Type of presentation: Oral

IT-11-O-1464 Split-illumination electron holography

Tanigaki T.[1], Aizawa S.[1], Park H. S.[1], Matsuda T.[2], Harada K.[3], Murakami Y.[1,4], Shindo D.[1,4]

[1]Center for Emergent Matter Science (CEMS), RIKEN, Saitama, Japan, [2]Japan Science and Technology Agency, Saitama, Japan , [3]Central Research Laboratory, Hitachi Ltd., Saitama, Japan, [4]Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Sendai, Japan

Email of the presenting author: tanigaki-toshiaki@riken.jp

Off-axis electron holography [1] has been used for observing microscopic distributions of magnetic fields, electrostatic potentials and strains at nanoscale level and for aberration-corrected electron microscopy by detecting phase shifts of electron waves. An off-axis electron hologram is formed by overlapping an object wave transmitted through a sample with a reference wave passed through the reference area. The inherent problem with this method is that the distance D between the object and reference waves, or the hologram width W, is limited by the lateral coherence length R or by the brightness of the illuminating electron waves.

We solved this long-standing problem by developing split-illumination electron holography (SIEH). Experiments were performed using a 300-kV cold field emission transmission electron microscope (TEM) (HF-3300X, Hitachi High-Technologies Co.).

In our SIEH (Fig. 1), we can illuminate a sample by using two highly separated and yet coherent electron waves without reducing the density of electron and form high-contrast holograms at regions far from the sample edge. The separation distance D can be controlled by a condenser biprism in the illuminating system. The fringe spacing s and the width W of the hologram can be independently controlled as in double-biprism electron interferometry [2]. Using SIEH, a fringe contrast of 50% can be attained even if the object wave is as far as 17 µm from the reference wave in the sample plane [3].

Recently, in order to improve precision of phase measurement in SIEH, double condenser biprism type SIEH without Fresnel fringes was developed (Fig. 2) [4]. Since demanded phase shifts to be measured in nanoscale are becoming smaller and smaller, it is important to improve precision of phase measurements to broaden the applications of the off-axis electron holography. The developed methods are used for varieties of applications and will be used for revealing electromagnetic phenomena in atomic scale.

References:
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Acknowledgement: The authors are grateful to the late A. Tonomura for his valuable discussions. This research was supported by a grant from JSPS through the “FIRST Program”, initiated by CSTP.

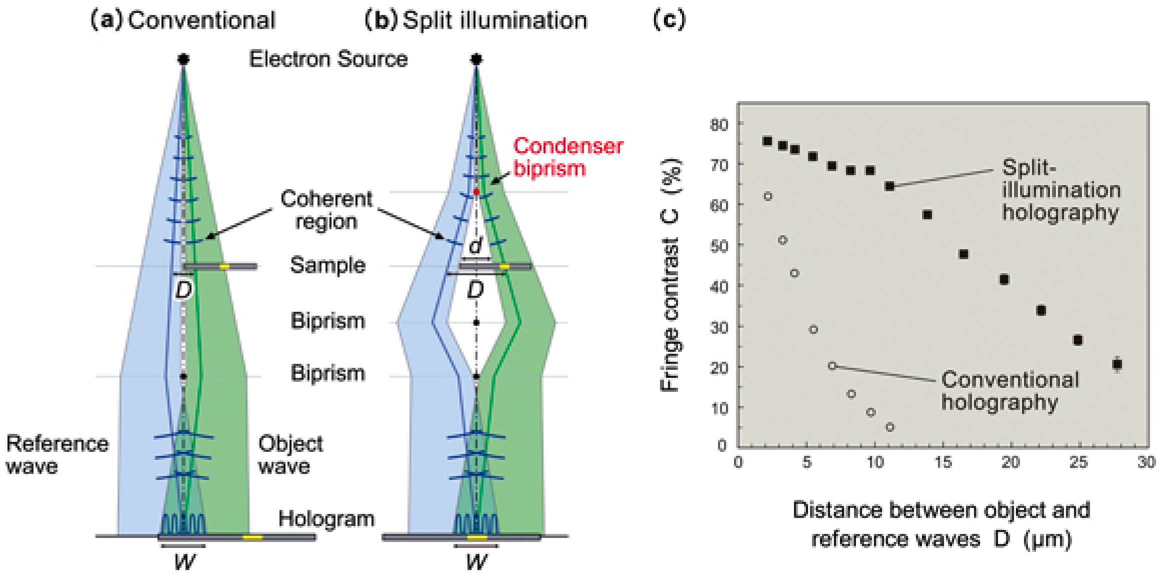

Fig. 1: Schematic diagrams of electron-optical method and fringe contrasts of holograms. (a) Conventional electron holography. (b) Split-illumination electron holography in which a coherent electron wave is split into two coherent partial waves. (c) Measured fringe contrasts C of holograms as function of distance D between object and reference waves.

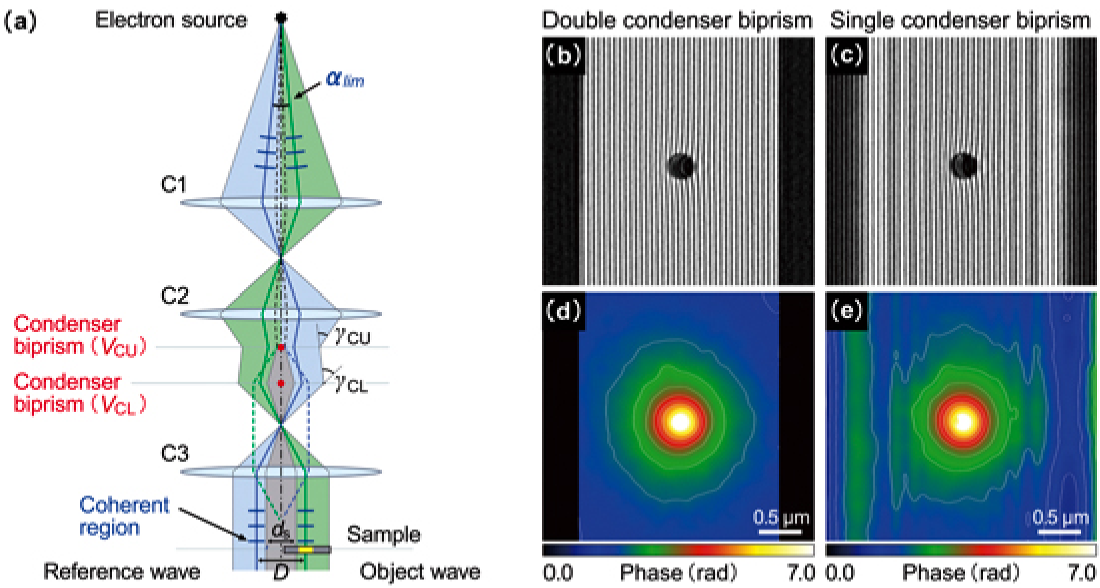

Fig. 2: Schematic diagram of double condenser biprism (CB) type split-illumination electron holography without Fresnel fringes (a) and holograms (b, c) and phase images (d, e) of charged latex particles. (b, d): double CB, (c, e): single CB.