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Investigation of Interfacial Structure and Surface Characteristics of NdF_3/Si (111) heterostructures

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1. Introduction

We have grown rare-earth trifluoride layers on Si (111) substrates by molecular beam epitaxy (MBE) and investigated their surface characteristics such as surface morphology, growth mechanism, layer crystallinity, and epitaxial relationship. In this article, we report on the interfacial microstructures of NdF_3/Si (111) heterostructures MBE-grown at different temperatures, which were investigated by transmission electron microscope equipped with selected area electron diffractometer (SAD). Also, we present the effect of the interfacial defect structures on the layer crystalline quality, which was estimated by full width at half maximum (FWHM) values for x-ray rocking curves from high-resolution x-ray diffraction (XRD) measurement.

2. Exprimental Procedure

NdF_3 thin films were grown on Si (111) substrate at 400, 550 and 700℃ by a molecular beam epitaxy (MBE). The surface morphology observed by atomic force microscopy (AFM) exhibits that the NdF_3 layers on Si (111) substrates grew as islands associated with the screw dislocation which coalesced less densely at higher growth temperatures.

3. Results and discussion

The TEM results show that NdF_3 thin films with uniform thickness were grown on Si substrate containing defects such as screw dislocations, stacking faults, and microcracks, in the direction of $NdF_3(0002)<11\bar{2}0>||Si(111)<1\bar{1}0>$. The nucleation of NdF_3 in the initial growth stage is thought to be origin of defects and it was confirmed that the screw dislocations and the microcracks were affected by the induced stress around the nuclei of NdF_3, which was developed by the lattice mismatch in NdF_3/Si interface and crystallographic orientational misfit in NdF_3 film. The crystallinity depending on the growth temperature was investigated by estimating full width at half maximum (FWHM) of the x-ray rocking curves for the NdF_3 (0002) diffraction and $NdF_3(11\bar{2}0)$ diffraction and shows that NdF_3 layer grown at a high temperature 700℃ showed better crystalline quality with smallest FWHM.

Reference

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