Ning Cao, Staff Engineer, Nano-Fabrication Lab, UCSB

# $SiN_x$ Etch Recipe using RIE#3

Sample: PR-ridge-pattern on ~1.2 μm-thick $SiN_x$/Si substrate.

Results:

1) Table 1

| SiNx Etch using RIE3 (7mx4=28m, O2 de-polymer [10mT, 200v, O2=20sccm] for 5m after each etch) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample# | Pressure (mT) | Bias Voltage (v) | Gas Flow-rate (SCCM) | | | Etch Rate (nm/min) | Etch Selectivity (SiNx/PR) | Note |
| | | | CF4 | CHF3 | O2 | | | |
| 5 | 10 | 250 | 20 | 0 | 2 | 33.8 | 1.5 | |
| 4 | 10 | 250 | 15 | 5 | 2 | 28.5 | 1.2 | |
| 6 | 10 | 250 | 5 | 15 | 2 | 22.8 | 1.1 | |
| 7 | 10 | 250 | 0 | 20 | 2 | 20.6 | 0.81 | |
| 3 | 10 | 250 | 10 | 10 | 4 | 24.7 | 1.1 | |
| 8 | 10 | 250 | 10 | 10 | 2 | 25.5 | 1 | |
| 9 | 10 | 250 | 30 | 0 | 2 | 28.4 | 1.3 | |
| 10 | 10 | 250 | 10 | 0 | 2 | 38.1 | 1.6 | PR etch mask was attacked |

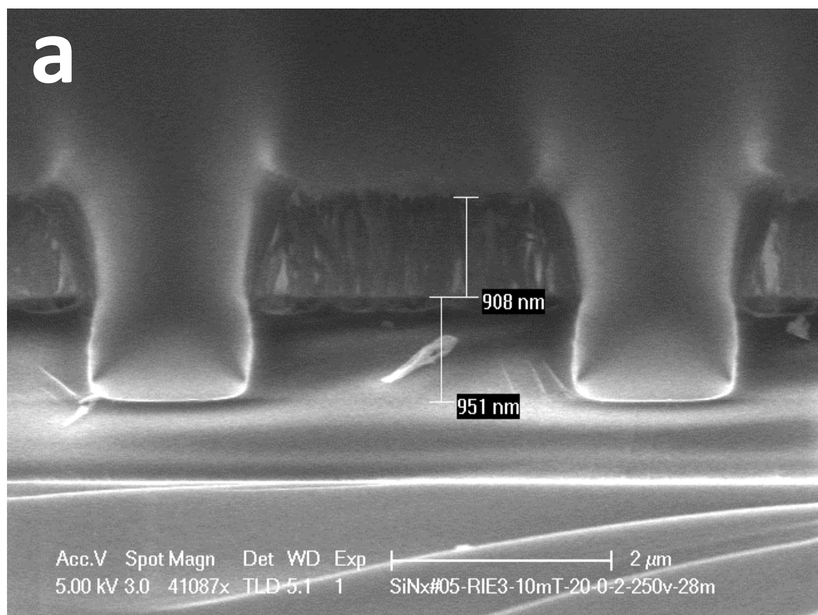
2) Recipe#1 (sample#5): 10 mT, $CF_4/O_2$=20/2 sccm, bias voltage=250 V [Note: etch every 7 minutes, then, do the $O_2$ plasma descum (see the descum parameters below) with the sample inside of chamber to remove the built-up polymer].

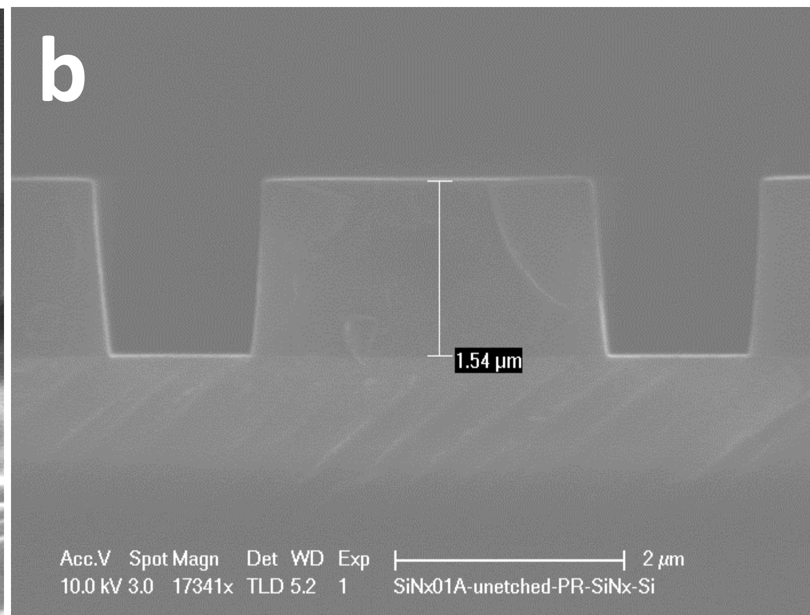
Etch Rate=33.8 nm/min [for the PR patterned ridge, see Figure 1 (b) below].

