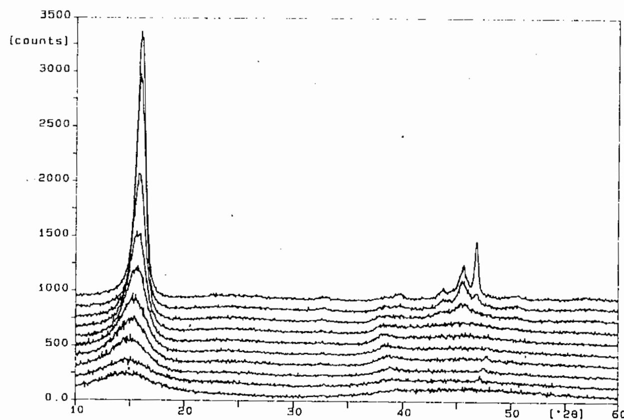

Fig. 1: Diffraction pattern of a 450 nm tick MoS_2 film at T = 35 (lower), 100, 200, 300, 400, 500, 600, 700, 800, 900°C (upper)

Parallel to the crystal growth a reduction of the fraction of stacking faults is observed indicated by the decrease of the c-lattice parameter and by the appearance of (hkl)-reflections. Differences in the initial film thickness influence the structural state of the untreated material but they disappear during heat treatment.

PS-11.02.16 THE STRUCTURE AND MAGNETIC ANISOTROPY OF Pt/Co MULTILAYERS

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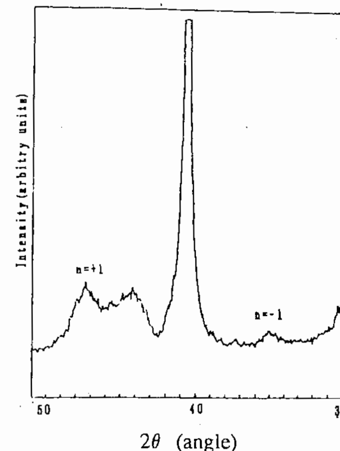
Recently, Pt/Co multilayer has stimulated the interests of many researchers due to its potential as a high-density magneto-optical storage material. Generally, such a candidate material must have a large Faraday or Kerr effect at short wavelength, a perpendicular anisotropy and a relatively large coercivity at room temperature. Pt/Co multilayers happen to satisfy all these conditions.

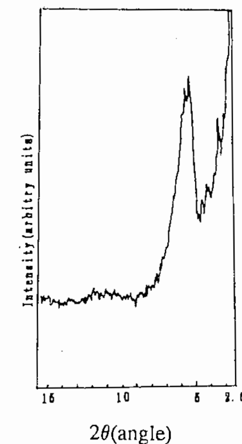
In our experiments, Pt/Co multilayers were prepared using dc magnetron sputtering on silicon substrates. The structures were determined by X-ray diffraction and the magnetic properties were measured by Kerr angle hysteresis loops. In table 1 are listed the sample parameters and their magnetic properties(omitted).

The low angle X-ray diffraction pattern, as shown in Fig.1, clearly confirmed the existance of multilayer structure of sample 1. The bilayer thickness deduced from Bragg fogmula agreed well with the sample parameter.

A simple simulation of high angle x-ray diffraction pattern was made. At any circumtances, the n=-1 satellite peak was higher than the n=+1 satellite peak, which is in contradiction to the real pattern(shown in Fig.2). We contribute this phenomena to the appearance of PtCo alloy at the interfaces, whose (111) peak overlaps with the Bragg peak of multilayers and (200) peak is at the same position of n=+1 satellite peak(C.-J. Lin and G.L.Górman, Appl. Phys. Lett., 1992, 61(13), 1600). In sample 2, when Co layer was much thicker, the multilayer diffraction overwhelmed the PtCo alloy diffraction and the relative heights of these two peaks reversed.



2θ (angle)
Fig.1 Low angle X-ray diffraction pattern of sample one



2θ(angle)
Fig.2 High angle X-ray diffraction pattern of sample one

In conclusion, we have found the PtCo alloy diffraction at Pt/Co multilayers. And the appearance of PtCo alloy did not destroy the perpendicular magnetic anisotropy which is believed to be mainly induced by interface anisotropy. the influence of interface atoms on the anisotropy can be further studied.

