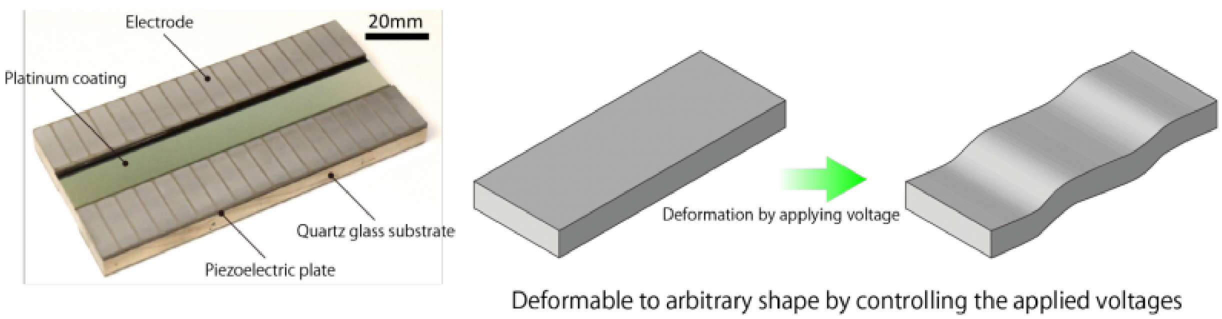

Achieving a breakthrough in the formation of beam size controllable X-ray nanobeams

July 11 2016

Fig. 1: Developed deformable mirror. Credit: Osaka University

A research team in Japan has now succeeded in developing high precision X-ray deformable mirrors that can be configured as necessary. They are the first to have achieved the formation of three types of X-ray focused beams, which differ in focused spot size, without changing the experimental setup. These findings constitute a considerable step towards developing a multifunctional X-ray microscope, which will be able to perform a variety of microscopic analyses in one device.

X-ray analysis is applied in many fields such as medicine, industry and research. By sharply focusing X-rays it is possible to conduct high-sensitivity and high-resolution analysis. So far, however, X-ray analysis and X-ray microscopes are lacking the flexibility of electron microscopes as one device is merely capable of sending a fixed set of focused beams thereby limiting the range of uses of the device. The research team centering around Professor Kazuto Yamauchi, Assistant Professor Satoshi Matsuyama both at Graduate School of Engineering, Osaka University, Professor Yoshinori Nishino at Research Institute for Electronic Science, Hokkaido University), Director Dr. Tetsuya Ishikawa and Group Director Dr. Makina Yabashi at RIKEN SPring-8 Center, Hyogo prefecture successfully developed deformable mirrors that can be configured as necessary. By combining four of these mirrors, a new X-ray focusing system, in which the focused spot size is controllable, was developed. This removes the necessity of having to change experiment setups, including the position of the sample. The adaptive focusing system were developed at the large-scale synchrotron facility SPring-8, located at Harima Science Garden City, Hyogo prefecture, where the world's brightest radiation light is created.

With the new system it is now possible to create light collection optical systems, which differ in numerical aperture, an index indicating the ability of a lens or mirror to focus light, just by changing the configuration of the deformable mirrors. Changing the numerical aperture allows for a controlling of the focused spot size close to the diffraction limit of a lens or mirror, that is the limit of its ability to focus light because light is being diffracted. The researchers developed an X-ray wave front measuring technique with which to determine mirror configuration errors with high precision and control deformation with an accuracy of 2nm. The research team conducted this procedure with precision for three optical systems with different numerical apertures.

