HIGH-ENERGY DIGITAL HOLOGRAPHIC MICROSCOPY VIA SPATIAL
FOURIER SPECTRAL SYNTHESIS

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High-numerical aperture (NA) objectives usually restrict the field of view and
working distances of high resolution microscopy. To address these restrictions, we
have developed a new coherent imaging technique capable of forming images with
sub-wavelength resolution with large (millimetre-scale) fields of view at long
(centimetre-scale) working distances [1]. Fourier holograms of different regions of
the object’s complex spatial Fourier spectrum are recorded and the full Fourier
spectrum is synthesised so that both amplitude and quantitative phase images of the
original object can be reconstructed digitally. Different regions of the Fourier plane
can be selected by changing the spatial and/or spectral properties of the illumination
beam. Altering the collection and solid angles also affects the captured range of
frequencies. The imaging lens is a low-NA objective which provides a long working
distance and a wide field of view with low aberrations. Due to the fact that the
complete complex sample field is acquired, digital post-processing procedures (e.g.,
refocusing or aberration correction) can be performed. This unique combination of
features enables high-resolution images to be obtained for both flat and non-planar
objects even if they are embedded in thick semi-transparent media. Phase information
can be used for three-dimensional reconstruction of the object surface. In this
presentation we will demonstrate synthesised images of different objects with
resolution several times higher than that of the optics used, obtained with a wide field
of view and long working distance.

In the figure, part (a) shows a reconstructed image of a TEM target, part (b), a
magnified selected area of the image, and (c), magnified phase images of the selected
boxes in (b). The fine structure of the target, with a period of approximately three
times lower than the resolution limit of the optics used, can be clearly seen in the
magnified fragment of the TEM target image.