Etch Selectivity ($SiN_x$/PR) =1.5

(Prior to the $SiN_x$ etch, do $O_2$ plasma chamber clean: 50mT, $O_2$=20sccm, bias voltage=500 V, and time=30 minutes. After an each 7-minute $CF_4/ChF_3/O_2$ etch, do the $O_2$ plasma descum with 10 mT, $O_2$=20sccm, bias voltage=200 V, and time=5 minutes)

Figure 1 a) $SiN_x$ etch profile of sample#5 using RIE#3 with 10 mT, $CF_4/O_2$ flow-rate=20/2 sccm, bias voltage=250 V, and etch time=28 minutes (7mx4). Note: the PR etch mask is still remained on the top of nitride ridge; b) Un-etched sample.



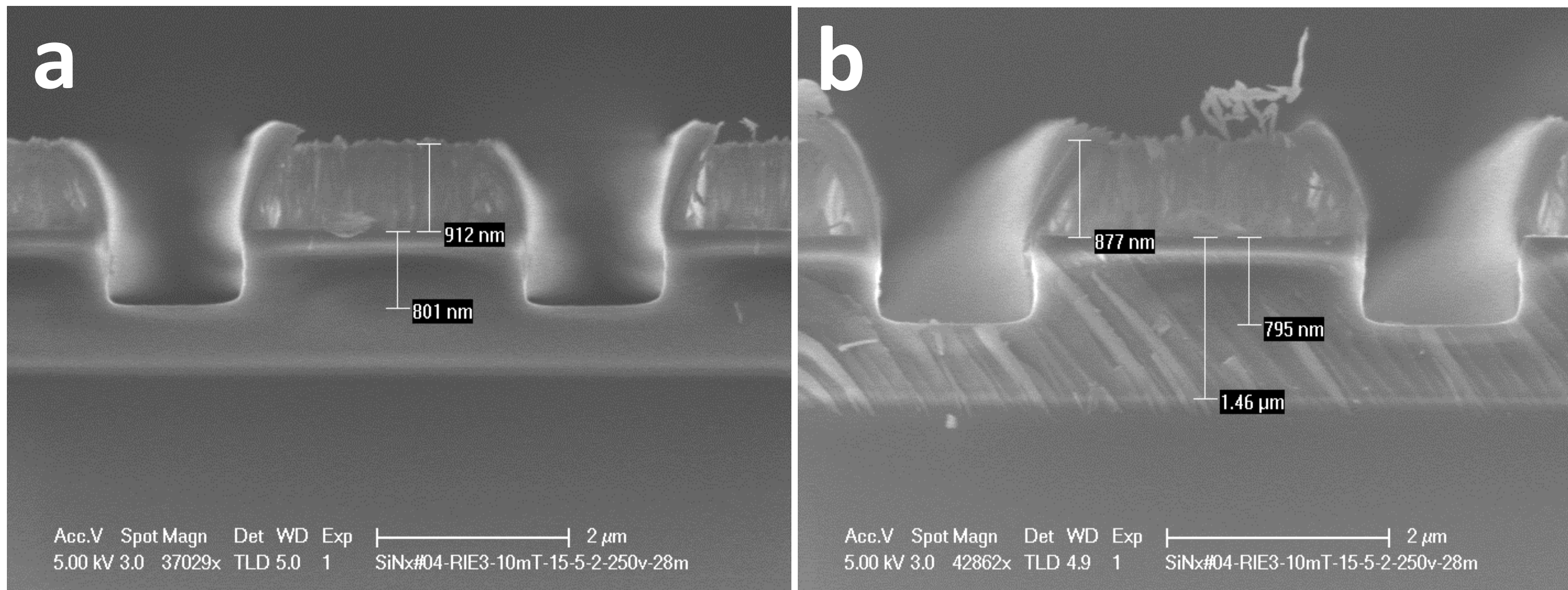
3) Recipe#2 (sample#4): 10 mT, $CF_4/CHF_3/O_2$=15/5/2 sccm, bias voltage=250 V [Note: etch every 7 minutes, then, do the $O_2$ plasma descum (see the descum parameters below) with the sample inside of chamber to remove the built-up polymer].

