Wavelength Dispersive Analyzer for Inelastic X-ray Scattering

G. Bortel, E. E. Alp, W. Sturhahn and T. S. Toellner
Advanced Photon Source, Argonne National Laboratory, Argonne IL 60439, USA

Introduction

For inelastic x-ray scattering experiments, where the energy and momentum transfer to the sample has to be measured, spherical focusing backscattering analyzers [1-2] present the common solution. However, in resonant inelastic x-ray scattering experiments or in measurements requiring flexible energy resolution or high momentum resolution, the performance of a single-reflection analyzer is usually poor. To overcome these limitations we suggest the use of a double flat-crystal arrangement, which has been developed for monochromatization in nuclear resonant scattering experiments [3]. Main feature of this optic is the dispersive setting of the two strongly asymmetrically cut crystals in order to optimize the angular acceptance, energy resolution and throughput.

Method and Experiment

The energy, E of the x-rays transmitted by a double flat crystal analyzer shows a correlation with its direction, α and position, x (see Fig. 1). This is described by $E(\alpha) = E_0/\cos\alpha$ and $E(x) = E_0\sqrt{x^2/l^2+1}$, where E_0 is the energy of the x-ray reflected in the central scattering plane and l is the source-to-detector distance [4]. This feature allows one to collect energy spectra for a range of energy transfers simultaneously.
An analyzer working at 8979 eV, the Cu K edge consisting of Si(111) crystals with asymmetry factors 60 and 1/60 was built to show the feasibility of such measurements. The experiment was performed at beamline 3-ID of the Advanced Photon Source.

Results

Measurements verified the expected dispersion properties of the analyzer. The energy resolution is in the 120-200 meV range, the momentum resolution is 0.003 $Å^{-1}$ and the total angular acceptance is approximately 10 $mrad^2$. Due to double reflection of the x-rays this optic possesses better energy selectivity than a single reflection spherical analyzer.

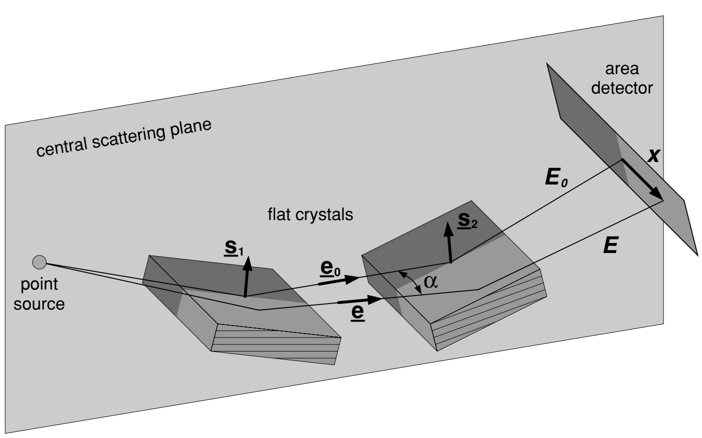

Figure 1. Schematic design of the double flat crystal analyzer.

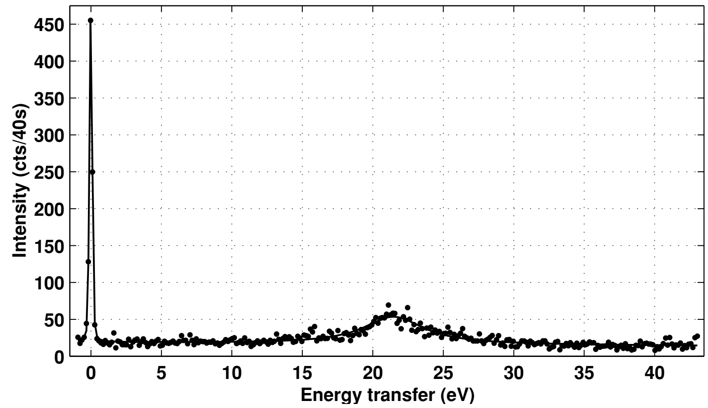

Figure 2. Inelastic x-ray scattering data from polycrystalline beryllium.

As an example, we show inelastic scattering data from polycrystalline beryllium (Fig. 2). The broad peak at 21.5 eV energy transfer results from plasmon excitations. The momentum transfer was 1.18 $Å^{-1}$, corresponding to 90% of the cutoff wavevector. This measurement demonstrates the good energy resolution and large accessible energy range of this analyzer.

Discussion

We showed that a double flat crystal analyzer is suitable for inelastic x-ray scattering experiments. The optic should be used along with a position sensitive detector to fully exploit its transmission properties. The gain compared to a single detector mode can be 10-50 depending mainly on the energy range covered by the analyzer. Comparative results show that a double flat crystal analyzer can be an alternative to a conventional spherical backscattering analyzer in anomalous or resonant inelastic x-ray scattering experiments or when high energy and momentum resolution is required.

Acknowledgments

The authors would like to thank P. Lee, M. Hu and H. Sinn of Argonne National Laboratory for many useful discussions and for their help in the experiments. Use of the Advanced Photon Source was supported by the U.S. Department of Energy, Basic Energy Sciences, Office of Science, under Contract No. W-31-109-Eng-38.

References

[1] W. Graeff et al., *Nucl. Instr. and Meth.* **195**, 97-103 (1982).
[2] B. Dorner et al., *Nucl. Instr. and Meth.* A **246**, 450-451 (1986).
[3] T. S. Toellner in *Nuclear Resonant Scattering of Synchrotron Radiation*, edited by E. Gerdau & H. deWaard, Baltzer Science Publishers (1999).
[4] G. Bortel, E. E. Alp, W. Sturhahn, T. S. Toellner, submitted to *J. Synchrotron Rad.*