13-Defects, Microstructures and Textures

PS-13.03.06 A STUDY OF THE EFFECT OF THE ORIENTATION OF MICROCRYSTALS ON THE PROPERTIES OF IRON-BASED AMORPHOUS ALLOY $Fe_{78}Si_9B_{13}$. By Sun Shi-Quan*, Wang Cheng-Zhong and Shi Song-Yue, Shanghai Iron and Steel Research Institute, 1001 Taihe Road, Wusong, Shanghai 200940, P. R. China.

It is known that the properties of amorphous alloys are closely related to their structural change during crystallization. The influence of crystallite size and crystallinity on properties (Sun Shi-Quan et al., PHYSICS, 1989, 19, 9, 561), and the influence of the annealing temperature on crystallinity (Sun Shi-Quan et al., Journal of Physical Testing and Chemical Analysis, Part A: Physical Testing, 1988, 24, 2, 9) have already been investigated. In this paper, the results of the effect of crystalline orientation on the properties of the iron-based amorphous alloy, $Fe_{78}Si_9B_{13}$, studied using X-ray diffraction associated with magnetic and mechanical testing, are reported. The tested alloys, A and B, were prepared with different processes but with the same constituents and the same treatment. The as-quenched ribbons were annealed at 450℃ for 0.5 hour in a furnace filled with argon. Then, the pole figures, the magnetic properties (B_1, B_{10}, B_{30}, Br, Hc) and the mechanical properties were measured for specimens A and B by means of X-ray diffraction, magnetic and mechanical testing. The results showed that: (a) the texture of specimen A is similar to (200) [HKL], and specimen B has an approximate cubic texture. The orientation of the microcrystals is parallel to the preferred magnetic direction for specimen B but not for specimen A. The measured magnetic properties of specimen B are better than those of A; (b) the pole figures obtained by X-ray diffraction are, for both specimens, slightly asymmetric, due to the deformation of the microcrystals during crystallization. The measured mechanical properties are also characterized by an anisotropy, i. e., the longitudinal bending forces are different from the transversal ones. To sum up, the experimental results obtained by X-ray diffraction are in good agreement with those obtained by magnetic and mechanical testing.

PS-13.03.07 INFLUENCES OF ELASTIC STRAIN AT OXIDE MASK EDGES ON THE DISTRIBUTION OF B IONS IMPLANTED IN SILICON CRYSTALS. By A. Yu. Nikulin*, O. Sakata and H. Hashizume, Tokyo Institute of Technology, Nagatsuta, Midori, Yokohama 227, Japan.

A method of reconstructing two-dimensional elastic deformation fields in near-surface layers was developed for the case of distortions which are periodic in one direction (Goureev, Nikulin & Petrashen, phys. stat. sol.(a) 130, 2 (1992). The method is based on the application of the solution of one dimensional inverse problem to the Fourier components of the deformation profile and analyzes interference patterns observed in triple-crystal X-ray rocking curves. It was applied to a silicon crystal with periodic surface SiO_2 strips (10 μm period) and a silicon crystal implanted with Ne^+ ions (300 keV, $\sim 10^{14}$ cm^{-2}) through a periodic mask which was removed after the implantation (Aristov, Goureev, Nikulin *et al.*, Semicond. Sci. Tech. 7, 1109 (1992)). In the latter application the obtained lattice deformation profile is in good agreement with the known character of the implanted ions. For instance, the deformation depth range (0.45 μm) and the average width of the profile maximum (0.1 μm) were very close to the results of Monte-Carlo calculations.

It is interesting to see if this method allows to study the influences of elastic strain at the edges of oxide masks on the distribution of implanted ions. Experiments were carried out on Si(111) crystals implanted with B^+ (100-300 keV, 10^{15} cm^{-2}) through a 0.5 μm-thick SiO_2 mask having a 5.83 μm periodicity. A triple-crystal diffractometer was used with synchrotron X-rays for the 111 and 004 reflections. It was attempted to obtain a unique solution of the inverse problem from data collected using two different X-ray wavelengths. Effects of anisotropic strain at the mask edges on the ion distribution will also be reported.

