Depth of Field Techniques for 3-Dimensional Imaging

Anne E. Sakdinawat[1,2], Mark A. LeGros[3], Weilun Chao[1], Erik H. Anderson[1], Peter Fischer[1], David Attwood[1]

[1] *Center for X-ray Optics, Lawrence Berkeley National Laboratory, Berkeley California 94720, USA*
[2] *University of California, Berkeley, Department of Bioengineering, Berkeley California 94720, USA*
[3] *Physical Biosciences Division, Lawrence Berkeley National Laboratory, Berkeley California 94720, USA*

Abstract. Soft x-ray tomography has been used to obtain high-resolution 3-D biological images at the cellular and sub-cellular level. However, the small depth of field for a high-resolution micro zone plate limits the sample thickness that can be reconstructed. Since the lateral resolution is directly proportional to the outermost zone width and the depth of field is directly proportional to the outermost zone width squared, an improvement in lateral resolution corresponds to an even greater decrease in depth of field. For example, at a wavelength of 2.4 nm, the depth of field for a 40 nm zone plate is 2.7 microns, but for a 15 nm zone plate, the depth of field is 375 nm. Therefore, obtaining 3-D images of specimens significantly thicker than the depth of field at higher resolution would require a different data acquisition and reconstruction method. A method of combining optical sectioning and tomography is proposed as a means of obtaining high-resolution 3-D images of weakly absorbing, thick samples. Utilizing the small depths of field, optical sectioning, which is performed by obtaining a series of through focus images and then deconvolving the images, can be used to form a 3-D data set. Combining optical sectioning with tomography allows improvement in the axial resolution of the 3-D image. This method involves performing optical sectioning at each angle, forming a projection image from the deconvolved set of images, and then reconstructing them using a tomographic reconstruction algorithm. A zone plate and a two-layer test sample have been fabricated using e-beam lithography to test this technique, and deconvolution results will be presented.