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Phase Plates Free from Contaminant Charging

K. Nagayama,*,** R. Danev,* H. Shigematsu,* Y. Kayama,* H. Okawara,** M. Ohara,**
T. Itoh, *** S. Sugitani,*** and A. Kitayama***

* Okazaki Institute for Integrative Bioscience, Okazaki, 444-8787, Japan
** National Institute for Physiological Sciences, Okazaki, 444-8585, Japan
*** Terabase Co., Okazaki, 444-8787, Japan

Development of two types of phase plates is underway in my group: thin-film phase plates (TFPP) made of amorphous carbon [1, 2] and Aharonov-Bohm (AB) effect phase plates (ABPP) made of metallic materials [3]. Particularly with TFPP several successful results for biological samples such as virus [4], bacteria [5], brain tissue [6] and membrane protein [7] have already been reported. These results, which are illustrating qualified high-contrast images, were obtained under the excellent condition of phase plates relatively free from contaminant charging. During observation, misalignment of the phase plate or specimen charging may cause the central beam to hit the phase plate. This induces severe contamination on the phase plate surface, which causes charging and the resultant image distortion. Hosokawa reported that heating phase plates to around 200ºC prevented contamination from possible sources such as vacuum pump oil or biological specimens [8]. This suggested that the phase plate with heating had to be free from contaminant charging if it was initially free from charging. The procedure to prepare an initially charge-free phase plate could follow a general method to eliminate electrostatic charging of TEM specimens, namely wrapping with conductive materials, particularly amorphous carbon, just before inserting the phase plate into the TEM column. We have reported how dramatically this procedure reduced contaminant charging of phase plates [3] (refer to Fig. 1).

Five years after the solution proposed, still, we have occasionally been suffered from the unpredictable phase plate charging. The charging problem has also been observed for AB phase plates, which are made of only metallic materials wrapped with gold and heated to higher temperature. We have observed phase shift due to charging of gold-coated bar magnet at a high temperature over Curie point (refer to Fig. 2). These results indicate that there is such a charging process progressing even on such a TFPP or ABPP surface as free from organic contaminants. Recently we have found what the cause of the unpredictable process happening at high temperature is. An effort to remove the ultimate obstacle to realizing charging-free phase plates will be reported.

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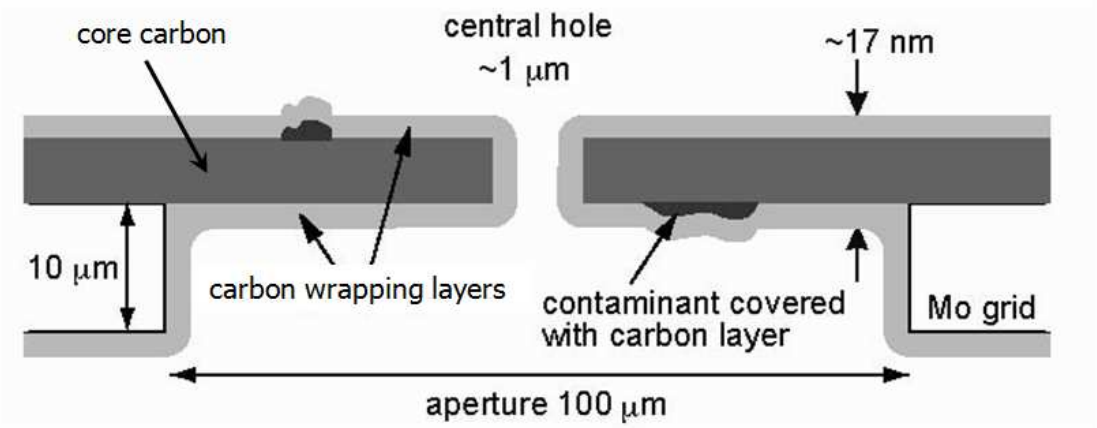

FIG. 1 Cross-sectional illustration of a thin-film phase plate designed for 120kV acceleration voltage. The scale of each feature shown in this illustration is schematical and important dimensions are indicated.

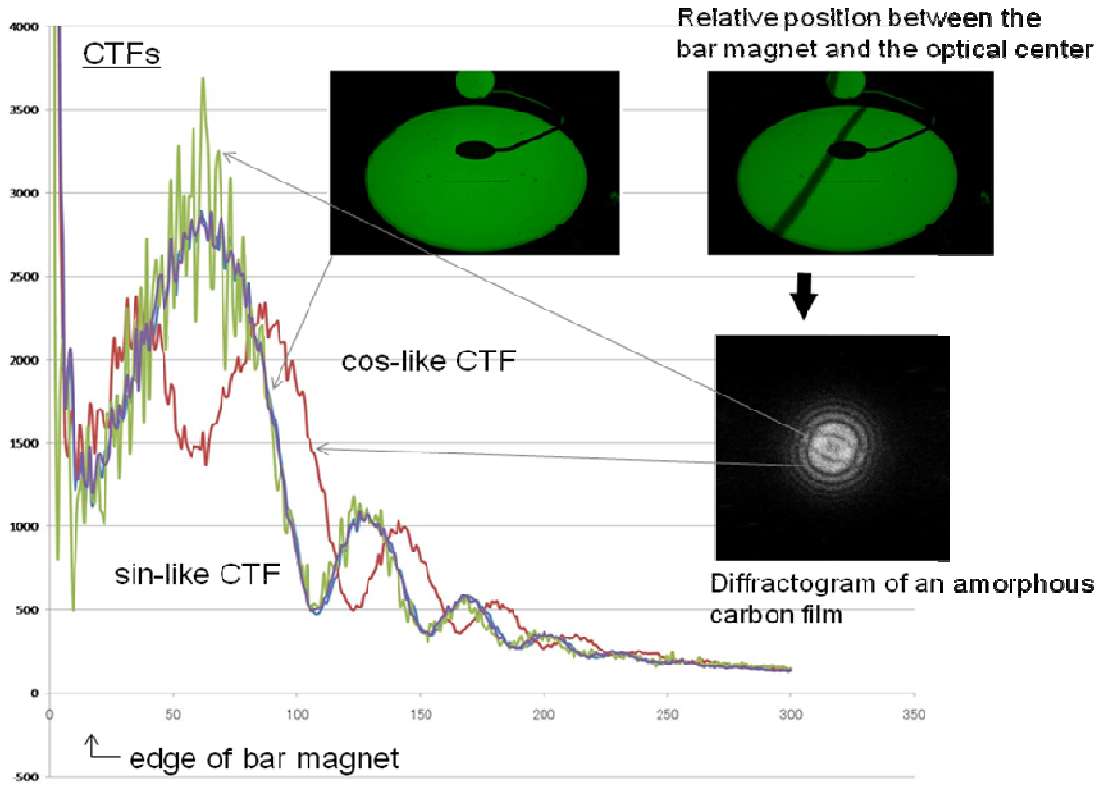

FIG.2 Deceptive phase shift observed for a ABPP, which was made of a nickel bar magnet coated with gold. A high temperature of 600ºC was set to exceed the Curie point of the nickel magnet. Judging from differential CTFs observed for two areas shown in the diffractogram, a phase shift solely due to charging was evidenced as they must be equivalent over Curie point where magnetization of ABPP was killed.

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