20 nm Flip Blazed Fresnel zone plates by a PMMA/ZEP bilayer technique

Jianpeng Liu, Jinhai Shao, Sichao Zhang, Yaqi Ma and Yifang Chen
Nanolithography and Application Research Group, State key lab of Asic and System,School of Information Science and Engineering, Fudan University, Shanghai 200433, China
yifangchen@fudan.edu.cn

Biao Deng, Tiqiao Xiao
Institute of Applied Physics, Chinese Academy of Sciences, Shanghai 200003, China

Transmission x-ray microscopy (TXM) based on Fresnel zone plates (FZPs) demands high resolution and high efficiency to meet application requirements. The resolution of a full-field-type TXM mainly depends on the width of the outmost zone of the FZP, and the efficiency is closely related to the zone thickness and zone profile. However, it was always a technical challenge to control the zone profile as needed in lithography[1].

In this work, we proposed a novel Flip Blazed Fresnel zone plate to improve the efficiency using a bilayer layer of PMMA/ZEP, as shown in figure 1. Fig2 (a) shows the contrast curve of the PMMA (350 k) and ZEP 520A resist. The dose range between the clearing doses of these two resists is the dose latitude. In this structure, the top layer of ZEP is four times more sensitive than the bottom PMMA layer. After electron beam lithography, the developed profile naturally becomes a flip blazed shape (figure 3a). By this way, any higher orders above the first would be hopefully eliminated. Fig2 (b) presents resist etching rates of the resists in O_2/CHF_3 plasma. It can be seen that the etch selectivity of PMMA/ZEP reaches the maximum when CHF_3 is 30% -50% in the gas. A clear U-shape on the bottom part of PMMA/ZEP, which is desired in this work, can be observed in figure 3. When the resist was lightly etched in the O_2/CHF_3 plasma, the U-shape would be transferred to the PMMA layer as shown in Fig 3(b). The reaming height is 120 nm. Fig 4 shows the complete zone plate pattern in PMMA/ZEP bilayer. Using the replicated resist profile as templates, zone plate in Au can be formed by electroplating.

By summary, in this work we has successfully innovated a new method to generate shaped profiles of zone plate by using PMMA/ZEP bilayer. This technique has the advantages of high reliability and high controllability in the process for higher efficiency and high resolution.

[1] Yin G. C., et al. 2006, Appl. Phys. Lett. 89, 221122

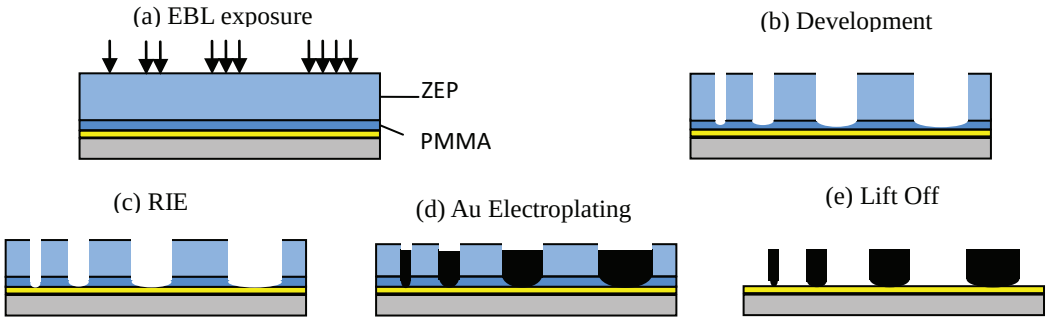

Figure 1 The process flow for the Flip Blazed Fresnel zone plate with PMMA/ZEP.

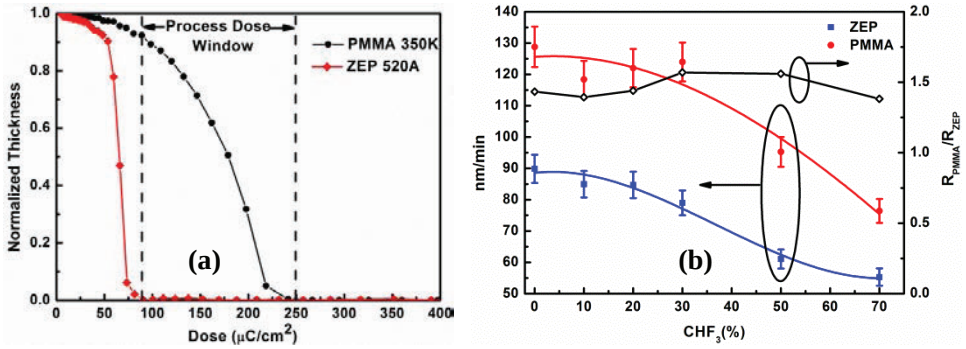

Figure 2 (a) The normalized contrast curves of PMMA and ZEP 520A; (b) The relationship between CHF3 content and etch rates of PMMA and ZEP resists

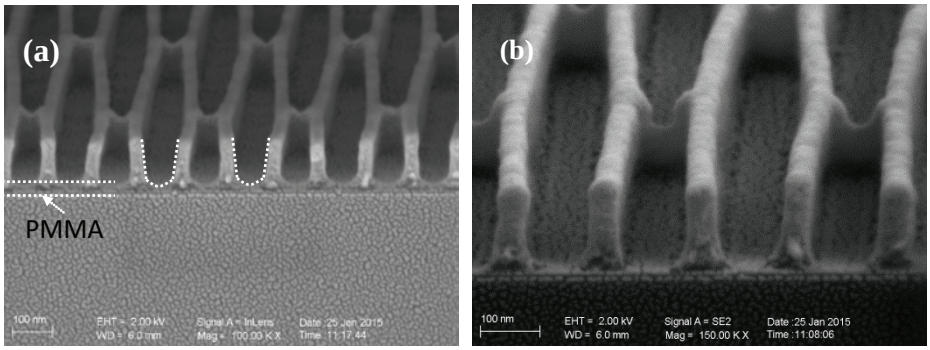

Figure 3 SEM images of resist profiles (a) after development; (b) after RIE process.

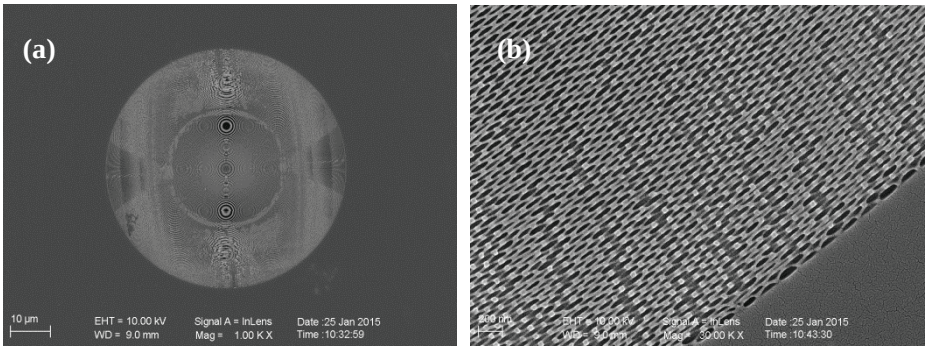

Figure4 SEM images of the Flip Blazed Fresnel zone plate in resist.