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Reduction of azimuthal domains in (100)- and (118)-oriented ferroelectric $Bi_{3.25}La_{0.75}Ti_3O_{12}$ thin films grown onto off-cut single crystal substrates

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Reduction of azimuthal domains in (100)- and (118)-oriented ferroelectric $Bi_{3.25}La_{0.75}Ti_3O_{12}$ thin films grown onto off-cut single crystal substrates

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Lanthanum-substituted bismuth titanate, a bismuth-layered perovskite (Aurivillius phase), is one of the most favourable candidates for non-volatile ferroelectric random access memories, because it combines a high remanent polarization with a very good fatigue resistance, and it requires rather moderate processing temperatures [1]. Epitaxial films are required if high memory densities of the Gbit range are to be achieved. However, due to the considerable structural and electrical anisotropies of this material, only films of specific crystallographic orientations ("non-*c*-axis orientations") possess the required properties. For applications in silicon-based memory technology, (100)-oriented („*a*-axis oriented") $Bi_{3.25}La_{0.75}Ti_3O_{12}$ (BLT) films on electrode-covered Si(100) wafers are most favourable. Films of this type were obtained on $SrRuO_3$(110)-electroded, YSZ(100)-buffered Si(100) wafers, achieving a high remanent polarization of 32 $\mu C/cm^2$ and a low fatigue of less than 10 % after 10^9 switching cycles [2,3].

These BLT films – although uniformly having the (100) plane parallel to the substrate surface – consist, however, of eight azimuthal ± domains ($D_{BLT} = 8$) involving 20°-, 70°- and 90°-azimuthal domain boundaries. The reason are the (110)-oriented $SrRuO_3$ electrode layers growing on the YSZ(100) buffer layers with four azimuthal domains ($D_{SRO} = 4$) due to a specific epitaxy relation. A most similar effect occurs in (118)-oriented BLT films. Many of the azimuthal domain boundaries have a rather large thickness of the order of a few nm to 15 nm and an amorphous crystallography. They may thus have a negative influence on film properties like leakage current, breakthrough behavior and fatigue resistance. It is the aim of the present work to reduce the number D of azimuthal domains in the $SrRuO_3$ electrode layer and thus in the BLT film, by working on off-cut substrates. The surfaces of the latter have a broken symmetry, which should result in a reduction of the number of azimuthal domains in films growing on these substrates.

$SrRuO_3$ electrode layers and BLT films were grown by PLD onto YSZ(100) single crystal and YSZ(100)-buffered Si(100) single crystal substrates. The angle α of the substrate offcut was varied from zero to 5° in steps of 1...2°. Two different azimuthal directions of the offcut were used, *viz*. [100] and [110]. The grown $SrRuO_3$ electrode layers and BLT films were investigated by XRD pole figures and Φ scans. Using a [110] offcut, an effective reduction of the number of azimuthal domains by about 50% was achieved in the $SrRuO_3$(110) layers as well as in the (100)- and (118)-oriented BLT films, as shown by XRD Φ scans. [100] offcuts did either not result in a reduction of D, or they just lead to an asymmetrical distribution of the azimuthal domains. Investigations by (high-resolution) transmission electron microscopy and ferroelectric measurements are in progress. The effectiveness of the [110] offcut and the ineffectiveness of the [100] offcut will be explained by a geometrical model.

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