X-ray Phase Imaging Based on Grating Interferometry

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Abstracts: *While X-ray phase imaging was studied at synchrotron radiation facilities since 1990s, X-ray grating interferometry has been attracting attention since early 2000s because X-ray phase imaging can be implemented with not only synchrotron radiation but also compact X-ray sources. Therefore, variety of configurations of grating interferometry are studied with the participation of industry for practical applications to medicine and non-destructive testing. Cutting-edge synchrotron-based X-ray phase imaging is also explored thanks to grating interferometry. In this presentation, our recent activities in this field are presented with the principle of grating-based X-ray phase imaging.*

Since the discovery of X-rays, X-ray transmission imaging relying on absorption contrast is widely utilized for various purposes. However, X-ray absorption contrast is not strong for the objects consisting of low-Z elements, X-ray transmission imaging is not effective for biological soft tissues and polymers. To overcome this problem, since 1990s X-ray phase imaging has been studied extensively. Various phase-contrast techniques were developed at synchrotron radiation facilities and excellent image quality beyond the common sense in conventional X-ray radiography was demonstrated. This is based on the fact that the interaction cross section of X-ray phase shift is about a thousand times larger than that of absorption for light elements. X-ray phase imaging has been one of key applications at synchrotron radiation facilities, and a spin-off movement is also expected strongly for its practical applications to medicine and industry. X-ray grating interferometry emerged in 2000s meets this demand.

X-ray grating interferometry, which consists of transmission gratings, is used to detect slight X-ray refraction caused by a sample. Unlike the phase-contrast methods based on the Bragg diffraction by single crystals, polychromatic plane-wave X-rays are available. This property allows us to establish various unexplored X-ray phase imaging setups. One is the combination with an X-ray imaging microscope equipped with a Fresnel zone plate for realizing X-ray phase imaging with a mesoscopic spatial resolution. Other is the operation of grating interferometry under white synchrotron radiation for realizing dynamic X-ray phase imaging and furthermore four-dimensional phase tomography. Outside the synchrotron radiation facilities, apparatuses for diagnosing joints by depicting cartilage and for mammography are under development in collaboration with Konica Minolta. The former is especially successful and prototypes have been installed in hospitals and used for the study of early diagnosis of rheumatoid arthritis. Statistical examination is in progress by the help of healthy volunteers and patients with informed consent. The developments for non-destructive testing was also launched successively in collaboration with Rigaku, and a scanner type X-ray phase imaging apparatus has been developed.

These activities both with synchrotron radiation and laboratory sources are presented with fundamental description of X-ray phase imaging principle.