Etch Rate=28.5 nm/min [for the PR patterned ridge, see Figure 1 (b) above].

Etch Selectivity ($SiN_x$/PR) =1.2

(Prior to the $SiN_x$ etch, do $O_2$ plasma chamber clean: 50mT, $O_2$=20sccm, bias voltage=500 V, and time=30 minutes. After an each 7-minute $CF_4/CHF_3/O_2$ etch, do the $O_2$ plasma descum with 10 mT, $O_2$=20sccm, bias voltage=200 V, and time=5 minutes)

Figure 2 a)-b) $SiN_x$ etch profile of sample#4 using RIE#3 with 10 mT, $CF_4/CHF_3/O_2$ flow-rate=15/5/2 sccm, bias voltage=250 V, and etch time=28 minutes (7mx4). Note: the PR etch mask is still remained on the top of nitride ridge.



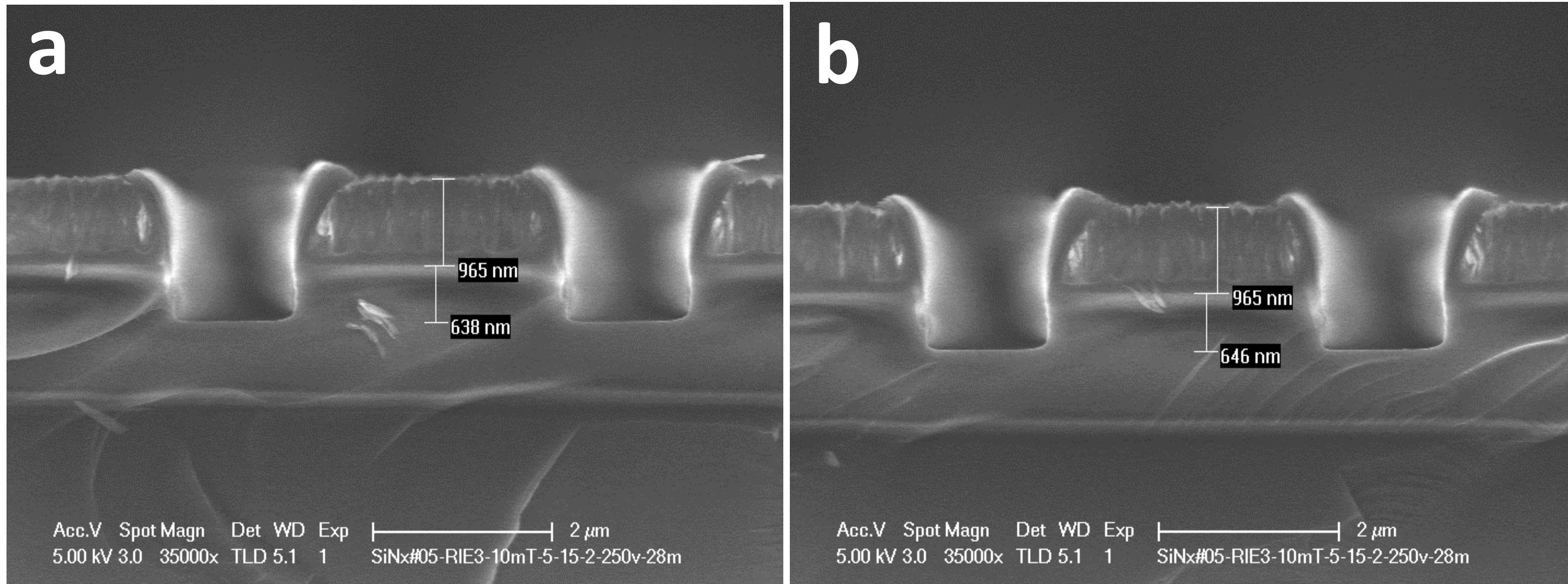
4) Recipe#3 (sample#6): 10 mT, $CF_4/CHF_3/O_2$=5/15/2 sccm, bias voltage=250 V [Note: etch every 7 minutes, then, do the $O_2$ plasma descum (see the descum parameters below) with the sample inside of chamber to remove the built-up polymer].

Etch Rate=22.8 nm/min [for the PR patterned ridge, see Figure 1 (b) above].

