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Development of Amorphous Carbon Thin Film Phase Plate

Y. Konyuba[1], H. Iijima[1], N. Hosogi[1], Y. abe[2], I. Ishikawa[1], and Y. Ohkura[1]

[1.] JEOL Ltd., 3-1-2 Musashino, Akishima, Tokyo, 196-8558, Japan.
[2.] Yamagata Research Institute of Technology, Matsuei 2-2-1, Yamagata, 990-2473, Japan.

Recent years, in transmission electron microscopy (TEM), the phase plate enhances phase contrast of a specimen image. Naturally, we expect that TEM with the phase plate enables us to obtain high contrast images of the samples, which are composed of light elements such as biological samples and polymer samples.

So far, many types of phase plates for electron microscopy have been proposed. The most productive type of the phase plate is the thin film. Above all thin film, Zernike phase plate has been producing promising results [1-2].

However, thin film Zernike phase plate had some problems, those are, their reliability, lifetime (due to charging and aging) and cost (due to craft production including hole forming by a focused ion beam). To solve these problems, we have been challenging to fabricate several kinds of the thin film phase plates with various materials and structures by a high throughput fabrication method utilizing a micro electro mechanical systems (MEMS) technology. As a first trial, we have fabricated titanium (Ti) / silicon nitride (SiN) / Ti sandwich type thin film Zernike phase plates [3] and we improved the manufacturing yield. However, we could not achieve sufficient stability, due to charging of the Ti/SiN/Ti thin film Zernike phase plate.

Next, we tried to fabricate the amorphous carbon thin film Zernike phase plate. The fabrication method for this phase plate is similar to one for the Ti/SiN/Ti thin film phase plate [4]. To improve the characteristics for the thin film phase plate: crystallization of the amorphous film, electro resistibility, thickness controllability and others, we adjusted the deposition condition for amorphous carbon thin film Zernike phase plates. Finally, we have succeeded to fabricate an amorphous carbon thin film phase plate having sufficient characteristics.

Figures 1(a) and 1(b) show SEM images of top and bottom surfaces of amorphous carbon thin film Zernike phase plate. As shown in the figures, the amorphous carbon thin films are clean. The thickness of the amorphous carbon film was fabricated to be approximately 30 nm that gave $\pi/2$ phase shift for 200 kV electrons. In the center of each square window, there is a small hole where the unscattered electrons pass through. The diameter of the hole was fabricated to be approximately 0.7 μm as shown in Figure. 2. The stability of thus-fabricated phase plate in TEM imaging was good enough for sample observation. It is worthy to say that a hole-free phase plate [5-6] fabricated with the same method was also confirmed to show good performance.

References:

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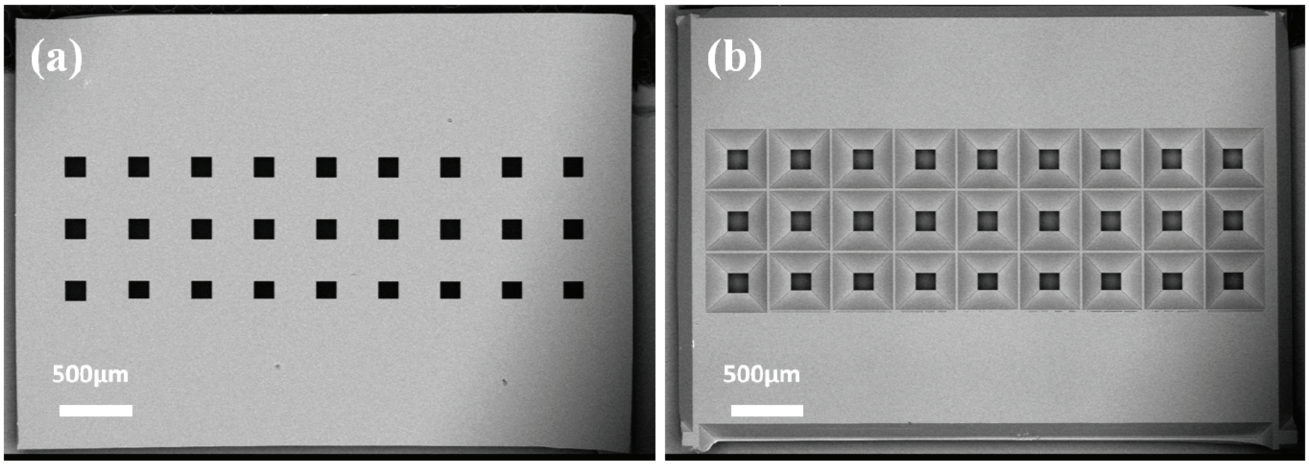

Figure 1. SEM images of the amorphous carbon thin film Zernike phase plate array. (a) top side (b) bottom side.

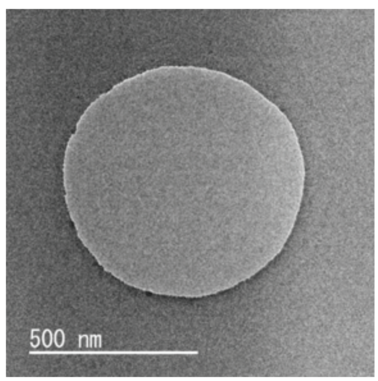

Figure 2. TEM image of the center holes in the amorphous carbon thin film Zernike phase plate. The hole diameter is approximately 0.7 µm.