Critical Thickness of High Structural Quality $SrTiO_3$ Films Grown on Orthorhombic (101) $DyScO_3$

Author(s): Biegalski MD (Biegalski, M. D.)[1], Fong DD (Fong, D. D.)[2], Eastman JA (Eastman, J. A.)[2], Fuoss PH (Fuoss, P. H.)[2], Streiffer SK (Streiffer, S. K.)[3], Heeg T (Heeg, T.)[4,5], Schubert J (Schubert, J.)[4,5], Tian W (Tian, W.)[6], Nelson CT (Nelson, C. T.)[6], Pan XQ (Pan, X. Q.)[6], Hawley ME (Hawley, M. E.)[7], Bernhagen M (Bernhagen, M.)[8], Reiche P (Reiche, P.)[8], Uecker R (Uecker, R.)[8], Trolier-McKinstry S (Trolier-McKinstry, S.)[1], Schlom DG (Schlom, D. G.)[1]

Addresses:

1. Penn State Univ, Mat Res Inst, University Pk, PA 16802 USA
2. Argonne Natl Lab, Div Mat Sci, Argonne, IL 60439 USA
3. Argonne Natl Lab, Ctr Nanoscale Mat, Argonne, IL 60439 USA
4. Forschungszentrum Julich, Inst Bio & Nanosyst IT IBN1, D-52425 Julich, Germany
5. Forschungszentrum Julich, Ctr Nanoelect Syst Informat Technol Cni, D-52425 Julich, Germany
6. Univ Michigan, Dept Mat Sci & Engn, Ann Arbor, MI 48019 USA
7. Los Alamos Natl Lab, Mat Sci & Technol Div MST 8, Los Alamos, NM 87545 USA
8. Inst Crystal Growth, D-12489 Berlin, Adlershof Germany

Source: JOURNAL OF APPLIED PHYSICS Volume: 104 Issue: 11 Article Number: 114109 Published: DEC 1 2008

Abstract: Strained epitaxial $SrTiO_3$ films were grown on orthorhombic (101) $DyScO_3$ substrates by reactive molecular-beam epitaxy. The epitaxy of this substrate/film combination is cube on cube with a pseudocubic out-of-plane (001) orientation. The strain state and structural perfection of films with thicknesses ranging from 50 to 1000 were examined using x-ray scattering. The critical thickness at which misfit dislocations was introduced was between 350 and 500Å. These films have the narrowest rocking curves (full width at half maximum) ever reported for any heteroepitaxial oxide film (0.0018º). Only a modest amount of relaxation is seen in films exceeding the critical thicknesses even after postdeposition annealing at 700ºC in 1 atm of oxygen. The dependence of strain relaxation on crystallographic direction is attributed to the anisotropy of the substrate. These $SrTiO_3$ films show structural quality more typical of semiconductors such as GaAs and silicon than perovskite materials; their structural relaxation behavior also shows similarity to that of compound semiconductor films. (c) 2008 American Institute of Physics. [DOI: 10.1063/1.3037216]