Lensless optical microscope

Hugues Giovannini*, Anne Sentenac*, Kamal Belkebir*, Denis Konan**
***Institut Fresnel, Université Paul Cézanne, 13397 Marseille Cedex 20, France**
****INP Houphouët-Boigny, Yamoussoukro, BP 1083, Ivory Coast**
E-mail : hugues.giovannini@fresnel.fr

KEY WORDS: diffraction tomography, synthetic aperture, optical microscope, inverse problem.

Due to the development of nanotechnologies strong efforts have been made to achieve sub-wavelength resolution with far-field optical microscopes. High numerical aperture objectives and image processing algorithms taking into account the calculated Point Spread Function (PSF) have been developed in order to increase the spatial resolution. Significant improvements have been obtained, however the use of an objective, which roughly performs an analogical Fourier Transform of the far-field diffracted by the object, limits the accessible information. Recently, solutions derived from the radiofrequency domain have been proposed[1]. The object is illuminated under various angles of incidence and the diffracted far-field is measured along many directions of observation. Then, inversion algorithms based on Maxwell's equations[2] are used to reconstruct the map of permittivity of the sample from the far-field data. Thus, the image is obtained numerically, without any lens. The first advantage of this technique is that, by changing the angle of incidence, it is possible to increase by a factor 2 the range of accessible spatial frequencies. The system behaves like a synthetic aperture imaging system[3] and theoretically the spatial resolution is two-times smaller than for a conventional microscope. Another advantage is that the method gives information not only on the topography of the object, but also on the value of the permittivity. This latter information is usually difficult to obtain with conventional optical far-field microscopes. In particular, with this method, inhomogeneous objects can be reconstructed. The main difficulty is that, in the optical domain, the phase of the field can only be obtained from interference measurements. Hence, a careful choice of the experimental configuration has to be made in order to reduce the sensitivity of the measurement to thermal fluctuations and to mechanical drifts.
In this presentation we describe an experimental set-up which allows one to perform an angle-resolved measurement of both amplitude and phase of the diffracted field. The inversion algorithms used are iterative and based on the minimisation of a cost function, thus the reconstruction can also be made by using only the intensity measurements. We show the results obtained in this case. We also show the improvement obtained when the phase of the diffracted field is taken into account.

[1] V. Lauer, *J. of Microscopy* **205**, 165 (2000)
[2] K. Belkebir, A. Sentenac, *J. of Opt. Soc. Am.* **A 20**, 1223 (2003)
[3] R. Binet, J. Colineau, J.-C. Lehureau, *Appl.Opt.* **41**, 4775 (2002)