RESOLUTION OPTIMIZATION OF THE KRAKOW X-RAY MICROBEAM

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HAMAMATSU X-RAY SOURCE

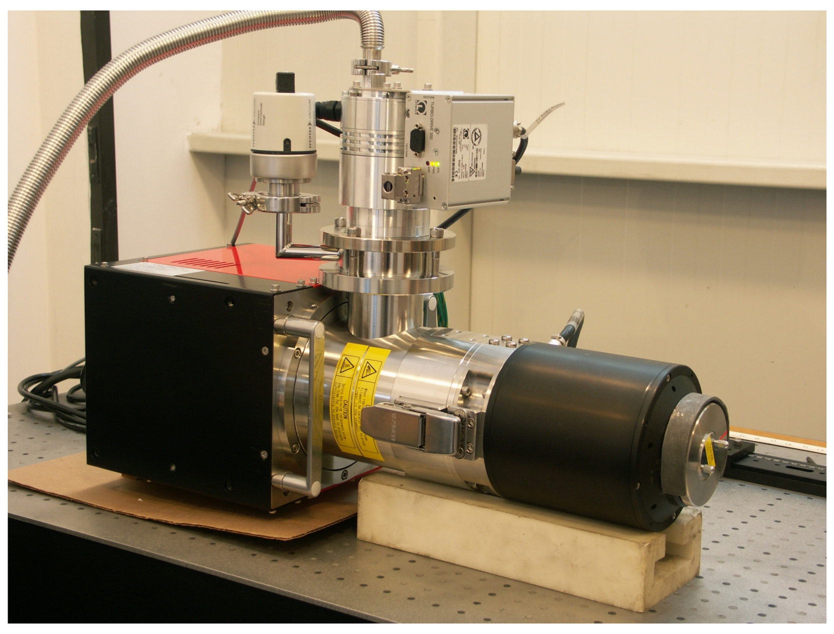


Fig. 1. Hamamatsu X-Ray Source

Voltage range: 20 kV - 160 kV
Current range: 0 - 200 μA
Minimum spot size: 1 μm
Cathode material: Tungsten
Targets materials: Ti (4.5 keV), Mo (17.47keV), Ag (22.2keV), W (8.4keV, 59.3keV)
X-ray beam angle: 120 degrees

