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Mini-Transfocator for X-ray Focusing and Microscopy

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Over the last 20 years, X-ray compound refractive lenses (CRL) [1] and lens-based optical systems became an important part of modern X-ray optics and synchrotron instrumentation. They currently play a significant role in high-resolution X-ray imaging, microscopy, beam-shaping, beam-conditioning and focusing of X-ray radiation down to a submicron scales. They can be adapted to X-ray energies from 2 to 200 keV by modifying their composition and number, and can be easily inserted and removed from the beam allowing a fast changing of the beam size [2]. As the index of refraction for lenses is extremely close to unity and energy dependent, a considerable, well defined number of lenses are necessary to focus X-rays of a given energy at a certain distance. Because of that, transfocators - systems with a tuneable number of lenses - have been proposed to provide permanent energy and focal length tunability [3-4]. The transfocators are comprised of several cartridges containing different numbers of lenses, so that the focal distance can be continuously adjusted by insertion or retraction of one or more of the lens cartridges.

The transfocators are very flexible, and has been used in several different configurations. Either as a standalone focusing device in the monochromatic beam, giving micrometer spot sizes. Or as pre-focusing devices in conjunction with a downstream micro- or nano-focusing elements. As a single optical device in the white beam, the transfocator can act as a fundamentally new kind of monochromator, delivering impressive flux in a ~1% band pass beam [4]. Changing the concept of synchrotron beamlines, transfocators have spread widely - currently around half of ESRF and DESY beamlines are equipped with them.

Despite all the advantages, the implementation of massive transfocators does not fully meet the needs of some experimental applications requiring compact and lightweight zoom-optics (with variable focal length) in order to perform *in-situ* X-ray imaging, microscopy and introscopy. Most importantly, the use of compact transfocators allows to identify the internal structure, features and morphology of samples, and to track dynamical and structural changes, which is especially necessary under extreme conditions [5]. And such studies do not necessarily require specialized imaging beamlines.

In this paper, we propose a mini-transfocator, which is depicted in Fig. 1. The length, width and height of the mini-transfocator are 150 mm, 100 mm and 90 mm, respectively. As a result, the overall weight of the device is less than 2 kg. All materials and components are vacuum compatible and manufactured with high accuracy. The device is supplemented by the control unit which is based on a single-board Linux computer, thus enabling easy integration into any synchrotron beamline. Stepper electromotor drives up to 50 of single refractive lenses in the beam path. In contrast to conventional heavy and complex transfocators, based on movable stacks with binary system of lens cartridges, the mini-transfocator moves lenses individually one by one, thus providing smooth variation of focus and magnification. Lenses are

located close to each other to reduce optical aberrations associated with gaps between lenses.

The transfocator was successfully tested for optical accuracy, mechanical performance and repeatability at the Micro-optics test bench in the X-ray optics laboratory of the Immanuel Kant Baltic Federal University. Tests for the accuracy of the lens positioning showed that the optical axis deviates from its mean position by less than 0.4 μm in both OX and OY directions. Further tests on X-ray focusing and microscopy were also done at the P14 beamline at the PETRA-III. Results indicate that mini-transfocator is suitable for a wide range of applications, being either a beam collimation system or a short-focal magnifying objective [6].

References:

[1] Snigirev, A., Kohn, V., Snigireva, I. & Lengeler, B. Nature 384, 49–51 (1996).
[2] Snigirev, A. & Snigireva, I. Comptes Rendus Phys. 9, 507–516 (2008).
[3] Snigirev, A. et al. J. Phys. Conf. Ser. 186, 8–11 (2009).
[4] Vaughan, G. B. M. et al. J. Synchrotron Radiat. 18, 125–133 (2011).
[5] Dubrovinskaia, N. et al. Sci. Adv. 2, e1600341 (2016)
[6] This research was supported by the Ministry of Education and Science of the Russian Federation № 14. Y26.31.0002

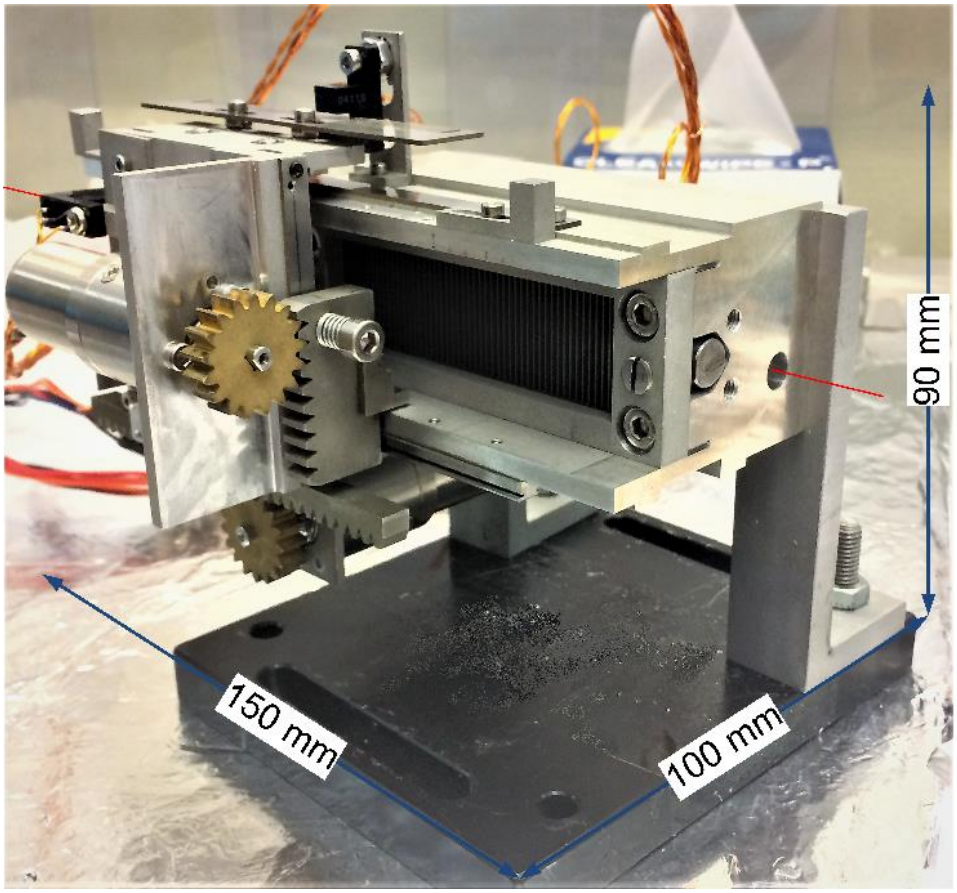

Fig. 1. Photo of the X-ray mini-transfocator

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