PS-13.03.08 CHARACTERIZATION OF QUANTUM WELL WIRES AND SURFACES GRATINGS BY X-RAY DIFFRACTION RECIPROCAL SPACE MAPPING. By G.T. Baumbach*[(a)], M. Gailhanou[(b)], U. Marti[(b)], P. Silva[(b)], M. Bessiere[(c)], F.K. Reinhart[(b)], M. Ilegems(b), (a) Institut Laue-Langevin, BP 156X, F38 042 Grenoble Cedex (France) (b) Institut de Micro- et Optoélectronique, Ecole Polytechnique Fédérale de Lausanne CH1015 Lausanne (Switzerland) (c) LURE, Bat.209d, Université Paris Sud, F91 405 Orsay Cedex (France)

One tendency in the present material research is the increasing ability to structure solids in one, two or three dimensions. Using semiconductor systems, quantum well wires (QWW) and quantum well dots (QWD) hold a great potential for the basic physics of semiconductors as well as for the improvement of integrated optical devices. One approach consists of post-growth patterning of quantum well materials, a second one of its fabrication on patterned non-planar substrates (PS).
The aim of our studies was to develop the method of X-ray diffraction as a powerful nondestructive technique for the structural characterization of periodic patterned substrates and QWW.
QWW and PS represent artificial superlattices. The PS have an one-dimensional lateral superstructure forming a surface grating with periods between 0.2 and 1 µm. The QWW are epitaxial multilayered surface gratings and show a two-dimensional superperiodicity. By applying triple crystal diffractometry longitudinal (Qz) truncation rods (TR) near the Bragg positions of the modulated crystal-lattice have been measured directly (see fig.1) (1). The transversal (Qx) positions of the TR's fulfil the Grating equation.
Realizing transversal (Q_X) scans, satellites occur around the substrate Bragg-peak. The angular space between neighbouring satellites is inverse to the grating period. A longitudinal scan through the substrate Bragg position shows thickness oscillations related with the grating depth. An intensity cross pattern is formed by the longitudinal truncation rods of the transversal satellites in fig.1, centered on the substrate reciprocal lattice point. It provides evidence of a non square shaped profile of the grating, found to be trapezoidal in this example. The grating acts simultaneously as a reflection and a transmission grating. Umweganregung between the (transmission)-grating and the dynamical diffracting substrate gives rise to additional sharp peaks in the maps, which cannot be explained by normal kinematical theory. For the quantitative interpretation a semi-dynamical treatment was developed.
In QWW's the Qz truncation rods obtain additional longitudinal satellites, representing the superperiodicity in growth direction. Both longitudinal satellites and transversal satellites would not be separable in a smooth way by applying only double crystal diffractometry. Reciprocal space mappings allow the characterization of the perpendicular profile of the QWW-stripes as well as the surface profile of the lateral grating. That will be demonstrated by the example of stepwise etched epitaxial multilayered surface gratings based on GaInAs/InP and AlAs/GaAs.

(1) M. Gailhanou, T.Baumbach, U.Marti, P.Silva, F.K. Reinhart, M.Ilegems; Appl.Phys.Lett. (1993) in press

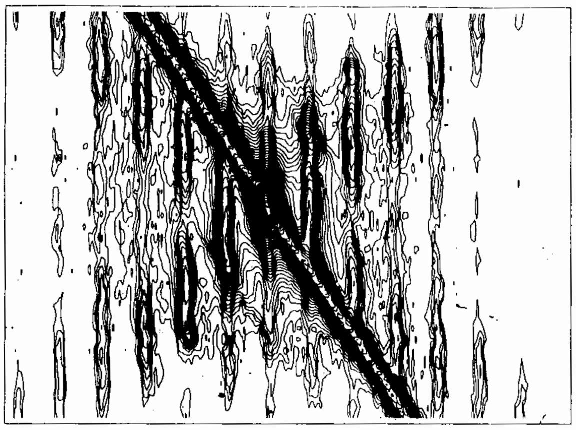

Fig.1 Contour plot of the reciprocal space mapping of a GaAs surface grating in the vicinity of (004) GaAs

working or if there has been recrystallization by heat treatment or due to welding. The texture distorts the true intensity ratios in the experimental data and gives an erroneous value to the austenite content. In these cases more reflections are usually measured and the final outcome is calculated as an average of different pair values.

