Silver Superlenses for Near-field Optical Nanolithography

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Diffraction-limited deep-UV systems are now pushing optical lithography well into the sub-100 nm domain. However, new techniques will be required to go further, and if optical patterning is to continue then some form of near-field effect may be required to achieve sub-diffraction-limited (super-resolution) pattering. Simple, mask-based near-field super-resolution lithography techniques have been demonstrated[1], even down to 32 nm linewidths[2], but the mask-resist contact requirement makes this unattractive for manufacturing. Is there equivalent to the pellicle for physically separating the mask and resist in near-field lithography?

Near-field imaging through silver 'superlensing' layers[3, 4] may be the answer, as this can offer improved working distance (i.e. introducing the equivalent of a focal length) and control over image intensity compared to conventional near-field imaging. In a photolithographic environment at ultra-violet (UV) wavelengths the imaging performance of single- and multi-layer silver plasmonic superlenses has been studied both experimentally and via computer simulations[5].

Silver superlens resolution and pattern fidelity is currently limited by issues of roughness in the silver layers and the ability to deposit high-quality silver-dielectric multilayers. Simulations have shown that super-resolved imaging should be possible using surprisingly thick silver layers (>100 nm), with the cost of reduced image intensity, which is something that is yet to be shown experimentally. The prospect of a trade-off between mask protection and throughput is therefore there to be explored.

The use of multilayer plasmonic superlenses also introduces richness to the imaging behaviour, with very high transmission possible for certain spatial frequency components in the image, which may be another route to achieving super-resolved imaging through 'thick' (>100 nm) mask-protection layers without compromising throughput. These and other practical issues will be discussed.

[1] M. M. Alkaisi, R. J. Blaikie, S. J. McNab, et al., Applied Physics Letters **75**, 3560 (1999).
[2] T. Yamaguchi, T. Yamada, A. Terao, et al., Microelectronic Engineering **84**, 690 (2007).
[3] D. O. S. Melville and R. J. Blaikie, Optics Express **13**, 2127 (2005).
[4] N. Fang, H. Lee, C. Sun, et al., Science **308**, 534 (2005).
[5] D. O. S. Melville and R. J. Blaikie, Physica B-Condensed Matter **394**, 197 (2007).