Etch Selectivity ($SiN_x$/PR) =1.1

(Prior to the $SiN_x$ etch, do $O_2$ plasma chamber clean: 50mT, $O_2$=20sccm, bias voltage=500 V, and time=30 minutes. After an each 7-minute $CF_4/CHF_3/O_2$ etch, do the $O_2$ plasma descum with 10 mT, $O_2$=20sccm, bias voltage=200 V, and time=5 minutes)

Figure 3 a)-b) SiNx etch profile of sample#6 using RIE#3 with 10 mT, $CF_4/CHF_3/O_2$ flow-rate=5/15/2 sccm, bias voltage=250 V, and etch time=28 minutes (7mx4). Note: the PR etch mask is still remained on the top of nitride ridge.



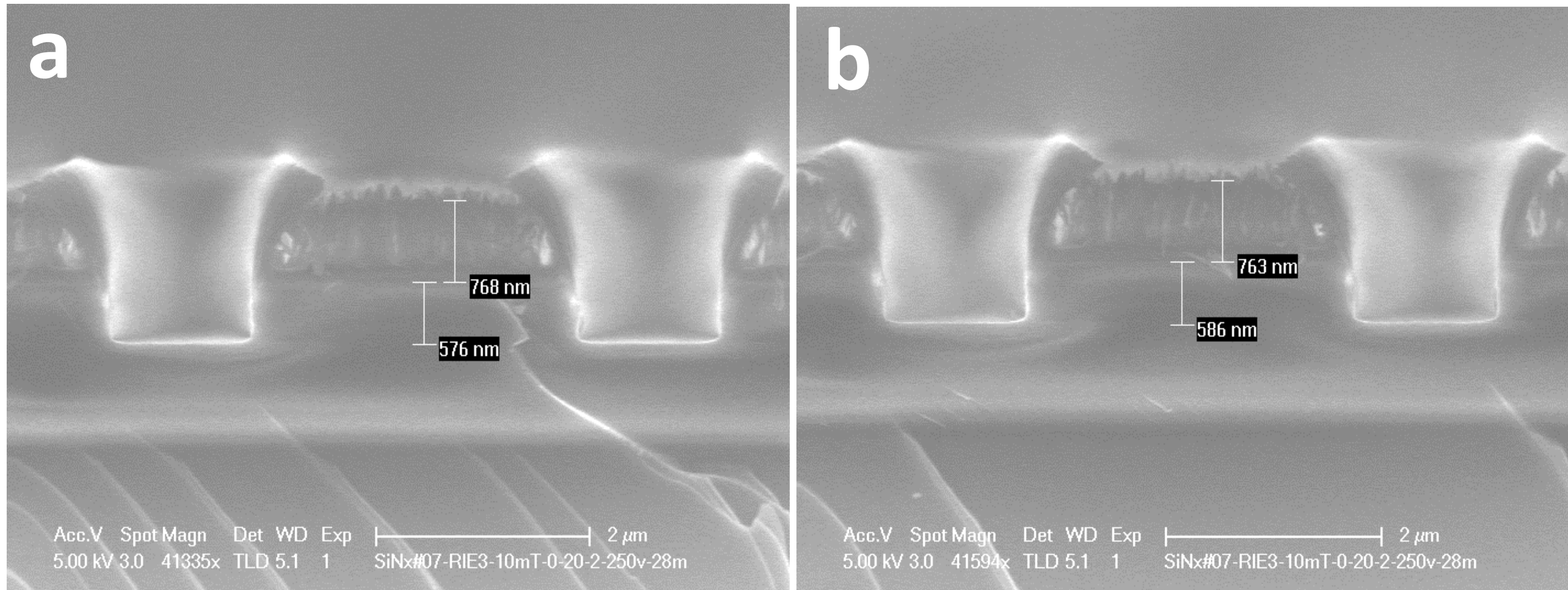
5) Recipe#4 (sample#7): 10 mT, $CHF_3/O_2$=20/2 sccm, bias voltage=250 V [Note: etch every 7 minutes, then, do the $O_2$ plasma descum (see the descum parameters below) with the sample inside of chamber to remove the built-up polymer].

Etch Rate=20.6 nm/min [for the PR patterned ridge, see Figure 1 (b) above].