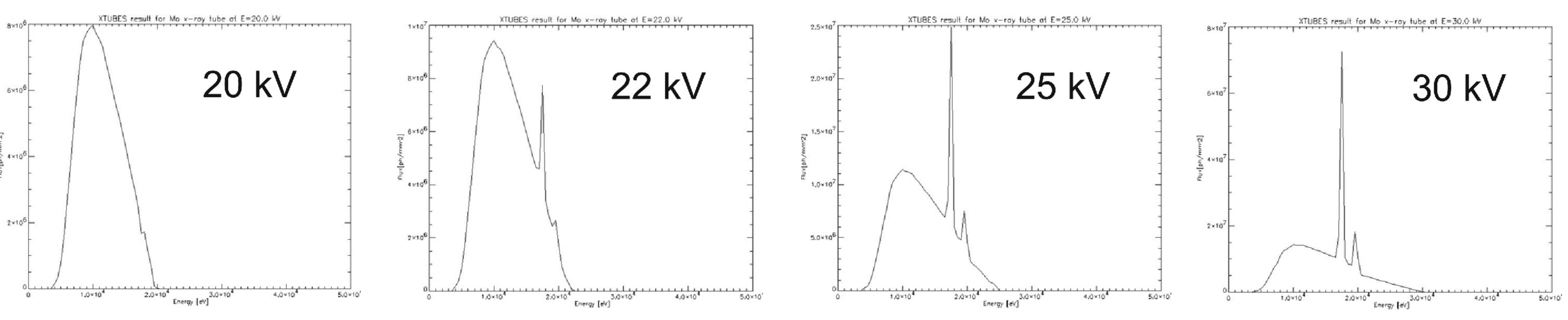


Fig. 2. Hamamatsu X-Ray Source Spectrum

KIRKPATRICK-BAEZ X-RAY FOCUSING MIRRORS

Total Reflection Mirrors

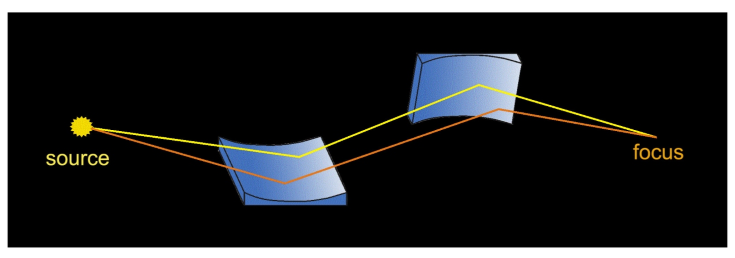


Fig.3

Two total reflection mirrors, with focusing distance of 220 mm, produced by the Xradia Inc. (USA) and optimized for the 17.5 keV radiation (Mo Kα) are used for the μXRF and TXRF beam line (fig.5). The geometry of mirrors permits for focusing radiation in the range 4-25 keV.

Multilayer Mirrors

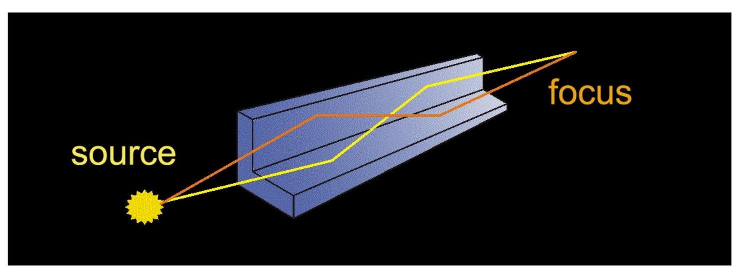


Fig.4

Two multilayer mirrors, with focusing distance of only 15mm, manufactured by the Rigaku Innovative Technologies Inc. (USA) and optimized for the 4.5 keV X-ray energy (Ti Kα) are used in the cell irradiations facility (fig.6). Due to interference in multilayer structure the focusing system is working as monochromator, reflecting only Kα titanium line.

