

# 15-nm nickel zone plates achieved using cold-developed electron-beam patterned ZEP7000

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Nanofabricated zone-plate lenses are essential components for high-resolution imaging in x-ray microscopy. The achievable resolution in these applications is proportional to the outermost zone width. Thus, for high-resolution x-ray microscopy, zone plates with narrow zones are needed.

In this contribution we present 50-nm thick soft x-ray nickel zone plates with 15-nm outermost zone width (cf. Fig. 1 and Fig. 2). This was achieved with a process including a cold-developed electron-beam patterned resist. For zone plates, this represents the highest reported resolution obtained by a single e-beam exposure. Previously, such high resolution has only been attained using an overlay technique to avoid dense patterning<sup>1</sup>.

The fabrication process is a tri-layer process combined with electroplating similar to our standard zone-plate fabrication process<sup>2,3</sup>. ZEP7000 was used as electron beam resist and it was developed at  $-50\text{ }^{\circ}\text{C}$  in hexyl acetate. In addition to the cold development, the process was optimized to obtain a successful transfer into electroplated structures. This will be further discussed in the paper.

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<sup>1</sup> W. Chao *et al.*, *Nature* **435**, 1210 (2005).

<sup>2</sup> A. Holmberg, S. Rehbein, and H. M. Hertz, *Microel. Engin.* **73-74**, 639 (2004).

<sup>3</sup> M. Lindblom, H. M. Hertz, and A. Holmberg, *J. Vac Sci. Technol. B* **24**, 2848 (2006).

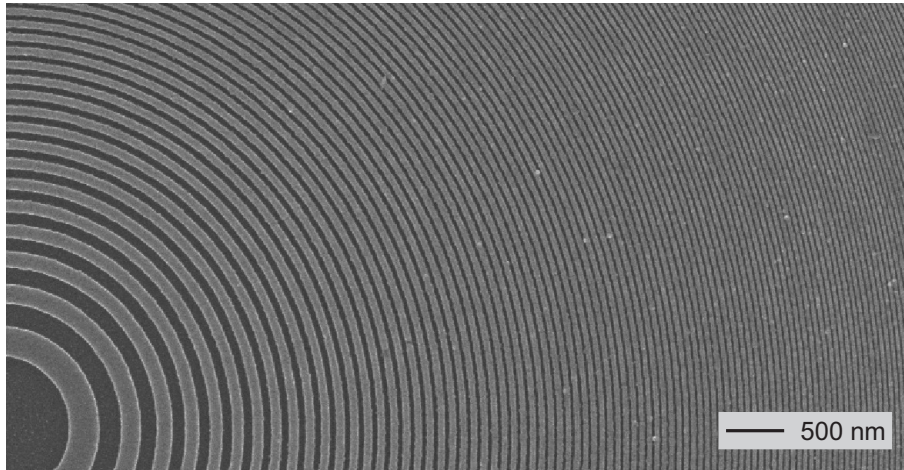


Figure 1. Inner part of a nickel zone plate lens with 15 nm outermost zone width.

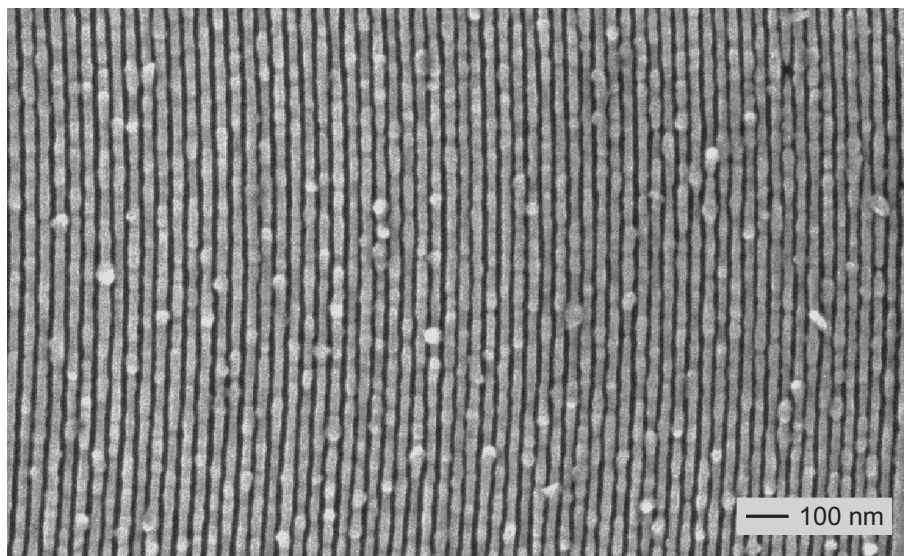


Figure 2. Outermost part of a zone plate fabricated by cold development. The outermost half-pitch size is 15 nm and the height of the nickel zones is 50 nm.