Spatial-Frequency Characterisation of Near-Field Imaging Systems

Ciaran P. Moore, Richard J. Blaikie
MacDiarmid Institute for Advanced Materials and Nanotechnology, Electrical and Computer Engineering Department, University of Canterbury, Christchurch, New Zealand

Near-field imaging systems have garnered much interest over the last decade since the discovery that left-handed materials (i.e. materials with ε_r, $\mu_r < 0$) are capable of enhancing evanescent waves [1]. Much theoretical work has been presented showing vastly improved resolution beyond the diffraction limit [2-4], with some experimental examples given to support this hypothesis [5-7]. There exists, however, a deficit between the small number of publications describing near-field experiments and the much larger body of literature dealing with the theory of such phenomena.

One of the reasons for this comparative lack of near-field experimentation is that such demonstrations are extremely difficult to set up. Intimate contact between fragile imaging components is often required, which dictates that only a small number of trials can be performed before individual components become worn down or contaminated and need to be replaced [8]. This is not ideal, as multiple exposures of objects with varying spatial periods are usually required to fully characterise a system.

As an improvement, we propose here the use of isolated, steep step profiles and single, minimally dimensioned line features that need to be imaged only once into shallow photoresist layers to give the step response and line spread function of a system. Provided sufficiently high resolution is maintained in the experimental data, the system's transfer function can be extracted using offline spectral analysis in the spatial-frequency domain, allowing extensive comparison with analytical performance predictions [9]. This reduces the number of trials that need to be done to thoroughly characterise an imaging system and lowers the barrier to experimental verification of conceptual near-field imaging systems.

[1] J. B. Pendry, Phys. Rev. Lett. **85**, 2000.
[2] S. A. Ramakrishna et al., J. Mod. Opt. **50**, 2003.
[3] K. Lee, Y. Jung and K. Kim, Phys. Rev. B **80**, 2009
[4] I. Karnadi, A. A. Iskandar and M.-O. Tjia, J. Opt. Soc. Am. A **27**, 2010.
[5] M. M. Alkaisi et al., Appl. Phys. Lett. **75**, 1999.
[6] D. O. S. Melville and R. J. Blaikie, Opt. Express **13**, 2005.
[7] S. Shi et al., Opt. Express **18**, 2010.
[8] D. O. S. Melville and R. J. Blaikie, J. Opt. Soc. Am. B **23**, 2006.
[9] C. P. Moore, R. J. Blaikie, and M. D. Arnold, Opt. Express **17**, 2009.