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Benchtop X-ray Fluorescence Microtomography Based Polycapillary

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As a unique methodology in the investigation of element distribution, the X-ray fluorescence microtomography (μXFCT) based on synchrotron radiation, has been applied to numerous fields. To meet user's requirements, a SR-μXFCT system has been designed and constructed at the Shanghai Synchrotron Radiation facility (SSRF)[1-3]. However, the applications of μXFCT, which takes an enormous amount of acquisition time to acquire a 3D tomographic image, is limited by the complex and huge experimental facilities. In recent years, the benchtop X-ray fluorescence microtomography system underwent rapid development. The laboratoryμXFCT system has many merits, such as wider applications, availability and convenience. In this paper, a laboratory-source-based μXFCT system was developed, in which a polycapillary lens is employed to focus the X-ray beam and improve the flux density. The maximum likelihood expectation maximization (MLEM) algorithm was used to reconstruct the FCT slices in a limited number of projections.

Fig. 1 is the schematic layout of the benchtop μXFCT system. In the system, the highest electric voltage of X-ray tube is 150kV. For μXFCT imaging system, usually a pencil beam which is used to achieve the projections is preferred. This means that for the case of focused beam, the depth of focus（DOF）of the polycapillary lens is a key parameter. If the DOF is less than the size of the sample, or the sample is not placed among the focal depth, the focused X-ray along the sample is divergent, which will result in an inaccurate reconstruction of the sample. Hence, the DOF of the polycapillary determines the maximal size of the experimental samples. According the experimental results, the focal spot size is 82 μm×82 μm and the DOF of the polycapillary lens is 7 mm in the system. To evaluate the capabilities of the XFT system, a series of test samples were used. The first test sample is a thin walled borosilicate capillary with an outer diameter of 2 mm and a wall thickness of 20 μm. The capillary was filled with standard iodine solution. As shown in Fig. 2(a), the capillary is filled with 1000ppm iodine solution. The sample is mounted on a high-precision stage. The sample is adjusted among the depth of focus. The sample was scanned with 60 translations in 150 μm. The exposure time per step was 6 s and a 6° angular interval for the CT scanning was adopted. The iodine distribution reconstructed by MLEM algorithm was shown in Fig. 7(b). The experimental results demonstrated that the developed system could reveal the elemental distribution inside the test sample.

In μ-XFCT studies, the sample is scanned line by line with a pencil beam of synchrotron X-rays, which takes an enormous amount of acquisition time to acquire a 3D tomographic image. A full-field X-ray fluorescence computed tomography is to be developed at SSRF to improve the test efficiency[4]. The object is illuminated with a whole-volume incident beam. And X-ray fluorescence photons are collected by an X-ray detector with a polycappillary collimator. Base image fusion from XFCT image and TCT image, the resulting image will be more informative: from structural imaging to functional imaging. Future 3D elemental imaging will greatly benefit from advances in detector technology, as it will allow to use shorter exposure times, faster read-out and a higher quantum efficiency. We expect significant instrumental improvement in the years to come making 3D elemental sensitive imaging widely used.

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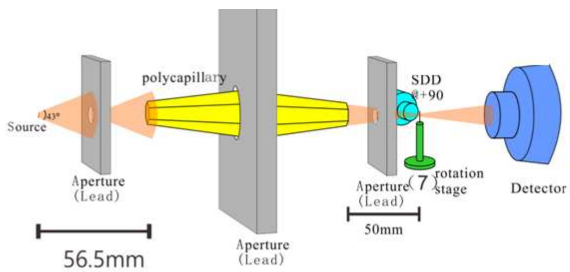

Figure. 1. Schematic layout of the laboratory XFT system

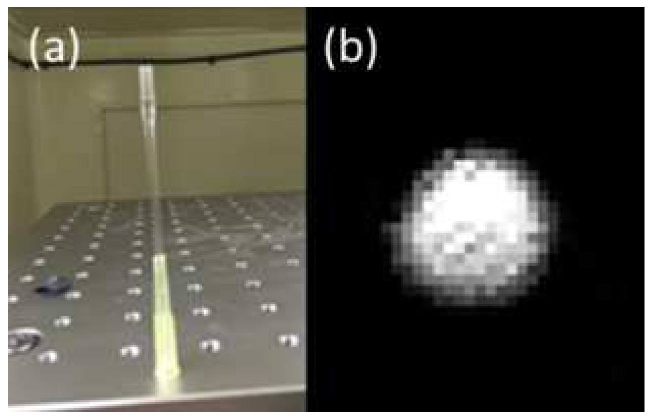

Figure. 2. The experimental results of the iodine, where (a) picture of the capillary filled with 1000 ppm iodine solution; (b) reconstructed iodine concentration

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