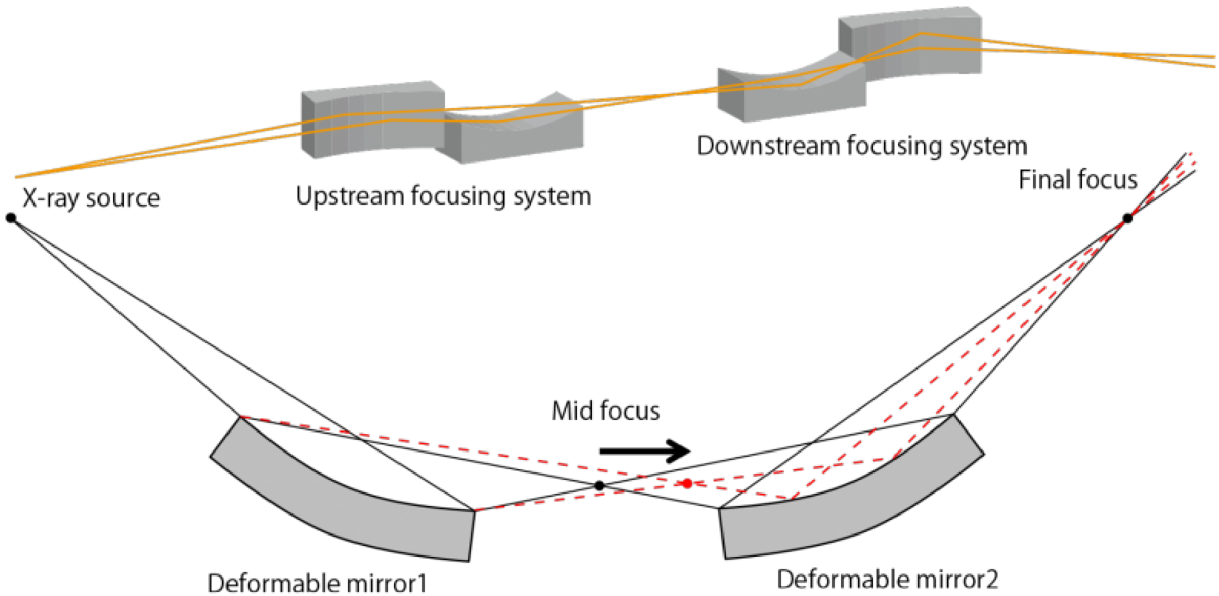

Fig. 2: Schematic of variable-NA focusing optical system. The two deformable mirrors are arranged perpendicular to each other (KB configuration). The variable-NA X-ray focusing system based on two sets of the mirror system were constructed (upper figure). The lower figure shows the schematic ray diagram. Credit: Osaka University

The results of this research will contribute to the development of a multifunctional X-ray microscope that is able to perform a variety of X-ray/X-ray-microscopic analyses by forming optimal beam sizes for each analysis. Especially in the development of advanced X-ray sources such as X-ray free electron lasers of which exist only two in the world (Japan and America) and ultra-low emittance radiation sources, an internationally competitive research field to develop the next generation radiation source, these research results will contribute to the introduction of new and effective styles of conducting experiments.

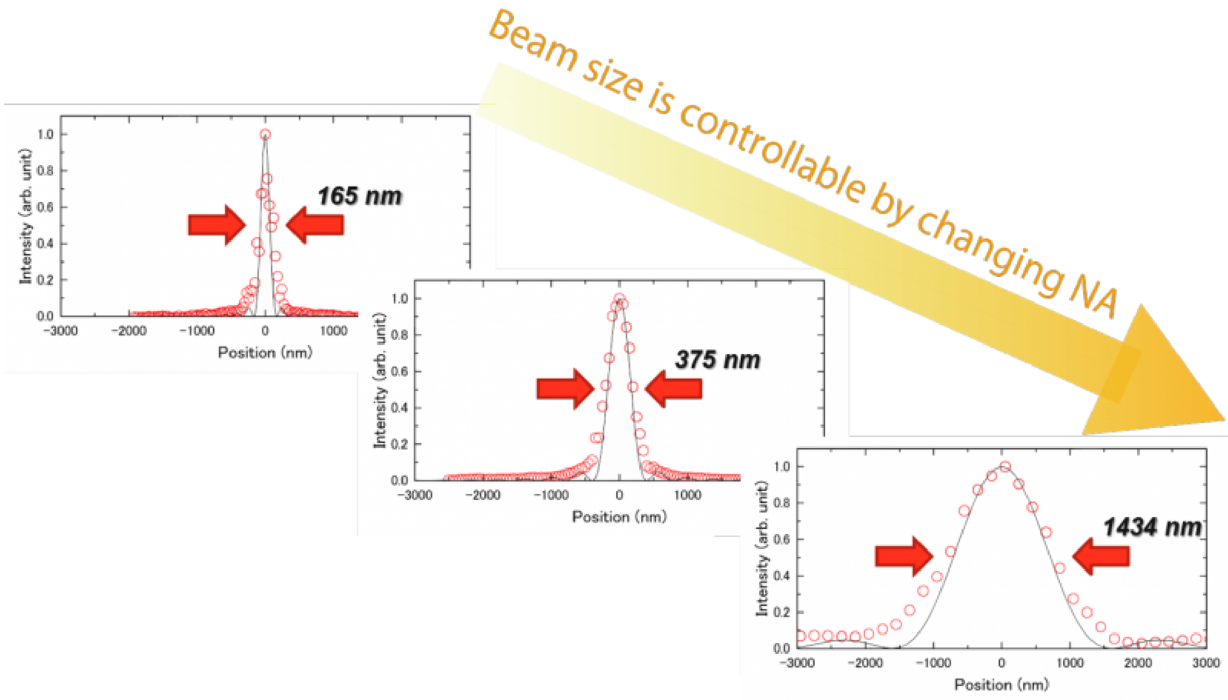

Fig. 3: Beam profiles of the formed X-ray nanobeam. The dots and the solid lines show experimental and simulated results, respectively. Credit: Osaka University

More information: Satoshi Matsuyama et al. Nearly diffraction-limited X-ray focusing with variable-numerical-aperture focusing optical system based on four deformable mirrors, *Scientific Reports* (2016). DOI: 10.1038/srep24801

Provided by Osaka University

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(2016, July 11) retrieved 26 April 2024 from https://phys.org/news/2016-07-breakthrough-formation-size-x-ray-nanobeams.html