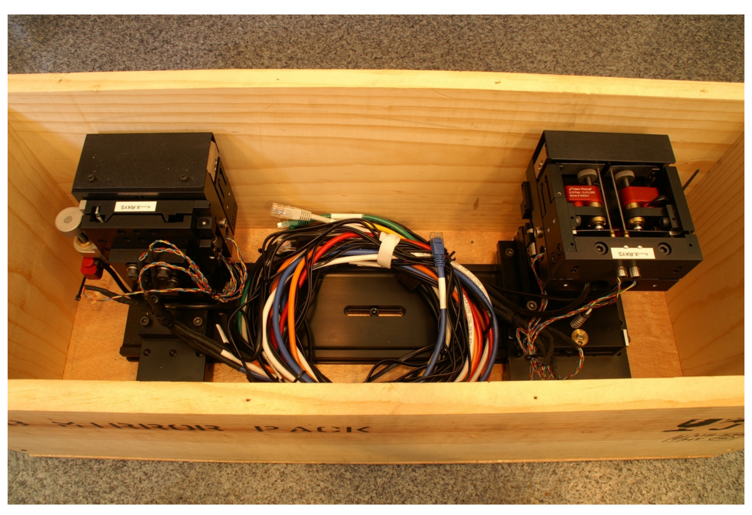


Fig.5

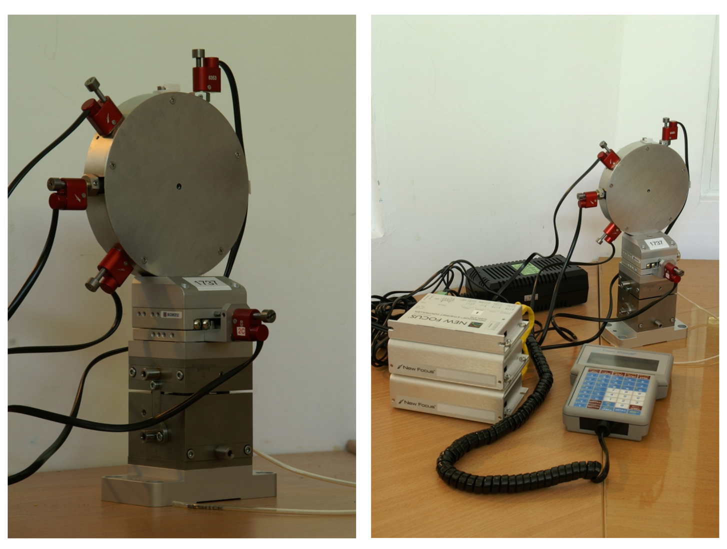
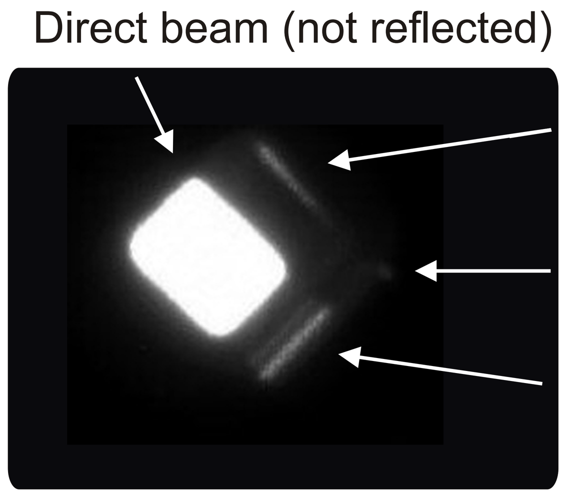


Fig.6

Multilayer mirrors focusing - preliminary results

Direct beam (not reflected)



Beam reflected from the first mirror

Doubly reflected beam (beam reflected from both mirror surfaces)

