

課題番号 : F-15-AT-0139
利用形態 : 機器利用
利用課題名 (日本語) :
Program Title(English) : Nanopore Patterning using Electron Beam Lithography
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1. 概要 (Summary)

This project is attempting to fabricate nanoscale size pore pattern using low current electron beam. The challenging of this approach is to overcome drawbacks from decreasing in resolution when lowering of beam energy. This is due to the fact that electrons with longer wavelength tend to scatter with longer mean free path in the resist. The Monte Carlo calculations show that the 1 keV electrons are scattered laterally up to 25 nm in the resist, much more than the higher energy electrons. Lower energy also primaries have a higher cross section for large angle scattering, decreasing their penetration depths, but allowing them to deposit almost all of their energy into secondaries generated in the resist layer. This study, we use CABL-9410TFNA EBL system equipped with 50 kV electron accelerating voltage, the focused electron beam lithography system with 500x500 um field size and 60000 dots each line resolution in vector mode. This configuration allowed us to squeeze the electron beam diameter down to 8.33 nm. In order to avoid the effect of electron scattering, the writing patterns have been designed into 3 conditions based on the features of the machine. The details of each EBL condition of are shown in experimental section.

2. 実験 (Experimental)

- 電子ビーム描画装置
- スピンコーター

The EBL patterns have been done on ZEP 520A.

The resist was layered with spin coating at 4000 rpm for 30 second with ramps for 5 seconds. The resulted resist thickness is approximately 360 nm after 5 minutes post baking at 180 degrees C. In this study, the substrate for resist deposition was a 60-nm-thick Si_3N_4 (on thermal oxide layer) with less than 1 nm roughness. The pattern was designed with marks as shown in figure 1. The EBL process conditions are shown in Table 1 belowed;

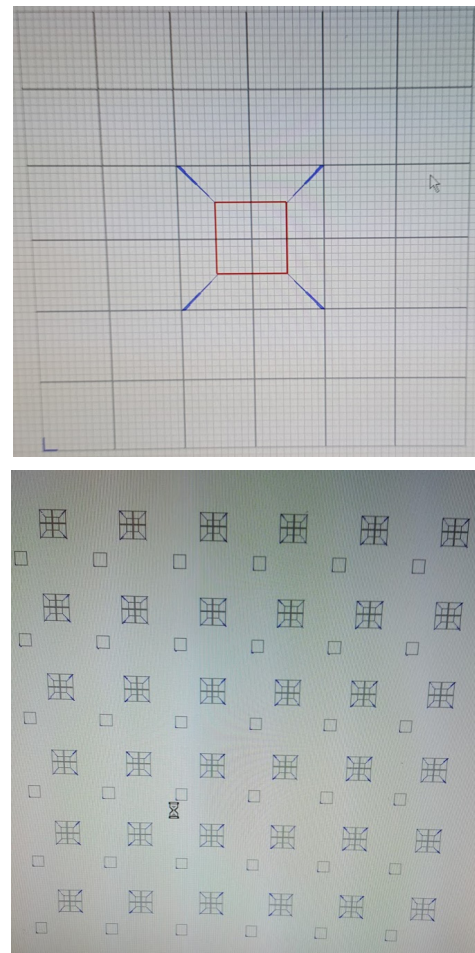


Figure 1 Design of EBL patterning (Top) and the array of patterns on the chip (Bottom).

Table 1 EBL Process condition of exposure recipes. The electron beam has acceleration voltage of 50 kV with 0.1 nA current. The shot pitch was 8.33 nm. Nanopores were patterned as 500x500 um array on 500nm pitch.

Recipe	Draw Features	Draw diameter, circle (nm)	Pitch (dots)	Dose ($\mu\text{C}/\text{cm}^2$)
1	Dot	8.33 (1 Dot)	n/a	200, 400, 600, 1000, 1500, 2000
2	Disc	50	10	400, 500, 600
3	Disc	50, 100	1	400, 500, 600

After EBL, the patterns were developed in ZED N50 for 5 minutes then rinsed in ZMD_B, IPA and DI water respectively.

3. 結果と考察 (Results and Discussion)

Drawing of nanopore pattern using low energy electron beam with difference recipes has shown distinct results. The nanopore patterns using recipes 1 and recipe 2 gave us quite surprise results. Recipe 1 shown larger diameter pore (~15 nm) with dose atleast 1500 $\mu\text{C}/\text{cm}^2$ which was in contrast with Recipe 2 whose gave the pore size around 8.3 nm with dose only 400 $\mu\text{C}/\text{cm}^2$. Recipe 3 was intended to control the diameter size of the pore, thus the shot pitch is assigned to equal to one. However, this recipe was heavily suffered from the electron scattering in resist resulting oversize patterns as shown in Fig. 2.

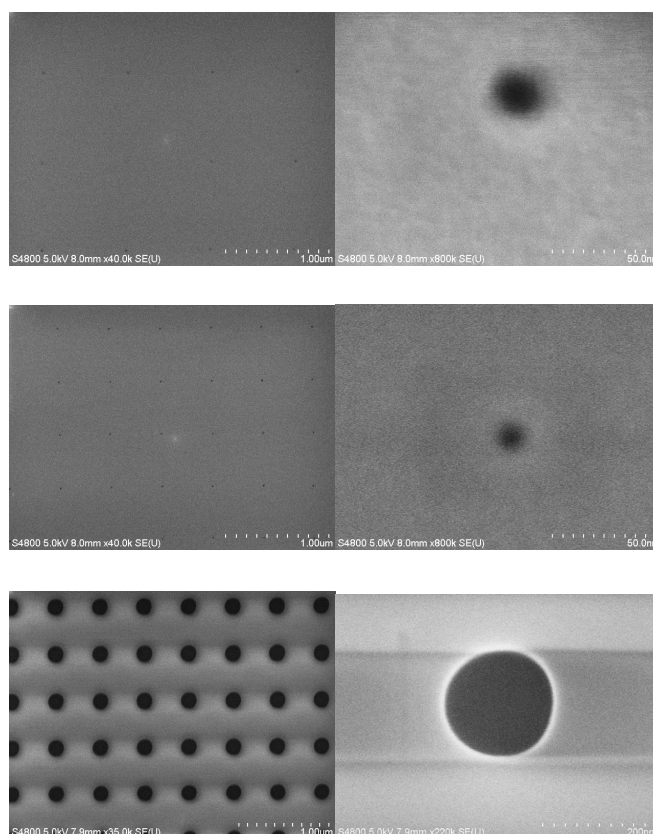


Fig. 2 Resist pattern after developed of recipe 1 2 and 3 from top to bottom respectively.

4. その他・特記事項 (Others)

• Reference

Tanenbaum et al., High resolution electron beam lithography J. Vac. Sci. Technol. B 14(6), Nov/Dec 19.

5. 論文・学会発表 (Publication/Presentation)

-None.

6. 関連特許 (Patent)

- Fabrication of Single nanopore membrane by matching nanopore pitch with window size (in preparation).