Type of presentation: Poster

IT-11-P-1659 Factors affecting phase noise in off-axis electron holography

Boothroyd C. B.[1], Dwyer C.[1], Chang S.[1], Dunin-Borkowski R. E.[1]

[1]Ernst Ruska-Centrum und Peter Grünberg Institut, Forschungszentrum Jülich, D-52425 Jülich, Germany

Email of the presenting author: ChrisBoothroyd@cantab.net

The amount of noise in the reconstructed wave of an electron hologram depends on the visibility of the interference fringes, which in turn depends on the coherence and intensity of the incident beam and the stability of the microscope[1]. Here we investigate the dependence of phase noise on condenser lens strength for holograms taken on a 300kV FEI Titan with two biprisms and no specimen present. We use a lower biprism voltage of 150V with no extra lens giving a fringe spacing of 0.08nm. The magnification was 450k and round illumination was used for reproducibility. A 4s exposure time, giving negligible biprism drift, was used. We did not change the gun extraction voltage[2]. The gun lens, spot size (C1 lens) and intensity (C2 & C3 lenses) were each varied starting from gun 3, spot 3 and intensity set so the beam filled the screen at 160k magnification.

For each illumination condition a hologram was taken with no specimen present, reconstructed in the standard way and the mean intensity within the hologram overlap region, the fringe contrast and the standard deviation of the reconstructed phase measured. Here the mean intensity is used as a simple measure of the coherence of the beam, a lower mean intensity is associated with a higher coherence. Fig. 1a shows a plot of the fringe contrast vs mean intensity. As the beam is made more coherent (lower mean intensity) using any of the gun lens, spot size or intensity the fringe contrast increases, as expected. The phase noise derived from the same holograms is shown in fig. 1b, from which it can be seen that the lowest phase noise is for a mean intensity of about 700 counts. When the coherence is increased so as to reduce the mean intensity below 700 counts, the increased fringe contrast is offset by increased noise due to fewer counts [3].

It can be seen from both figures that it does not matter whether the coherence is increased by increasing the spot size or the intensity, the resulting phase noise is the same. Increasing the gun lens has almost the same effect except that the fringe contrast and the phase noise are slightly worse for the highest gun lens than for the same coherence set with either the spot size or the intensity. While this observation is to be expected for a perfect microscope with no instabilities[4], it is an important result to demonstrate experimentally.

We thus conclude that for adjusting the beam coherence it makes no difference whether the intensity or spot size are used and that using the gun lens produces only slightly higher phase noise.

[1] H Lichte, KH Herrmann and F Lenz, Optik 77 (1987) 135
[2] A Lenk and H Lichte, Proc EMC 2012 ed DJ Stokes and JL Hutchison (RMS, 2012) 515
[3] WJ de Ruijter and JK Weiss, Ultramic 50 (1993) 269
[4] H Lichte, Ultramic 108 (2008) 256

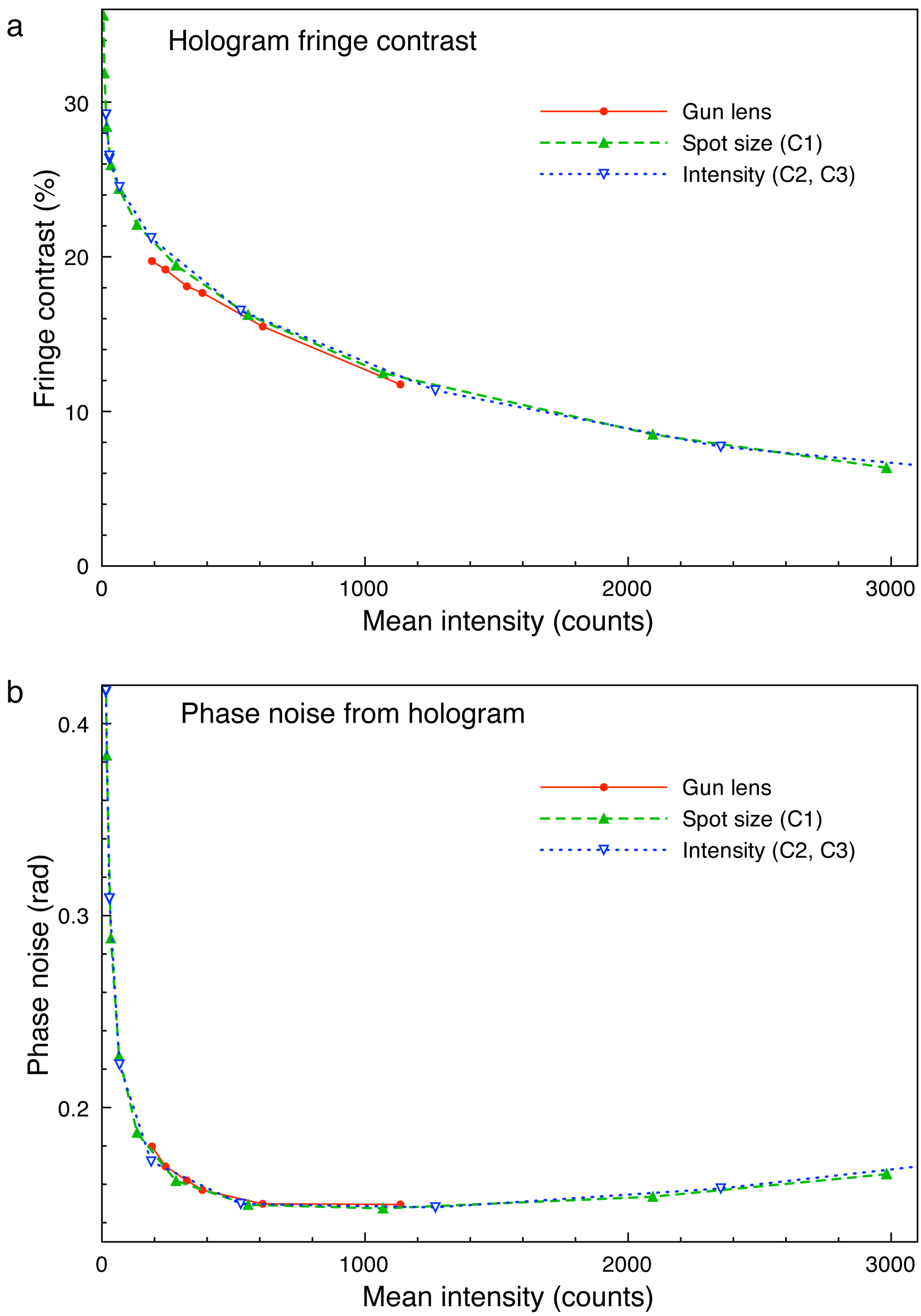

Fig. 1: (a) Hologram fringe contrast (I_{max}-I_{min})/(I_{max}+I_{min}) and (b) standard deviation phase noise plotted against mean intensity within the overlap region for different settings of the gun lens, spot size and intensity.