Beam reflected from the second mirror

Fig.7

X-Ray Source Resolution Measurements

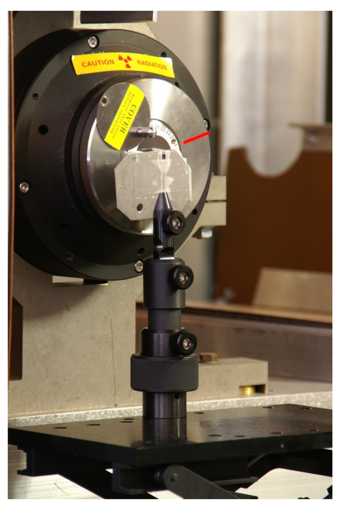


Fig.8

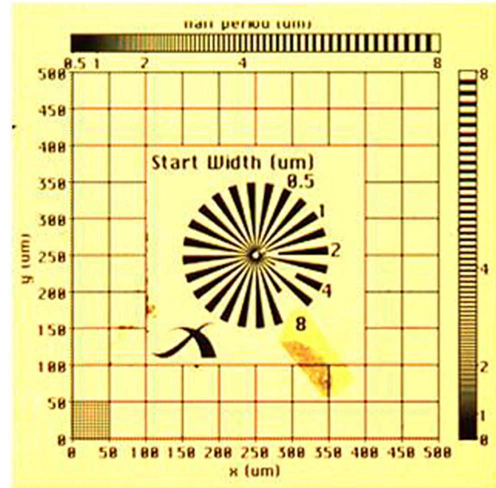


Fig.9. Pattern tile

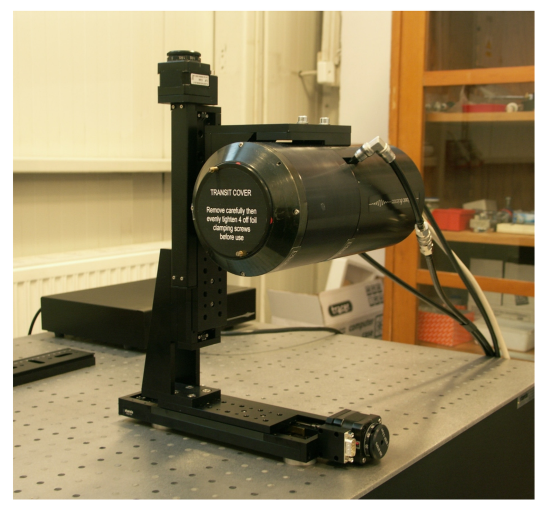


Fig.10. Photonics X-ray camera

In order to determine the emission spot size we use the special tile delivered by Xradia Inc., which is situated in front of the tube (fig.8). Pieces of high density material create the pattern on the tile (fig.9). Radiation emitted from the tube creates the image of the pattern in the Photonics X-ray camera (fig.10). The ability to distinguish individual details in the picture gives us information about the spot size, which determines the resolution. Measurements for various values of the tube voltage have been carried out. Some results are presented below.

20 kV

80 kV

100 kV

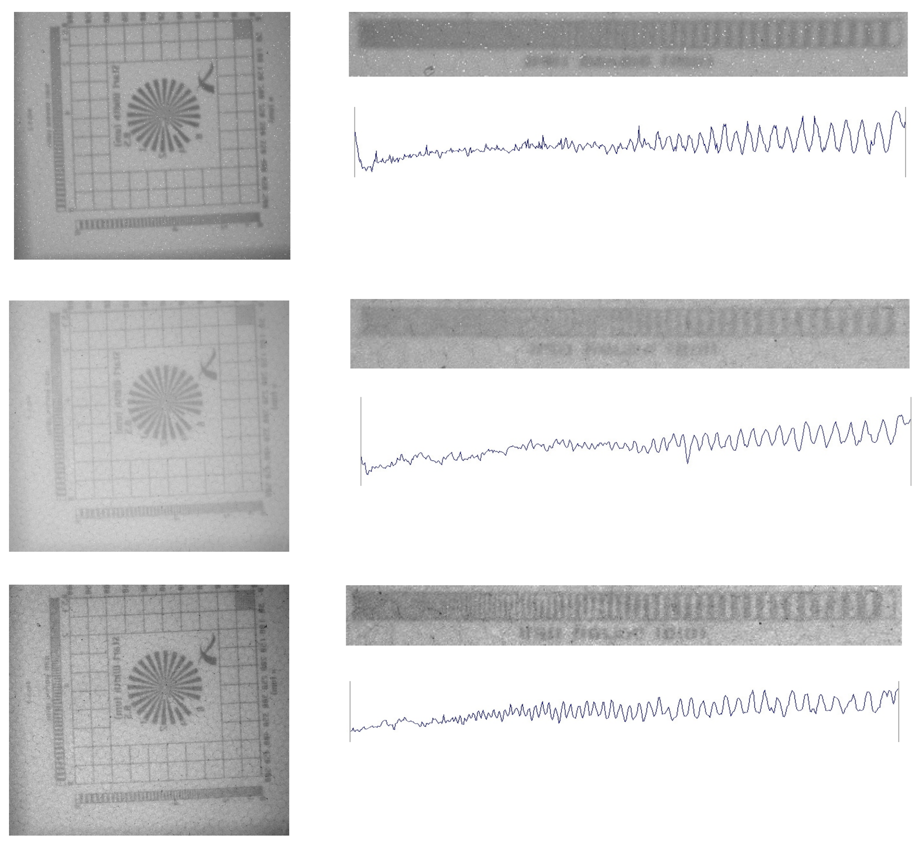


Fig.11. X-ray images of the pattern tile for the tube voltage of 20, 80 and 100 kV. Graphs present pixel brightness.

