11-Surfaces, Interfaces and Thin Films

PS-11.02.20 X-RAY SCATTERING TOPOGRAPHIC OBSERVATION OF MIGRATION ENHANCED EPITAXY GROWN GaAs LATTICE-MISMATCHED HETEROEPITAXIAL LAYER ON Si

Yoshifumi Suzuki, Yoshinori Chikaura, Hideki Kii, Kazuhiko Nozawa* and Yoshiji Horikoshi*,
Department of Physics, Faculty of Engineering, Kyushu Institute of Technology, Sensui-cho, Tobata-ku, Kitakyushu-shi 804 Japan,
**NTT Basic Research Lab., Musashino-shi, Tokyo 104 Japan.*

X-ray scattering topography, which the present authors proposed,[1,2] 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 InP on Si, of which systems have crystal mosaicities which gave 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. Lang-camera) 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.[3,4] And crystallographical correlation between the epitaxial layers and substrates have been also discussed.[5-8] The result of MO-CVD grown GaAs on Si indicated the following. The bending was concave. The bending mechanism was explained primarily by the difference in thermal expansion coefficients between the epitaxial layer and the substrate. It was proposed that climb motion of misfit dislocation may cause the anisotropic lattice bending of the epitaxial layer.
In this congress we report the X-ray scattering topographic observation of MEE (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 MEE growth method[9,10] 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 1-2 arc min, respectively, in a specimen of 6×6 mm^2 dimensions. Comparing the results of the previous MO-CVD grown GaAs on Si system,[7] the epitaxial layer and the substrate were concavely bent with 5-6 arc min and 2-3 arc min, respectively, of which lattice was bent around the different direction between the epitaxial layer and the substrate. It is suggested that on account of lower temperature growth the MEE gown epitaxial layers are smaller bending, and that amount of defects and motion of defects are smaller than those of MO-CVD grown one.

References

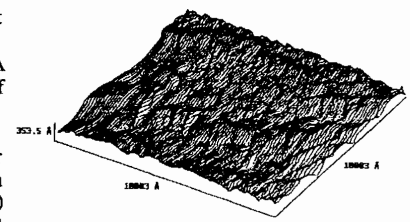
1) Y.Yoneda and Y.Chikaura, Z. Naturforsch. **A37**, 412 (1982).
2) Y.Chikaura, Y.Yoneda and G.Hildebrandt, J. Appl. Cryst. **15**, 48 (1982).
3) Y.Chikaura and Y.Takata, Jpn. J. Appl. Phys. **29**, L378 (1990).
4) Y.Chikaura and Y.Suzuki, J.Appl.Cryst. (1993) in print.
5) Y.Suzuki, Y.Chikaura and T.Akazaki, Appl. Phys. Lett. **56**, 1858 (1990).
6) Y.Chikaura, H.Kii and Y.Suzuki, J.Cryst. Growth **15**, 48 (1982).
7) Y.Suzuki and Y.Chikaura, J.Appl.Phys. **70**, 1290 (1991).
8) Y.Suzuki, Y.Chikaura and H.Kii, J.Phys.D (1993) in print.
9) Y.Horikoshi, M.Kawashima and H.Yamaguchi, Jpn.J.Appl. Phys., **25**, L868 (1986).
10) K.Nozawa and Y.Horikoshi, SSDM extended abstract (1992).

PS-11.02.21

STM AND XRD STUDIES ON STRUCTURE OF AMORPHOUS INDIUM SELENIDE FILMS

By N.Mukherjee, N.K.Banerjee, M.V.H.Rao, B.K.Samantaray* and B.K.Mathur. Department of Physics, Indian Institute of Technology, Kharagpur-721 302.

The surface structure of vapour deposited InSe films was observed by recording various images using a Scanning Tunneling Microscope. A through study of these images revealed that these films deposited at room temperature are amorphous. A columnar type of growth consisting of numerous flakes, arranged one after another with thickness around 40 Å and height around 300 Å was observed.



The growth direction is normal to the substrate. The column of flakes are in turn arranged step wise as shown in the figure.

