X-ray scattering topography, which the present authors have proposed, has been successfully applied to lattice-mismatched heteroepitaxial layer systems, an MBE (molecular beam epitaxy) grown InAs on GaAs, Mo-CVD (metal-organic chemical vapor deposition) grown GaAs on Si, and InGaAs on Si, of which systems have crystal misfits which give a local rocking curve of X-ray diffraction as broad as several hundreds arc sec. Since, for such a locally imperfect crystal, conventional X-ray diffraction topography (e.g. LANGMUIR) provides little significant information, X-ray scattering topography has been applied to characterizing lattice-mismatched heteroepitaxial layer systems. Microcomputer-assisted X-ray scattering topography has enabled us to observe a quantitative orientation distribution. And crystallographical correlation between the epitaxial layers and substrates have been also discussed. The result of MO-CVD grown GaAs on Si indicated the following. The bending was concave. The bending mechanism is determined by the difference in thermal expansion coefficients between the epitaxial layer and the substrate. It was proposed that clinet motion of misfit dislocation may cause the anisotropically lattice bending of the epitaxial layer. In this congress we report the X-ray scattering topographic observation of MEML (migration enhanced epitaxy) grown GaAs on Si. The structures revealed were different from that of MO-CVD grown GaAs on Si. One of the feature of MEML growth method, which exists in comparable lower growth temperature and the method made an epitaxial layer with lower dislocation density. It was found that the epitaxial layer and the substrate have lattice isotropically concave bend 3-4 arc min and 2 arc min, respectively, in a specimen of 0.6 mm² dimension. Comparing the results of the previous MG-CVD grown GaAs on Si system, the epitaxial layer and the substrate were concavely bent with 5.6 arc min and 2.6 arc min, respectively, of which lattice was bent around the direction between the epitaxial layer and the substrate. It is suggested that on account of lower temperature growth the MEE grown epitaxial layers are smaller bending, and that amount of defects and density of defects are smaller than those of MO-CVD grown one.

References
11-Surfaces, Interfaces and Thin Films

PS-11.02.23 PREPARATION OF C-ORIENTED POLYCRYSTALLINE ZnO THIN FILM BY SOL-CEL TECHNIQUE. By Zuoyuan Fang, Ting Cong, Jingyi Chang. China Building Material Academy, Beijing 100024, China. Oriented polycrystalline ZnO thin films were prepared from metallo-organic compounds by a sol-gel method. The precursor solution was synthesized with zinc acetate, acetic acid, and alcohol through refluxing. Thin films were deposited on single-crystal Si(100), Si(111) and fused silica using dip-coating technique. C-oriented polycrystalline ZnO thin films were obtained with a special isothermal treatment. The pyrolysis and crystallization of powder and films were investigated by differential thermal analysis, thermogravimetric analysis, X-ray diffraction and scanning electron microscope. The effects of substrate, sintering and other processing parameters on the crystal structure were also investigated.

In this experiment, the crystal structure of thin films had a strong dependency on the heat treatment, while the substrate played a smaller role than we expected.

Decomposition of gel films occurred below 200°C. Nucleation of films started at about 300°C. The densified crystalline films were obtained above 500°C; they transformed to c-oriented films with increasing the temperature to 800°C.

PS-11.02.24 A STUDY OF Fe-Dy MULTILAYERED FILMS. By Peixuan Wang, Shengli Li* and Ruzhang Ma. Department of Materials Physics, University of Science and Technology Beijing, Beijing 100083, China. Fe/Dy compositionally modulated films were prepared by alternate evaporation of the two elements onto substrates in the vacuum of 10⁻⁷ Torr range. RBS and AES were used for the composition profile determinations, and XRD and TEM for microstructure observations. Measurements of magnetic properties were also performed with vibrating sample magnetometer. Two kinds of multilayers have been investigated. The first group has short periodicity, A = 4–6 nm and constant chemical ratio Fe80Dy20. The second group has longer periodicity A = 25–50 nm and various compositions ranging between Fe90Dy10 and Fe24Dy66.

TEM shows that the Dy layers are in the amorphous state when their thickness < 2.4 nm, whereas Fe layers > 2.4 nm give typical diffraction patterns of bcc structure. These as-deposited structures are very unstable against the film heating. Sharp diffraction rings characteristic of hcp-Dy will take the place of diffuse rings of amorphous Dy in ~60 sec during irradiation with intense electron beam (100 keV). Meanwhile the aggregation of Fe can also be observed. However, these processes occurred relatively slowly (in tens of minutes) when the films were heated at TEM hot stage.

For samples of the second group ion beam mixing have been studied with Ar ions. The ion energy of 95–110 keV was selected so that the mean projected range of bombarding ions is about in the middle of the multilayers (~100 nm thick). The amount of mixing, Q, of adjacent elemental layers can be determined from RBS spectra (Hewett C. A. et al., Nucl. Instr. Meth., 1985, 278, 597). It is found that Q increases with increasing the ion fluence. For all the competition studied, complete mixing (i.e., Q = 1) can be achieved at 1x10¹⁷ ions/cm². In particular, the samples of ~Fe60Dy40 exhibit a striking contrast to those of other compositions. For that, Q = 0.8 can already be obtained at 1x10¹⁶ /cm². After irradiations with 1x10¹⁷ /cm², these films consist of only amorphous compound as shown by XRD, while those of other compositions give extra reflections contributed either by excess bcc-Fe (e.g., in Fe60Dy20) or by excess hcp-Dy (e.g. in Fe24Dy66). As is expected, the saturation magnetization, Ms, of the as-deposited multilayers varies with respect to their Dy content. For all the films Ms drops sharply after bombardments with the least fluence used (5x10¹⁵/cm²). Further increase in ion fluence up to 1x10¹⁷ merely results in small change of Ms. Among all samples, those of ~Fe60Dy40 show maximum reduction of Ms induced by ion beam mixing.

In this paper the behavior of multilayers depending on the composition is discussed in the connection with the phase diagram, the enthalpy of compounds formation and the magnetic coupling of Fe-Dy atoms.