AN X-RAY DIFFRACTION STUDY OF HETEROEPITAXIAL GROWTH OF RARE EARTH FLUORIDE FILMS

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Fluoride films are used extensively in micro device applications, such as heteroepitaxial insulating materials, opto-electronic and photonic monolithic laser devices on Si and on compound semiconductor substrates. In these applications, fluoride films are most promising due to their lattice matchings with substrate materials.

MBE-grown NdF_3 and ErF_3 epitaxial films of various thicknesses grown at various temperatures on Si(111) and CaF_2(111) substrates were characterized by Grazing-incidence X-ray diffraction using a newly developed Rigaku high-resolution X-ray diffractometer, ATX-G. The ATX-G was used to make in-plane diffraction measurements of crystal planes which are perpendicular to the surface of a film.

In this paper, we present the results obtained by both out-of-plane and in-plane X-ray diffraction. The orientation along the growth direction was first identified as NdF_3(0001) // Si(111) by conventional 2θ-θ diffraction. FWHMs of the X-ray rocking curves for the NdF_3(0002) reflections were improved with increasing in growth temperature (from 400°C to 550°C) and film thickness. At 700°C, a thick film showed a larger FWHM value than that of a thin film. This difference can be attributed to a difference in the growth mode. An AFM observation revealed a difference in surface morphology. Films grown at 400°C to 550°C showed an island growth mode, films grown at 700°C, however, exhibited a spiral growth mode with screw dislocations in wide terraces.

An in-plane diffraction analysis revealed twisting of crystallites and an improvement in crystallinity following a similar tendency as indicated by out-of-plane diffraction.

Epitaxial growth of orthorhombic ErF_3 exhibited complicated domain formation, which was resulted by following a six-fold symmetry of (111) planes of substrates. Azimuthal alignments of the crystallographic axis ErF_3 were different for the cases on a Si(111) substrate and on a CaF_2(111) substrate.