For improving this calculation procedure I have developed a method that takes the special features of texture effect into account (Järvinen,M. 1985. Lecture notes 2/85. Lappeenranta Univ. of Technology, Finland.). The method is based on symmetrized harmonics expansion for the representation of the orientation distribution of the crystallites in the sample. The method presumes the use of specimen spinner in data collection.

In retained austenite analysis the orientation distribution of each phases is represented separately by cubic harmonics expansion. This introduces adjustable parameters into the formula of theoretical intensities. The parameters of the model, including consentration parameters of ferrite and austenite phases, are determined by fitting theoretical integrated intensities with the experimental data.

For demonstrating the use of the method, integrated intensities of six reflections (*200, 220, 311* for austenite and *200, 211, 220* for ferrite) from several samples were measured using $CuK\alpha$ radiation. It was found that this information was sufficient for determing the parameters, but the result was much more accurate when more reflections was measured.

PS-13.03.09 SKELETON STRUCTURES IN POROUS SILICON.

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The micro structure of luminescent and non-luminescent porous silicon formed by electrochemical etching has been characterized by X-ray and electron diffraction. Experimental and theoretical research has been recently focused on light emission properties of porous silicon. The mechanism resulting in the visible luminescence at room temperature is still a controversial question but it seems to be related to the structural features of the porous layer. The structure of porous silicon has been studied previously (Barla et al.,J.Cryst. Growth, 1984, **68**, 727).and several authors confirm the single-crystalline nature of the layers. Diffuse scattering around Bragg reflections has also been analyzed recently to obtain information on the pore structure of the films (Bensaid et al., Solid State Comm., 1992, **79**, 923). This communication deals with the comparison of X-ray and electron diffraction patterns of etched silicon wafers with two different crystallographic orientations. Transmission electron microscopy and double crystal diffractometry were used to characterize the samples. Photoluminescence measurements were performed to correlate the results with the structural features of the layers. Results of this study reveal several differences in the crystallinity of the skeleton structure for luminescent and non-luminescent samples.

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PS-13.03.10 TEXTURE EFFECT IN ANALYSIS OF RETAINED AUSTENITE IN STEEL.

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X-ray diffraction is a standard tool for determining austenite concentration in polycrystalline steel. If the grains of austenite and ferrite are randomly orientated in the sample, the work can be done rapidly and accurately. To resolve the problem it is sufficient to measure carefully the integrated intensity of only one reflection from each phase.

However, very often the metallurgical samples have preferred orientation or texture, especially if the material is made by mechanical

PS-13.03.11 TEXTURE STUDY OF $YBa_2Cu_3O_{7-\delta}$ THIN FILMS USING X-RAY DIFFRACTION.

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Recently there has been growing interest in texture analysis of high temperature superconductors because preferred orientation is closely linked to electrical properties. The superconducting currents are stongly anisotropic and flow in the CuO_2 planes, so the orientation of the ab-planes of individual domains markedly influences the properties of thin films. In the case of $YBa_2Cu_3O_{7-\delta}$ (YBCO) thin films on single-crystal substrates, textures are extremely strong and routine procedures developped for texture analysis of metals are generally inappropriate. This has led us to develop special procedures (Chateigner et al., J. Appl. Cryst., 1992, 25, 766-769).

YBCO films grown on MgO substrates are generally found to consist of domains oriented with either the a-axis or c-axis perpendicular to the substrate surface. The in-plane texture were carefully studied by X-ray pole figure measurements. That texture is revealed by the complex (103/013) pole due to the (110) twinning in the samples. The pole figure data were analysed from χ and ϕ scans (χ and ϕ being the classical angles in the four-circle diffractometer geometry). It was found that there were two in-plane epitaxial state in which the YBCO a-axis (or b-axis) was parallel to either [100] direction or [110] direction of the substrate. For the description of texture components the general formulation : $c_{\perp\alpha}$ is used when the c-axis direction of the film is aligned with the substrate normal, α being the angle between the in-plane a or b direction of the film and the [100] of the substrate.