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学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（情報科学）　　氏名　カクレル　クリシュナ　プラサード

学　位　論　文　題　名

Apodized illumination coherent diffraction microscopy for imaging non-isolated objects
（非孤立物体のイメージングのためのアポダイズ照明コヒーレント回折顕微鏡）

Microscopy is one of the widely exploited tools in the modern scientific research. Various modalities of microscopes with different probes exist today. With the nature of the probe used, the complexity of the design and the functioning of the microscopic techniques differ. The core content of this thesis describes the development of a category of microscopic technique which performs imaging without making the use of any imaging (objective) lens. It rather reconstructs the image computationally by using iterative phase retrieval algorithms. Such microscopic or imaging technique is known in the user community as lensless imaging.

The lensless imaging method that will be discussed in this thesis is coherent diffraction imaging (CDI). The method is characterized by image formation by computational lens dispensing the need of physical objective (imaging) lens. Hence, coherent diffraction imaging is a technique more appropriate at shorter wavelengths where fabrication of high numerical aperture objective lens is challenging.

The successful phasing of diffraction patterns in CDI requires the satisfaction of oversampling requirement. Experimentally, this condition is satisfied by limiting the measurement of only the samples with the lateral dimension smaller than that of the illumination. Such restrictions, however, precludes the imaging of a wide range of important samples. This thesis introduces the development of coherent diffraction imaging method which relaxes the experimental constraint of sample isolation and images the non-isolated objects with focused illumination in a non-scanning mode. This is achieved by making use of optically generated localized illumination. This optically generated localized illumination will be referred as apodized illumination.

The design and construction of optical setup, at the visible light wavelength, for the generation of apodized illumination will be discussed. Coherent diffraction imaging of extended amplitude and phase object with apodized illumination will be elaborated. The imaging technique discussed here can, in principle, provide a wide field of view with resolution limited only by the wavelength of light. It also has the potential to extract the quantitative phase information from cells and tissues. The non-scanning nature of the proposed imaging method would be particularly helpful in studying the dynamics of the cellular process.

The proof-of-principle experiment at the visible light is extended to x-ray wavelength. A special optical system designed for this purpose will be discussed. The optical setup comprises of two pairs of a deformable mirror system. The process of generation of the apodized x-ray illumination using such optical setup will be explained. The application of the apodized illumination to scanning x-ray fluorescence microscopy (SXFM) and to coherent diffraction imaging will be presented. Suppression of the background in the image of a test pattern, as a consequence of the use of apodized illumination, in SXFM will be presented. In addition, imaging of non-isolated test object by coherent diffraction will also be discussed. The preliminary results of image-quality enhancement in SXFM can be extended to biologically important specimens. Imaging of non-isolated specimen by coherent diffraction imaging can also be further developed to obtain structural and functional information of samples with biological and material importance. The method will be more advantageous for imaging extended objects by coherent diffraction imaging with x-ray free- electron laser where other existing methods fall short.