The spot size, which determines the resolution, depends also on the current of electomagnetic lenses focusing electrons inside the tube. These relations for the tube voltage of 20kV and 100kV are shown in the graphs below. Such curves have been obtained for tube voltages of 20 (fig.12), 60, 80 and 100 kV (fig.13). The last graph (fig.14) presents the relation between the accelerating voltage and minimum spot size obtained.

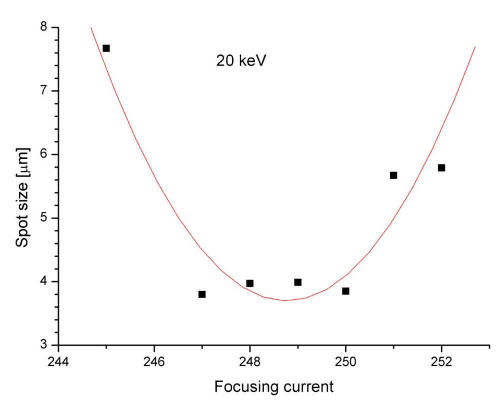


Fig.12

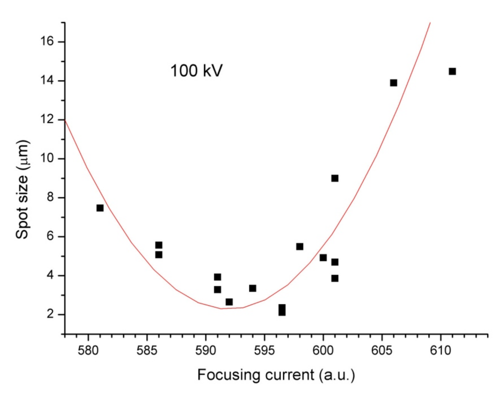


Fig.13

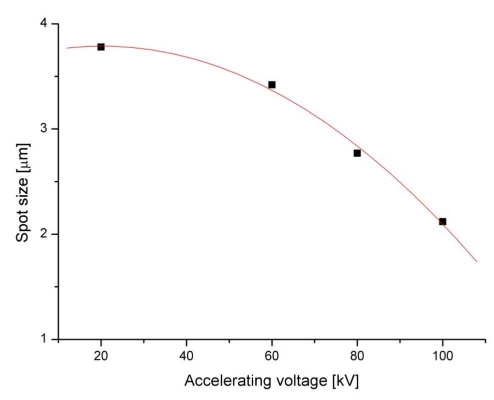


Fig.14

FUTURE APPLICATIONS

- Micro X-ray Fluorescence and Total Reflection X-Ray Fluorescence
- Irradiation of individual biological cells
- Microtomography, microcrystallography

Fig.15. PI motorized translation stages provide linear motion in range of 25 millimeters with minimum incremental motion of 50 nanometers for precise irradiation of individual biological cells.

Experiments at the microprobe are controlled by a program basing on the LabVIEW software (fig.16). LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. This reminds of block algoritms in classical programming, however LabVIEW compilates and executes these drawings without necessity of rewriting them into the lines of text. LabVIEW is a very useful tool to process data from miscellaneous devices, control their work and connect their functionality together in a one common project.

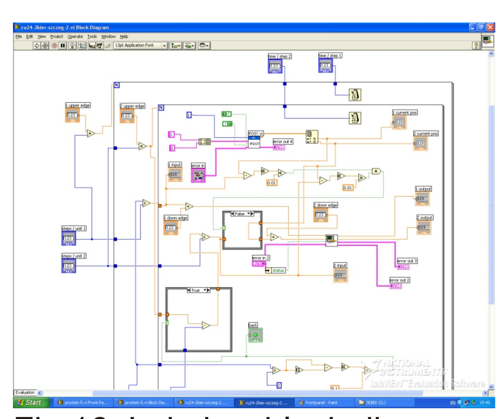


Fig.16. Labview block diagram

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