Full-field X-ray fluorescence imaging with coded apertures

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X-ray spectroscopy is a valuable investigation tool for many applications in various research fields. However, imaging with X-rays is a challenging field, due to their optical properties. The fabrication of appropriate optics is usually expensive and requires an elaborate manufacturing process. One simpler and less expensive possibility of imaging high energy radiation is coded aperture imaging, a technique well established in astrophysics [1, 2] and also used in nuclear medicine [3] or radiation detection, e.g., for nuclear decommissioning [4].

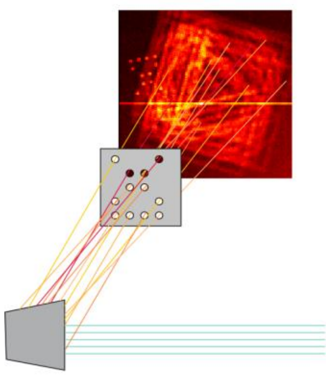

Figure 1: Scheme of full-field X-ray fluorescence imaging with coded apertures

Here, we present the adaption of coded aperture imaging (CAI) for X-ray fluorescence spectroscopy in the nearfield. The principle has already been described [5, 6]. The sample is irradiated with X-rays and the produced fluorescence falls through a mask, the coded aperture, onto a position sensitive detector (see Figure 1). The obtained picture consists of many overlapping projections of the object. The information of this picture is retrieved in a reconstruction step. In this work we compare different reconstruction methods. We used a mask based on a modified uniformly redundant array (MURA) [7]. The most commonly used reconstruction method, the convolution of the detected image with a decoding mask, does not always deliver satisfactory results. This is more noticeable for small distances between the object, mask and detector. Hence, we developed a new reconstruction method, based on iterative algebraic optimization, a technique adapted from computed tomography (CT). It shows good performance even in those cases where the convolution method fails. This provides a basis for further investigations of the ideal parameters for near field coded aperture imaging and refinements of the algorithms. Further reconstruction methods that were tested are based on an evolutionary algorithm and a mixed-scale dense convolutional neural network (msdnet [8]).

We performed first measurements with a coded aperture at the BAM*line* at BESSY II. The detector we used is a pnCCD, an energy-dispersive array detector, which allows spatial and energy-resolved measurements [9]. This allows mapping the elemental distribution of the sample in a single measurement, with an increase in count rate compared to a single pinhole or a polycapillary optic. We could successfully reconstruct different test objects with different elemental compositions from the obtained recorded images [10]. This opens the way for fast, element-specific X-raw fluorescence measurements.

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