Etch Selectivity ($SiN_x$/PR) =0.81

(Prior to the $SiN_x$ etch, do $O_2$ plasma chamber clean: 50mT, $O_2$=20sccm, bias voltage=500 V, and time=30 minutes. After an each 7-minute $CF_4/CHF_3/O_2$ etch, do the $O_2$ plasma descum with 10 mT, $O_2$=20sccm, bias voltage=200 V, and time=5 minutes)

Figure 4 a)-b) $SiN_x$ etch profile of sample#7 using RIE#3 with 10 mT, $CHF_3/O_2$ flow-rate=20/2 sccm, bias voltage=250 V, and etch time=28 minutes (7mx4). Note: the PR etch mask is still remained on the top of nitride ridge.



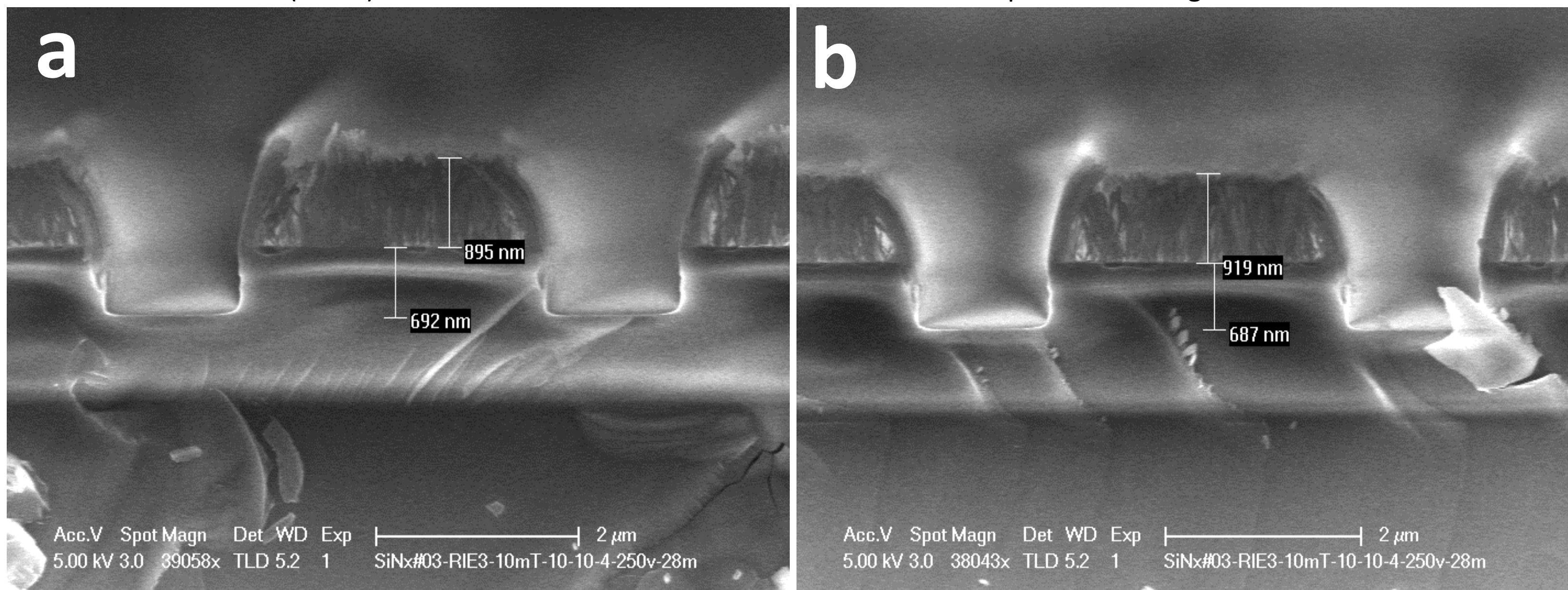
6) Recipe#5 (sample#3): 10 mT, $CF_4/CHF_3/O_2$=10/10/4 sccm, bias voltage=250 V [Note: etch every 7 minutes, then, do the $O_2$ plasma descum (see the descum parameters below) with the sample inside of chamber to remove the built-up polymer].

Etch Rate=692/28≈24.7 nm/min (for the PR patterned ridge, see Figure 1 above).

Etch Selectivity ($SiN_x$/PR) =692/ (1540-904) ≈1.1

(Prior to the $SiN_x$ etch, do $O_2$ plasma chamber clean: 50mT, $O_2$=20sccm, bias voltage=500 V, and time=30 minutes. After an each 7-minute $CF_4/CHF_3/O_2$ etch, do the $O_2$ plasma descum with 10 mT, $O_2$=20sccm, bias voltage=250 V, and time=5 minutes)

Figure 5 a)-b) $SiN_x$ etch profile of sample#3 using RIE#3 with 10 mT, $CF_4/CHF_3/O_2$ flow-rate=10/10/4 sccm, bias voltage=250 V, and etch time=28 minutes (7mx4). Note: the PR etch mask is still remained on the top of nitride ridge.