PS-11.02.17 CROSS-HATCHED SURFACE MORPHOLOGY IN InGaAs/GaAs SUPERLATTICES.

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The cross-hatched morphology (CHM) has been commonly noticed in strained III-V semiconductor films (K. H. Chang et al, J. Appl. Phys., 1990, 67, 4093-4098). The CHM has been observed by means of Nomarski interference, x-ray topography, TEM, chathodeluminesence and photoluminesence but few results about the CHM were presented for InGaAs/GaAs strained-layer superlattices (SLSs).

In the present letter we report the x-ray topographic examinations of InGaAs/GaAs SLSs. The specimens used in the experiments were grown by molecular beam epitaxy (MBE) on GaAs substrates. The nominal structure of the SLS samples were 150 periods of 70 Å $In_{0.04}Ga_{0.96}As$ and 250 Å GaAs with about a 1 μm GaAs buffer layer and a 3 μm capping layer, respectively. In order to eliminate the influence of the capping layer on the reflection topographs a sample (denoted A) was etched to remove its capping layer. The synchrotron radiation experiments on sample A were performed at 4W1A beam line of the Beijing Synchrotron Radiation Facilities (BSRF).

The actual structure of the specimens were determined by the simulations of experimentally measured rocking curves based on the dynamic diffraction theory for deformed crystals (Z. H. Mai, S. F. Cui and C. G. He, Phys. Rev. B, 1990, 41, 9930-9934). Percentage relaxations of the two component layers of SLS were particularly found from the simulations.

224 reflection topographs were taken at the zeroth order peak of the SLS and the substrate peak, respectively. They were characterized as orthogonal striation parallel to the [110] and [$\bar{1}$10] directions, respectively. X-ray topographs were also taken under anomalous transmission conditions using Cu $K\alpha_1$ radiation (μt=17, where μ is the linear absorption constant and t the sample thickness). In 220 or $\bar{2}$20 anomalous transmission topographs shown in Fig. 1 the striations parallel to [110] or [$\bar{1}$10] disappeared, respectively. According to the invisibility criteria of dislocations, both the striations parallel to [110] or [$\bar{1}$10] were edge-type dislocations with Burger's vectors in [$\bar{1}$10] or [110] direction in the (001) growth plane.

It is interesting to see that in addition to the striations in the (001) growth plane other striations (see regions C of Fig. 1) which obeyed the same extinction law were observed on the cleavage planes of sample A. The stereoscopic topographs provide us a evidence that the misfit dislocations distribute over the SLS and

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are packed in columns along the surface normal. This is in agreement with the simulation of experimental rocking curves in which the partial relaxations were considered in every periods of the SLS.
Based on a series of experimental results a relaxed growth mechanism for InGaAs/GaAs SLSs is proposed.

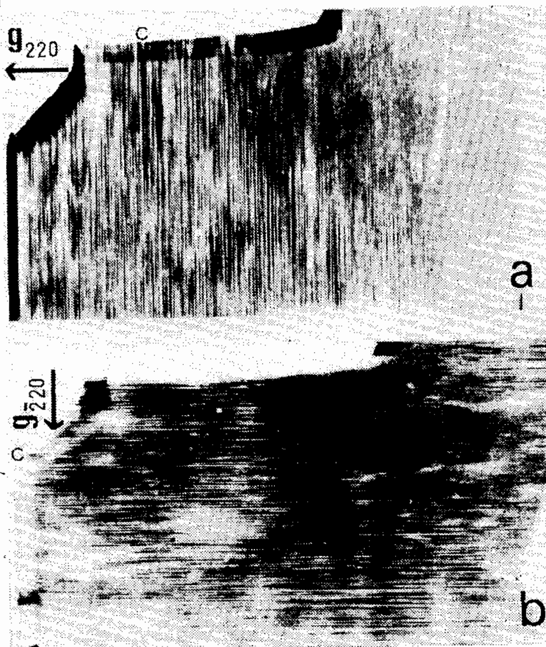

Fig. 1 Anomalous transmission topographs of sample A (a) 220 reflection (b) 2̄20 reflection.

