Synchrotron Radiation X-Ray CT Technique for Non-Destructive and High-Resolution Investigation of Internal Structures of Materials

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As a precise observation for the three-dimensional internal structures of object, an x-ray micro-CT using a simple x-ray projection optics, and an x-ray nano-CT based on an x-ray microscope using an x-ray optical device Fresnel zone plate (FZP, Fig. 1) are available at the large synchrotron radiation facility SPring-8. They are used properly according to the purpose such as the size of the sample and required spatial resolution. Although micro-CT has a certain flexibility in the size of sample (several hundred μm to several cm) and in the x-ray energy (several keV to several tens keV), but the spatial resolution is limited to be about 1 μm or larger. On the other hand, although nano-CT has a high spatial resolution of approximately 100 nm, x-ray energy range is limited to be around 10 keV or lower. In applications such as metals, minerals, ceramics, devices, batteries and so on, therefore, it is necessary to cut out the sample to be smaller than about 100 μm in diameter in order to sufficiently transmit x-rays. In order to investigate the physical properties, however, it is necessary to observe the internal structure with high spatial resolution while maintaining the bulk state as much as possible. In order to make it possible, it is necessary to realize a high-energy x-ray nano-CT, but it has not been realized so far because of the manufacturing difficulties of FZP; very fine and thick zone structure are required for high energy x-ray region. We developed a new FZP called apodization FZP as shown in Fig. 1. This device has gradually thick zone structure at the central region that realizes high efficiency at the high energy x-ray region. This device enables to realize a high-energy x-ray nano-CT. In addition, as shown in Fig. 2, multiscale-CT using a micro-CT and a nano-CT becomes possible. At first, the entire sample is observed with micro-CT, then the region of interest is locally observed with higher spatial resolution by high-energy x-ray nano-CT. Details of the multiscale-CT will be presented in the symposium.

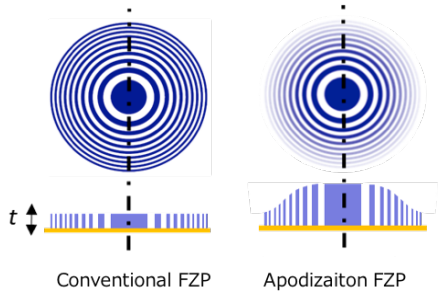

Fig. 1 Schematic drawings of x-ray optical device Fresnel zone plate (FZP). Left: conventional FZP with flat zone structure, right: apodization FZP with gradually changing zone thickness.

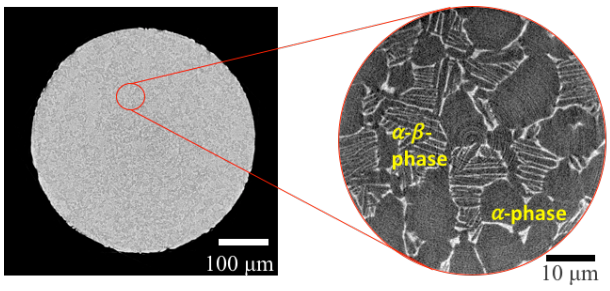

Fig.2. Measurement example of multiscale-CT. sample: Ti-6Al-4V alloy. Left: CT image obtained with micro-CT, right: CT image corresponding to the circled region in the left figure observed with high-energy nano-CT newly developed.

Bibliography

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