SOLID IMMERSION IMAGING INTERFEROMETRIC NANOSCOPY TO THE LIMITS OF AVAILABLE FREQUENCY SPACE

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Imaging interferometric microscopy (IIM) allows the acquisition of high-resolution images using a low NA objective combined with multiple exposures, off-axis illumination, interferometric reconstruction and digital image processing. We have previously demonstrated a resolution beyond the linear systems limit ($\lambda/4$) [1] using illumination propagating beyond the total-internal reflection angle in a transparent substrate providing a frequency space extension up to $(n_{\text{sub}}+\text{NA})/\lambda$ without tilt and to $(n_{\text{sub}}+1)/\lambda$ with a tilted optical axis with a modest NA = 0.4 objective.

Solid-immersion, collecting the high angle scattered light in the substrate with the use of auxiliary grating, allows us to extend the resolution to $2n/\lambda$ [2]. Resolution of patterns with 120-nm CD features which is beyond the half-pitch linear systems limit in air of $\lambda/4 \sim 158$ nm, and the half-immersion limit of 126 nm with tilt, clearly demonstrate the evanescent coupling and evanescent collection. The experimental results in comparison with SEM image of a 1D structure is shown in Fig 1. The reconstruction of images for this case requires correction of the experimental high frequency images due to aberrations induced by the substrate propagation.

High-index materials may further expand the available resolution. At a 193-nm wavelength, the resolution may approaches typical SEM resolutions without requiring vacuum and indeed being fully compatible with water immersion. These resolutions are well beyond the current perceptions of microscopy capabilities and suggest that advances in optical microscopy will have important impacts across a broad swath of science and technology.