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Fluorescence XAS by Highly Segmented X-ray Detection –Beyond Conventional Applications

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Abstract content

X-ray absorption spectroscopy (XAS) is a powerful local structural tool which rapidly prevailed in chemistry, biology and materials science, associated with the dedicated synchrotron radiation facilities (2nd generation storage rings) in the 1980's. Severely limited applicability of conventional XAS, partricularly, sensitivity in transmission experiments was solved by a fluorescence detection, for which high photon flux and high efficiency in x-ray detection were both essential. For the former, focusing optics (bent mirrors and sagittal focusing) and insertion devices (multipole wiggler etc.) improved excitation efficiency, while for the latter, x-ray detection with a high energy resolution and throughput was required. Combination of the two approaches successfully lowered concentration limit since the late 1980's, that was reflected in the rapid growth of applications to dilute systems (biological samples) and thin films.
Since x-ray detection effiency is dependen on the two competing specifications, i.e., energy resolution and throughput, segmented fluorescence detection is realistic in recording x-ray signals over a wide solid angle. Here we focus on a germanium pixel array detector (PAD) that consists of densely arranged (10 x10 array) pure germanium pixels (5 mm x 5 mm)1. This x-ray detector not only improved the quality (statisctics) of XAS but also opend up novel application fields beyond a conventional use. As examples of new research fields available by PAD, polarized experiments on HTSC thin film single crystals (100 nm)2 and photo-induced phase transition in powder (<1 mg) specimen3 are described.
In the 1990's, demands on high brilliance of synchrotron radiation aimed at imaging accelerated the costly ultra-low emittance (<10 nmrad) storage rings with a high energy (6-8 GeV). Tunable x-ray undulator radiation provided high brilliance and high flux x-ray beam in the hard x-ray region (5-40 keV), makinmg possible probing samples with a limited size or volume. However, more recently, a new class of ultra-low emittance storage rings with a medium energy range (2.7-3.5 GeV) is taking over the leadership. The successful proliferation of the 3rd generation storage rings is strongly dependent on the progress in "in-vacuum" undulator technology4 that allows a small gap distance of magnets. Indeed a comparable high brilliance with that of high energy machines is achievable by "in-vacuum" undulators inserted in a "cost-concious" medium energy storage ring. Future prospects of fluorescence XAS using such facilities will be discussed.

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Summary

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