PS-11.02.18 X-RAY POWDER DIFFRACTION STUDY OF KINETICS OF CRYSTALLIZATION OF PULSED LASER-DEPOSITED $BaTiO_3$ THIN FILMS

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Thin films of $BaTiO_3$ were prepared on unheated Pt substrates using a pulsed excimer laser operating at 193 nm (ArF), 10 Hz repetition rate, 20 ns nominal pulse width, with a laser fluence of ~ 15 J/cm_2 and a background oxygen pressure of 13.33 Pa. Following deposition, films were isothermally annealed in air for progressively longer periods of time. Films were examined after each annealing using an x-ray powder diffractometer (theta-two theta) with CuKa radiation and a two-theta compensating slit. The diffractometer was run under computer control with a step size of 0.03 degrees and a counting interval of 1.7 sec. As deposited, films were amorphous, showing only a broad amorphous hump in the x-ray pattern near 28 degrees two-theta. X-ray diffraction did not indicate significant crystallization at temperatures below 500°C. At 550°C, annealing times in excess of 30s were required to produce measurable crystallization. At 750°C, crystallization was extensive after only a few seconds of annealing time. Plots of crystallization (as deduced from the integrated area of the (011) $BaTiO_3$ peak) as a logarithmic function of time show linear relationships. Two rate laws appear to have been operative, with a relatively rapid process dominant at 550° and 600°C, and a more gradual process dominating at 700 and 750°C, for crystallization times greater than 30s. At 650°C, both processes were operative, as judged from a break in slope of the linear trend. Ferroelectric and dielectric properties of the annealed thin films are discussed.

PS-11.02.19 DISTRIBUTION OF CRYSTALLITES IN AMORPHOUS SiO_2 FILM ON Si WAFER AND ITS CHANGE WITH OXIDATION PROCESS.

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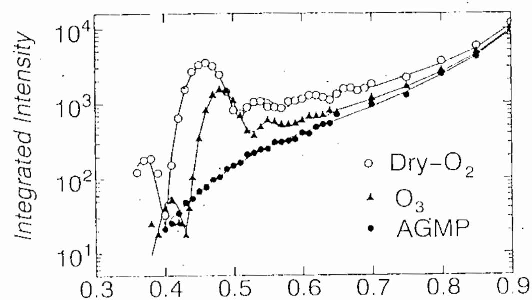
Electrical and mechanical properties of amorphous SiO_2 film grown on the Si substrate have been attracted much attention because of an industrial application as an atomically thin insulator on semiconductor devices. As a non-destructive method in investigating the structure of the amorphous phase and its interface, Iida *et al.*(Surface Science, **258**, 1991, pp.235-238) have recently applied the technique of X-ray crystal truncation rod(CTR) scattering and have found extra peaks on the low angle side of the 111 CTR scattering. It has been suggested that some crystalline scatterers exist in the amorphous film. In this paper we show that the profile of the peak strongly depends on the condition of oxidation of Si wafer and the distribution of crystalline scatterers in the amorphous film can be obtained from the analysis of the profile. Three kinds of samples were prepared; normal dry O_2 oxidation heated at 900 degree denoted as Dry-O_2: low temperature oxidation(about 650 degree) with ozone atmosphere denoted as O_3: low temperature oxidation(about 650 degree) under the atmosphere of afterglow of microwave plasma of O_2 molecule denoted as AGMP. X-ray measurement was performed at Beam Line 4C in Photon Factory, KEK Tsukuba. Figure shows the change of the profile of the peak for three samples. Soild curves show the calculation obtained by the least squares fitting where the distribution of the crystalline scatterers in amorphous phase was refined. We found that the distribution depends on the oxidation process. For instance the crystallites exist only at the interface especially for the sample AGMP.
This study was supported by a Grant-in Aid for Scientific Reacarch on Priority Areas, No. 03243105 and No. 04227105 from the Ministry of Education and Culture, Japan.



CTR scattering near 111 Bragg point along 001 direction