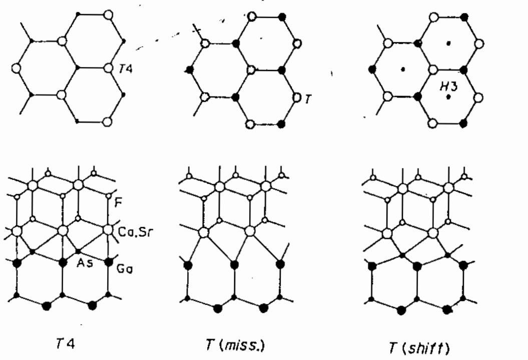
X-ray diffraction intensities have been recorded and structure of these has been studied using radial distribution analysis technique. Inter atomic peaks are observed at r values equal to 2.70, 3.80, 4.40, 5.30, 6.40, and 7.20 Å. The structure at r_1=2.70 Å and r_3=4.40 Å very nearly satisfies the ratio for a regular tetrahedron ($r_1 = 0.612 r_3$). r_1 =2.70 Å corresponds to the In-Se and r_2=3.80 Å corresponds to In-In bond length. r_3= 4.40 Å corresponds to Se-Se distances. The effect of annealing for different duration on the structure of the film has been investigated and it is found bond distances progressively approaches towards their corresponding crystalline values.

PS-11.02.22 STRUCTURE OF EPITAXIAL FLUORIDE THIN FILMS GROWN ON GaAs(111) SUBSTRATES

By H. Hashizume*, O. Sakata, T. Niwa and M. Sugiyama, Res. Lab. of Engineering Materials, Tokyo Inst. of Technology, Nagatsuta, Yokohama 227, Japan.

X-ray standing waves (XSWs) and scatterings along the surface normal (XSASNs) were used to determine the atomic structure and stoichiometry of $CaSrF_2$/GaAs(111) and CaF_2/S/GaAs(111) heteroepitaxial interfaces at a synchrotron radiation source. Lattice-matched $CaSrF_2$ alloy films on the As surface of GaAs(111) have a high crystalline order with a first F monolayer missing at the heteroepitaxial interface. (Ca, Sr) atoms are located in the T sites on top of the first-layer As atoms with little random disorder in the vertical direction. Least-squares fits of the XSASN data favored missing first-layer As atoms (*T*(*miss.*) model) over As atoms shifted to the stacking-fault H3 sites (*T*(*shift*) model). The As-Ga double layers in the interface region are relaxed to the outward direction.

11-Surfaces, Interfaces and Thin Films



$CaF_2/S/GaAs(111)$ samples were prepared by growing 54 monolayers of F-Ca-F from a molecular-beam source on a sulfide-treated GaAs(111) surface. XSW data collected using 3.5 keV photons support three-fold coordinated S atoms located in slightly shifted top-layer As atom sites. CaF_2 epilayers on the S-chemisorbed GaAs(111) surface have a good crystalline order in the vertical direction, but the first F monolayer is again missing. The first-layer Ca atoms are placed at a short vertical height close to 2.1 Å above the S layer, which disfavors the on-top sites for the Ca atoms. The $CaF_2/S/GaAs(111)$ interface was found to be more rough (rms roughness 8~10 Å) than the $CaSrF_2/GaAs(111)$ interface.

PS-11.02.23 PREPARATION OF C-ORIENTED POLYCRYSTALLINE ZnO THIN FILM BY SOL-GEL TECHNIQUE.

By Zuoyan*Fangtian Gong, Jingyi Chang. Chima 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, acetylacetone, 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 wewe obtained with a special isothermal treatment. The pyrolysis and crystallization of powder and films were investigated by differential thermal analysis, thermogravimetric analysis, X-ray diffration 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 occured 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.

Fe/Dy compositionally modulated films were prepared by alternate evaporation of the two elements onto substrates in the vacuum of 10^{-7} Pa 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 periodic length, Λ=4--6nm and constant chemical ratio Fe80Dy20. The second group has longer periodicity Λ=25--50nm and various compositions ranged between ~Fe90Dy10 and ~Fe34Dy66.

TEM shows that the Dy layers are in the amorphous state when their thickness <2.4nm, whereas Fe layers >2.4nm 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 (~100nm 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, B7/8, 597). It is found that Q increases with increasing the ion fluence. For all the competitions studied, complete mixing (i. e. Q=1) can be achieved at $1x10^{17}$ ions/cm^2. 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 $1x10^{16}$ /cm^2. After irradiations with $1x10^{17}$ /cm^2, 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 Fe80Dy20) or by excess hcp-Dy (e. g. in Fe34Dy66). 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 ($5x10^{15}$ /cm^2). Further increase in ion fluence up to $1x10^{17}$ 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.