14-Diffraction Physics and Optics

Transmission phase retarders of Bragg and non-absorptive Laue geometries have a remarkable characteristics that (i) phase retardation has opposite sign on the opposite tails of the Bragg peak, so that we can easily switch the photon helicity by rotation around a single axis, (ii) phase retardation depends on the deviation from the exact Bragg condition, which is slowly varying on the far tails of the Bragg peak. These directly lead to realization of energy-tunable production of circularly polarized x-rays and fast switching of photon helicities. Both have been shown experimentally by using Bragg-transmission phase-retarder. In addition to the production of circularly polarized x-rays, phase retarders can be used for the complete determination of the unknown polarization state. By this, polarization state including naturally polarized component were determined for x-rays from elliptical multipole wiggler installed on NE1 beamline of the Accumulation Ring of TRISTAN. Transmission phase retarders using Borrmann effect was also experimentally characterized. Helicity switching capability utilizing crystal symmetry was demonstrated. Several beamline optics for production of circularly polarized x-rays from linearly polarized synchrotron radiation are discussed. Double-crystal monochromator with inclined scattering plane followed by a phase retarder, which make (+,-,+) parallel setting as a whole, is one of the practical solution for the design of the beamline for high flux as well as well-defined circular polarization. Another practical solution is to use transmission phase retarders with inclined scattering plane in a conventional monochromatic beamline equipped with a usual vertically dispersed double-crystal monochromator under certain conditions.

MS-14.01.05 CHARACTERIZATION OF YB_{66} CRYSTALS FOR USE AS A NEW SOFT X-RAY MONOCHROMATOR WITH SYNCHROTRON RADIATION. By Z.U. Rek(1)*, M. Rowen(1), Joe Wong(2), T. Tanaka(3), 1) Stanford Synchrotron Radiation Laboratory, SLAC, Stanford, CA 94309, USA, 2) Lawrence Livermore National Laboratory, Livermore, CA 94551, 3) National Institute for Inorganic Materials, Tsukuba, Ibaraki, 305 Japan.

YB_{66}, a complex binary semiconducting compound with a cubic crystal structure and lattice parameter of 23.44Å , was selected for monochromatization of soft X-rays in the 1-2 KeV energy range (Wong, Shimkaveg, Eckart, Tanaka, Rek,Tompkins, Nucl. Instr. and Meth.,1990, A241,243). The crystals were grown by an indirect heating floating zone method (Tanaka, Otani, Ishizawa, J. Crystal Growth, 1985, 73,31). Characterization of crystal grain structure and growth-induced defects as a function of crystal growth parameters was performed with white beam X-ray topography and rocking curve measurements. By numerous modifications of the growth parameters, crystals perfect enough were grown to be used as a double crystal monochromator to measure high resolution XAFS spectra of Mg, Al and Si in a number of compounds and minerals. The measurements were performed on the JUMBO beam line at SSRL. The results demonstrate the excellent performance of YB_{66} crystals as a new type of crystal monochromator for this energy range. The effects of crystal heating by synchrotron radiation were observed and studied. Recent experiments in crystal growth of YB_{66}, results of crystal characterization and performance of this material as an actual monochromator will be discussed.

PS-14.01.06 GIAR-FILMS FOR NUCLEAR RESONANT FILTERING OF SYNCHROTRON RADIATION. By K. Kaneko, Y.Kashiwase*, I.Nishida, M.Kogiso, M.Mori, M.Minoura, X.W.Zhang+ and T.Kado++, Department of Physics, College of General Education, Nagoya Univ. Chikusa, Nagoya 464-01, +Nat. Lab. for High Energy Physics (KEK), Oho, Tsukuba,Ibaraki 305,++Gov. Indus. Res. Inst., Chugoku, Kure, Hiroshima 737-01, Japan.

For the purpose of producing filters for monochromatization of synchrotron radiation to band width 10^{-7}-10^{-8}eV, GIAR (Grazing Incidence Antireflection)-films are designed to suppress enormous background scattering by electrons in the angular region where nuclear resonant reflection amplitude is large near the critical angle of the total reflection. The purpose of this study is to prepare and develop GIAR-films by investigation of the structure as well as X-ray interference between reflections from the films. An about 250-Å-thick Fe film coated with about 70-Å-thick Al film was deposited on a flat surface of a quartz glass plate by evaporation. The reflectivity curve of the specimen was measured by means of the optical system installed on the BL-14B of the Photon Factory (KEK). The radiation of 0.86025 Å was obtained using finally the 10 6 4 double reflections from a channel-cut Si crystal. It is made clear by the experiment that a GIAR-film with low reflectivity minima about 4×10^{-4} around glancing angle 5 mrad can be produced. Good simulation of the curve fitted to an observed interference pattern is obtained by assuming a three-layer model with boundary roughnesses 10-20 Å between layers.

PS-14.01.07 COHERENT INTERACTION OF MULTIPLE-BEAM DIFFRACTION IN A CRYSTAL WITH CIRCULARLY POLARIZED X-RAYS. By Qun Shen* and K.D. Finkelstein, CHESS, Cornell University, Ithaca, New York, 14853, U.S.A.

A novel x-ray diffraction technique has been developed over the past few years here at CHESS. The idea is to combine circularly polarized x-rays with coherent multiple-beam diffraction (the Renninger effect) in a crystal. There are two main effects that can occur in a multi-beam diffraction process. One is the phase sensitive interference among the multiple Bragg excitations and the other is polarization state mixing which results from the double Thomson scattering mechanism. The combination of these effects can produce an interference intensity that involves both the phases of the structure factors and the phase difference between the **s** and **p** components of the incident beam polarization.

This research has resulted in two main areas of applications. The first is to determine noncentrosymmetric phases or to detect noncentrosymmetry in a crystal using elliptically or circularly polarized x-rays [Shen & Finkelstein, Phys. Rev. Lett. 65, 3337 (1990); Shen, SPIE Proceedings 1550, 27 (1991)]. An experiment on a GaAs crystal has demonstrated that determination of the polarity or the chirality of a noncentrosymmetric crystal is possible by using both right- and left-handed elliptically polarized synchrotron radiation. The second application is to use the multi-beam diffraction from a crystal of known structure to measure the degree of circular polarization of an x-ray beam [Shen & Finkelstein, Phys. Rev. B45, 5057 (1992)]. This unique way of characterizing circular polarization at low-to-medium x-ray energies has created a great deal of interest in the x-ray and synchrotron communities. Because the multi-beam interference intensity depends on all three Stokes-Poincare parameters, a complete characterization of the incident beam polarization is possible. The relatively high throughput of such analyzer may allow us to perform polarization-in/polarization-out measurements in magnetic and/or resonant scattering experiments to obtain a complete analysis of the scattering cross-section.

PS-14.01.08 DELTA-CRYSTAL - A PROGRESS IN X-RAY OPTICS AND A CHALLENGE FOR CRYSTAL GROWERS. By H. Bradaczek, G. Hildebrandt and W. Uebach, Institut für Kristallographie, Freie Universität Berlin, Germany.

