Coherent Diffraction Imaging

J. Miao
Department of Physics and Astronomy, and California NanoSystems Institute, University of California, Los Angeles, CA 90095.
miao@physics.ucla.edu

For centuries, lens-based microscopy, such as light, phase-contrast, fluorescence, confocal and electron microscopy, has played an indispensable role in the evolution of modern science and technology. In 1999, a novel form of microscopy, *i.e*. coherent diffraction imaging (also termed coherent diffraction microscopy or lensless imaging), was developed and transformed our traditional view of microscopy, in which the diffraction pattern of a non-crystalline object or a nanocrystal is first measured and then directly phased to obtain an image. The well-known phase problem is solved by the oversampling method in combination with iterative algorithms. Since the first experimental demonstration, coherent diffraction imaging has been applied to study a wide range of materials science and biological samples such as nanoparticles, nanocrystals, biomaterials, cells, cellular organelles and virions using synchrotron radiation, high harmonic generation and soft X-ray laser sources, free electron lasers, and electrons. In this talk, I will present the principle of coherent diffraction imaging and illustrate its broad application in materials/nano-science and biology.

References

1. H. Jiang, C. Song, C.-C. Chen, R. Xu, R., K. S. Raines, B. P. Fahimian, C. Lu,. T.-H. Lee, A. Nakashima, J. Urano, T. Ishikawa, F. Tamanoi, J. Miao, "Quantitative 3D Imaging of Whole, Unstained Cells by Using X-ray Diffraction Microscopy", *Proc. Natl. Acad. Sci. USA* **107**, 11234–11239 (2010).
2. K. S. Raines, S. Salha, R. L. Sandberg, H. Jiang, J. A. Rodríguez, B. P. Fahimian, H. C. Kapteyn, J. Du and J. Miao, "Three-dimensional structure determination from a single view", *Nature* **463**, 214-217 (2010).
3. J. Miao, T. Ishikawa, T. Earnest and Qun Shen, "Extending the Methodology of X-ray Crystallography to Allow Structure Determination of Non-Crystalline Materials, Whole Cells and Single Macromolecular Complexes", *Annu. Rev. Phys. Chem*. **59**, 387–409 (2008).
4. H. Jiang, D. Ramunno-Johnson, C. Song, B. Amirbekian, Y. Kohmura, Y. Nishino, Y. Takahashi, T. Ishikawa and J. Miao, "Nanoscale Imaging of Mineral Crystals inside Biological Composite Materials Using X-ray Diffraction Microscopy", *Phys. Rev. Lett*. **100**, 038103 (2008).
5. C. Song, H. Jiang, A. Mancuso, B. Amirbekian, L. Peng, R. Sun, S. S Shah, Z. H. Zhou, T. Ishikawa and J. Miao, "Quantitative Imaging of Single, Unstained Viruses with Coherent X-rays", *Phys. Rev. Lett.* **101**, 158101 (2008).
6. R. L. Sandberg, C. Song, P. W. Wachulak, D. A. Raymondson, A. Paul, B. Amirbekian, E. Lee, A. E. Sakdinawat, M. C. Marconi, C. S. Menoni, M. M. Murnane, J. J. Rocca, H. C. Kapteyn, J. Miao, "High Numerical Aperture Tabletop Soft X-ray Diffraction Microscopy with 70 nm Resolution", *Proc. Natl. Acad. Sci. USA* **105**, 24-27 (2008).