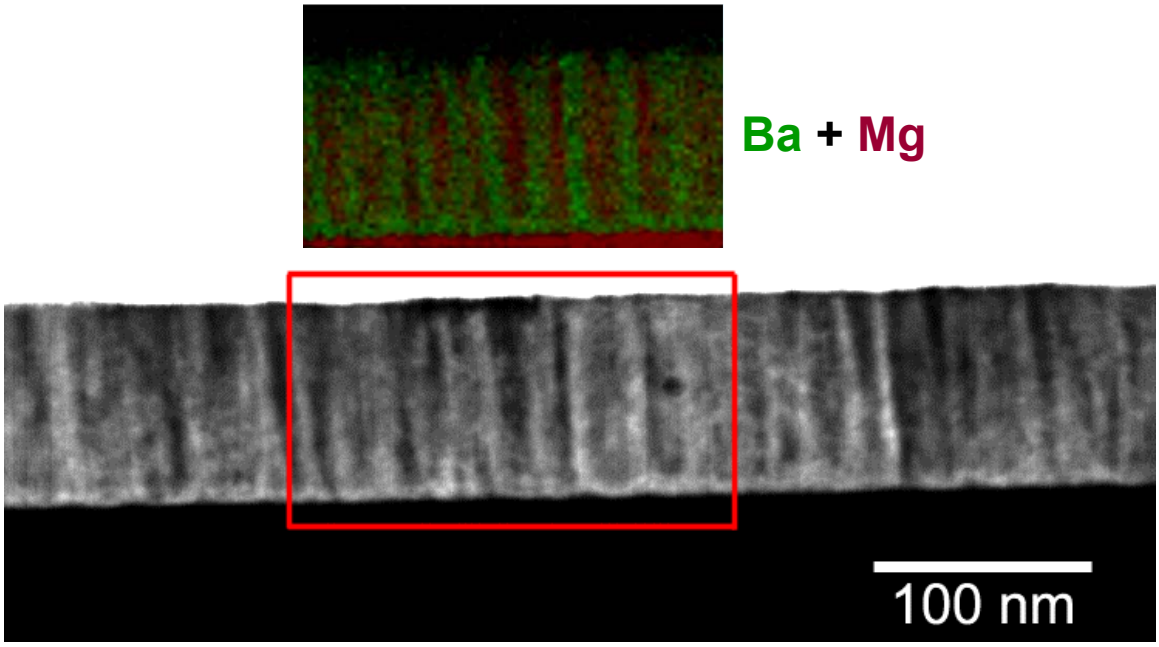

Fig. 2. EDS Spectrum-Image showing the composition of the columnar structure.

https://doi.org/10.1017/S1431927609095063 Published online by Cambridge University Press