TF4:
Mechanical Properties and Stress
Oral Presentations

TF4.1.O

REAL-TIME MEASUREMENT OF SrO EPILAYER STRAIN ON H-TERMINATED Si

H. Asaoka[a]*, Y. Machida[a], H. Yamamoto[a], K. Hojyou[a], K. Saiki[b], A. Koma[b]
[a]Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki 319-1195, Japan
[b]The University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan

SrO is a well-known buffer layer on Si for $SrTiO_3$ and $BaTiO_3$ which are highly desirable complex oxides for future generation transistor gate dielectric and ferroelectric memory applications. Furthermore, these complex oxides work as good substrates for various functional oxides including high-T_c superconductors. To fabricate integrated devices of semiconductors and such oxide materials, the epitaxial growth of SrO films on Si is very attractive. However, these properties depend strongly on the quality of thin oxide films in which large mechanical stress might be produced during their preparation.

To characterize the film stress as a function of Si surface conditions, we use real-time measurement of substrate curvature during Sr film growth both on bare Si (111) 7x7 and on H-terminated Si (111). The growth of epitaxial Sr films has been achieved at room temperature by MBE. At the beginning of Sr growth on bare Si (111) 7x7, strong compressive stress is generated, indicating an immediate expansion of the surface. The compressive stress in Sr film is a result of strong interfacial strain from lattice mismatch between the film and the substrate. In case of Sr growth on H-terminated Si, however, the maximum total stress in the film is one-third of the film stress on bare Si. Stress-free Sr layers are grown from a thickness of 3 atomic layers corresponding to 1 unite cell. The H-terminated Si whose surfaces have no active dangling bonds are like quasi Van der Waals surfaces. It is known that growth of heteroepitaxial films with weak Van der Waals force leads to a relaxation of lattice matching requirement. Inert Si surfaces also result in the relaxation of interfacial force between films and substrates and thus the lattice mismatch stress is controlled to be minimized.

Real-time measurement also shows change of intrinsic stress during oxidation process after metal film growth on H-terminated Si (111). The epitaxial growth of SrO films has been achieved by oxidizing epitaxial Sr films at room temperature. The sharp interface structure without silicon oxide layer has been also formed on the H-terminated Si. The total stress in the film is affected drastically by introducing the O_2 gas. The film stress turns to tensile, indicating a shrinking of the film surface. When Sr films are exposed to the O_2 gas, O atoms can penetrate Sr films without changing the position of Sr atoms to form SrO structure, because Sr has a face-centered cubic structure and SrO has a NaCl type structure. The in-plain lattice constant of Sr film changes during the oxidation from 0.430 nm to 0.363 nm, that is, the lattice constant of oxidized film decreases to 94.6 % of the Si lattice. These cause a variable mismatch between the effective lattice parameter of Sr or SrO film and substrate, and lead to the stress change during oxidation process.

*Corresponding author: E-mail: asaoka@maico.tokai.jaeri.go.jp
Full address of the corresponding author:

<Permanent address>
Hidehito ASAOKA
Department of Materials Science, Japan Atomic Energy Research Institute, Tokai-mura, Ibaraki 319-1195, Japan
e-mail; asaoka@maico.tokai.jaeri.go.jp, Tel.; +(81)-29-282-5479, Fax; +(81)-29-282-6716

<Temporary address from March 2002 for one year>
Hidehito ASAOKA, c/o Bert Voigtlander, Forschungszentrum Julich / ISG 3, Leo Brandt Str., 52428 Julich, Germany
e-mail; asaoka@maico.tokai.jaeri.go.jp, Tel.: + (49) 2461 61 4116, Fax: + (49) 2461 61 3907