Further Development of Multilayer Analyzer Array Detectors

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We report our efforts for the further development of energy-resolving x-ray fluorescence detectors using synthetic multilayers.[1,2] The energy photon selection is based on diffraction of graded multilayers. After the multilayer "discrimination," energy photons will be collected with non-energy-resolving detectors. Thus the system will have no count rate limitation problems encountered by solid-state detectors at the third-generation synchrotron sources. In last year's report, we demonstrated the performance of our testing unit of such a detector, which yielded a throughput of 26% and a rejection rate of 15.

To improve the throughput and rejection rate, we have modified the design and multilayer deposition parameters. Our second unit of the Multilayer Analyzer Array Detector (MAAD) containing 20 elements was constructed. Similar to the first testing unit, the detector is tunable over a wide energy region, with decreased solid angle at higher energies. Two large area scintillator/PMTs are used for data collection behind the multilayers, which are working under current integration or a photon counting mode.

The detector was tested at beamline 18-ID (BioCAT), at the Advanced Photon Source, Argonne National Laboratory under real data collection conditions. The tests were performed in a wide energy region, namely from Ca Kα to Hg L_{III}, to access the reliability of the detector. The beam was generally 0.2 mm vertical and 0.3-0.5 mm horizontal. It was found that the multilayers remain tuned in the region once aligned to each other at the Fe Kα energy. The initial setup of the detector usually takes a few hours or less to adjust the vertical and horizontal position of the detector relative to the x-ray beam. Once aligned to the beam, an energy change can be established by collection of detector calibration curves, which can be as short as a few minutes.

Figure 1 shows a detector calibration curve collected on a 0.7 mM Fe sample solution with fixed beam entrance slits. By increasing the angle of the multilayers in the diffraction plane, the detector elements started to block the direct beam (which is the portion directly from the sample and without interception by the multilayers) from entering the ionization chamber. This decline of direct beam signal is followed by a large peak and a much smaller peak from the reflection of the multilayers. The large peak corresponds to the diffraction of elastically scattered x-ray photons having an energy at 7.4 KeV and the smaller peak corresponds to Fe Kα fluorescence energy. Since the photons having the incident x-ray energy are the major part impinging on the multilayers, the reflectivity at this energy will be a measure for throughput, which is approximately 38%. It can be seen from the figure that the signal-to-background ratio in this case is roughly 18 to 1. XAFS data collected using the multilayer detector on this sample (data not shown) shows a signal-to-background ratio of 2 to1 in reference to the edge step. Thus the resulting background rejection ratio is 36.

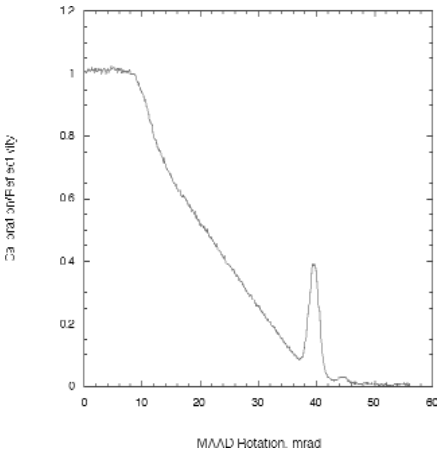

FIG. 1. Prototype detector calibration on a 0.7 mM Fe sample solution. The vertical entrance slits size was approximately 3.5 mm.

Initial tests of the detector at synchrotron beamlines show that this improved multilayer detector has a better throughput and background rejection rate. Similar to the testing unit, the detector is easy to operate and reliable. The throughput of the detector is 35-40%, and the rejection ratio is 30 to 40 times, resulting in an effective count increase of 10 to 16. The detector has been deployed at the BioCAT beamline for XAFS data collection. Further tests and improvements of the MAAD are underway.

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References

[1] K. Zhang, G. Rosenbaum, and G. Bunker, J. Synchrotron Rad. **5**, 1227-1234 (1998).

[2] K. Zhang, G. Rosenbaum, and G. Bunker, J. Synchrotron Rad. **6**, 220-221 (1999).