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 low *NA* objectives combined with multiple exposures, off-axis illumination, interferometric reconstruction and digital image processing. We have previously demonstrated a resolution approaching the linear systems limit ($\lambda/4$) with a modest NA = 0.4 objective, and described problems appeared in image reconstruction due to the frequency space distortions for sub-images made in a tilted mask geometry [1,2].

Here, instead of off-axis illumination in air we use illumination propagating beyond the total-internal reflection angle in a transparent substrate. An evanescent wave extends beyond the substrate into the sample region where it is scattered by the subwavelength sample structure into propagating waves that provide information on the details of the object at spatial frequencies up to $(n_{sub}+NA)/\lambda$ and to $(n_{sub}+1)/\lambda$ with a tilted optical axis. For the tilted optical axis, additional spatial frequencies are accessible and the resolution becomes independent of *NA*. Resolution of patterns with 150-nm CD features, which is beyond the half-pitch linear systems limit in air of $\lambda/4 \sim 158$ nm, clearly demonstrating the evanescent coupling. The reconstructed image with 150 nm structures is shown in Fig 1 (a), the corresponding model in Fig 1 (b) and compared crosscuts in Fig 1 (c).

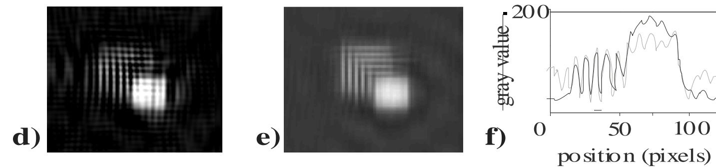

Figure. 1. Reconstructed image of a 150 nm CD pattern: a) experiment, b) simulation, c) experimental and simulation cross-cuts of the full images.

High-index materials further expand the available resolution. At a 193-nm wavelength, the resolution may approaches typical SEM resolutions while being fully compatible with water immersion. These resolutions are well beyond the current established perceptions of microscopy. Yet higher spatial frequencies are available by collecting the scattered light propagating in the substrate beyond the critical angle, with the possibility of extending the resolution to $\lambda/4n_{sub}$.

[1] C. J. Schwarz, Y. Kuznetsova, and S. R. J. Brueck, "Imaging interferometric microscopy", *Opt. Lett.* **28**, 1424 (2003).
[2] Y. Kuznetsova, A, Neumann and S. R. J. Brueck, "Imaging interferometric microscopy – approaching the linear systems limits of optical resolution," *Opt. Exp.* **15**, 6651 (2007).