Calibration of coherence scanning interferometry and the effects of defocus

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Coherence scanning interferometry (CSI) is a well-established technique for 3D measurement of surface topography with sub-nanometre precision in the axial direction. As with most 3D optical imaging systems, the performance of CSI depends strongly on the local tilt and curvature of the sample surface. Based on 3D linear systems theory, the performance of CSI can be characterised in terms of the 3D transfer function (TF) in the spatial frequency domain or the 3D point spread function (PSF) in the spatial domain [1,2]. From the measurement of a precision sphere, a CSI system can be calibrated and partly corrected based on the so-called "foil model" of the surface [3]. A recent study has investigated the tilt and curvature dependent errors in CSI, and demonstrated that an aberration-free CSI system is capable of measuring the topography of surfaces with varying tilt with sub-nanometre accuracy [4]. When defocus is present in a CSI system, the measurement accuracy and resolution of the system are degraded. Usually, a Mirau-type interferometer is used in CSI for lenses with 50× magnification (NA of 0.55) and an offset of the axial position of the reference mirror may cause defocus aberration. We demonstrate here (see figure 1), the theoretically calculated 3D TF and PSF of a CSI system with 0.55 NA at different conditions of defocus, and the corresponding fringes from a spherical surface. The results show that defocus causes distortion of the modulus and phase of the TF, and modifies the PSF. The reduced fringe contrast in the tilted surface regions may reduce the detectable area and cause significant errors when calculating the surface topography.

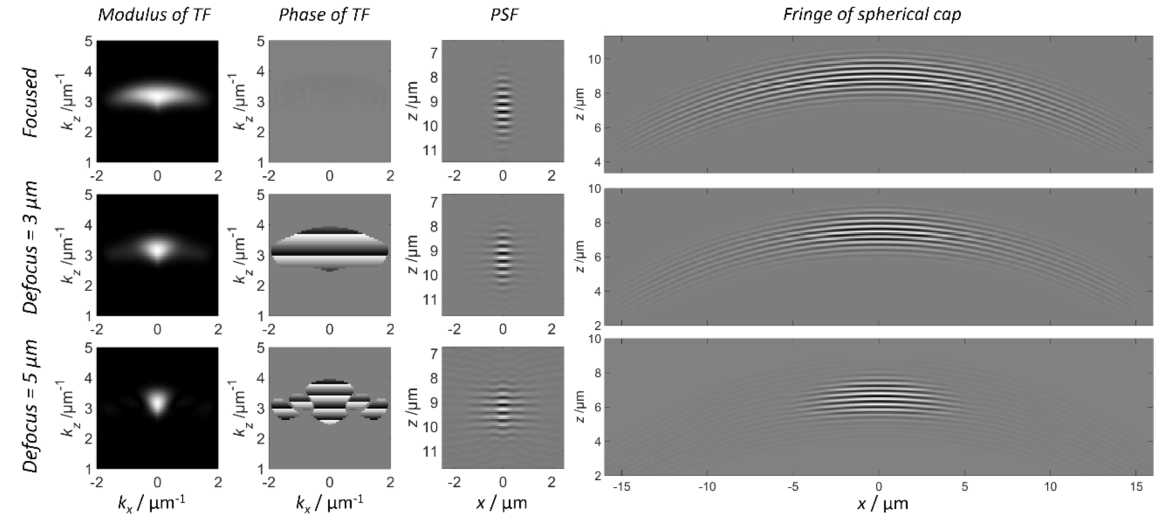

Figure 1. Effects of defocus in CSI

[1] J. M. Coupland and J. Lobera, "Holography, tomography and 3D microscopy as linear filtering operations," *Meas. Sci. Technol.* 19, 07010 (2008).
[2] J. M. Coupland, R. Mandal, K. Palodhi, and R. K. Leach, "Coherence scanning interferometry: linear theory of surface measurement," *Appl. Opt.* 52, 3662-3670 (2013).
[3] R. Mandal, J. M. Coupland, R. K. Leach, and D. Mansfield, "Coherence scanning interferometry: measurement and correction of three-dimensional transfer and point-spread characteristics," *Appl. Opt.* 53, 1554-1563 (2014).
[4] R. Su, Y. Wang, J. M. Coupland, and R. K. Leach, "On tilt and curvature dependent errors and the calibration of coherence scanning interferometry," *Opt. Express*, 25, (2017).