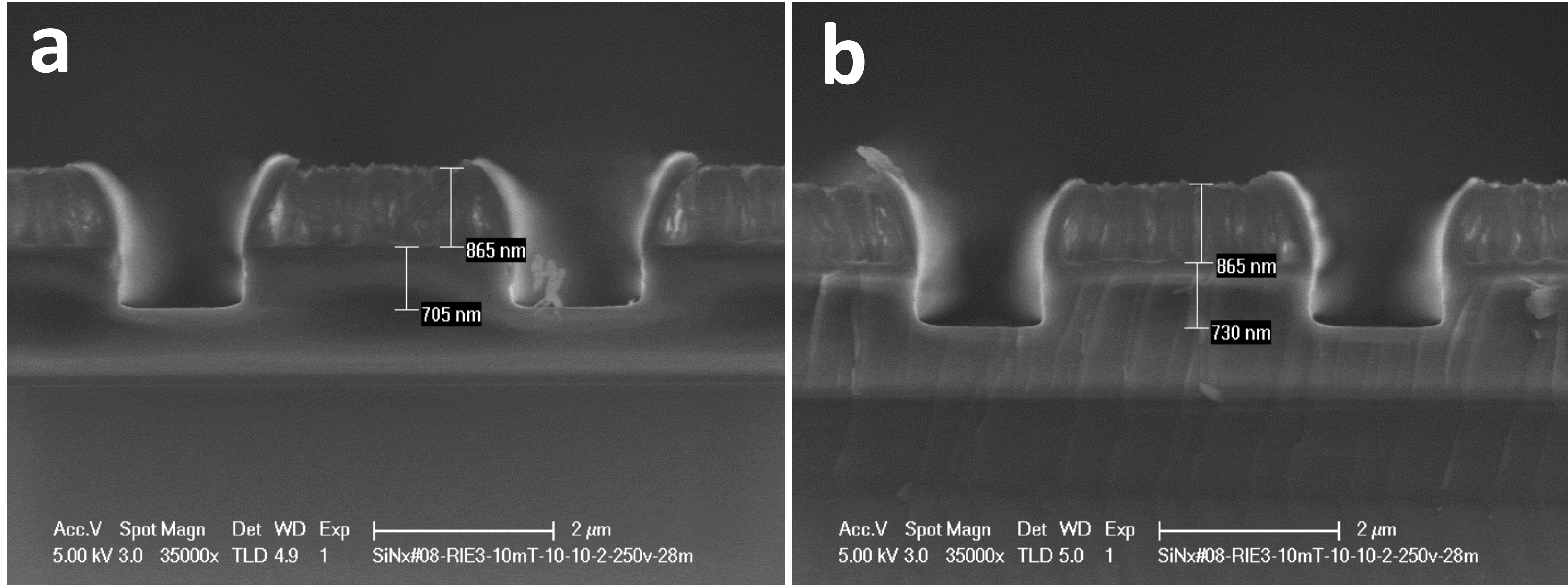
7) Recipe#6 (sample#8): 10 mT, $CF_4/CHF_3/O_2$=10/10/2 sccm, bias voltage=250 V [Note: etch every 7 minutes, then, do the $O_2$ plasma descum (see the descum parameters below) with the sample inside of chamber to remove the built-up polymer].

Etch Rate=715/28≈25.5 nm/min (for the PR patterned ridge, see Figure 1 above).

Etch Selectivity ($SiN_x$/PR) =715/ (1540-855) ≈1.0

(Prior to the $SiN_x$ etch, do $O_2$ plasma chamber clean: 50mT, $O_2$=20sccm, bias voltage=500 V, and time=30 minutes. After an each 7-minute $CF_4/CHF_3/O_2$ etch, do the $O_2$ plasma descum with 10 mT, $O_2$=20sccm, bias voltage=250 V, and time=5 minutes)

Figure 6 a)-b) $SiN_x$ etch profile of sample#8) using RIE#3 with 10 mT, $CF_4/CHF_3/O_2$ flow-rate=10/10/2 sccm, bias voltage=250 V, and etch time=28 minutes (7mx4). Note: the PR etch mask is still remained on the top of nitride ridge.



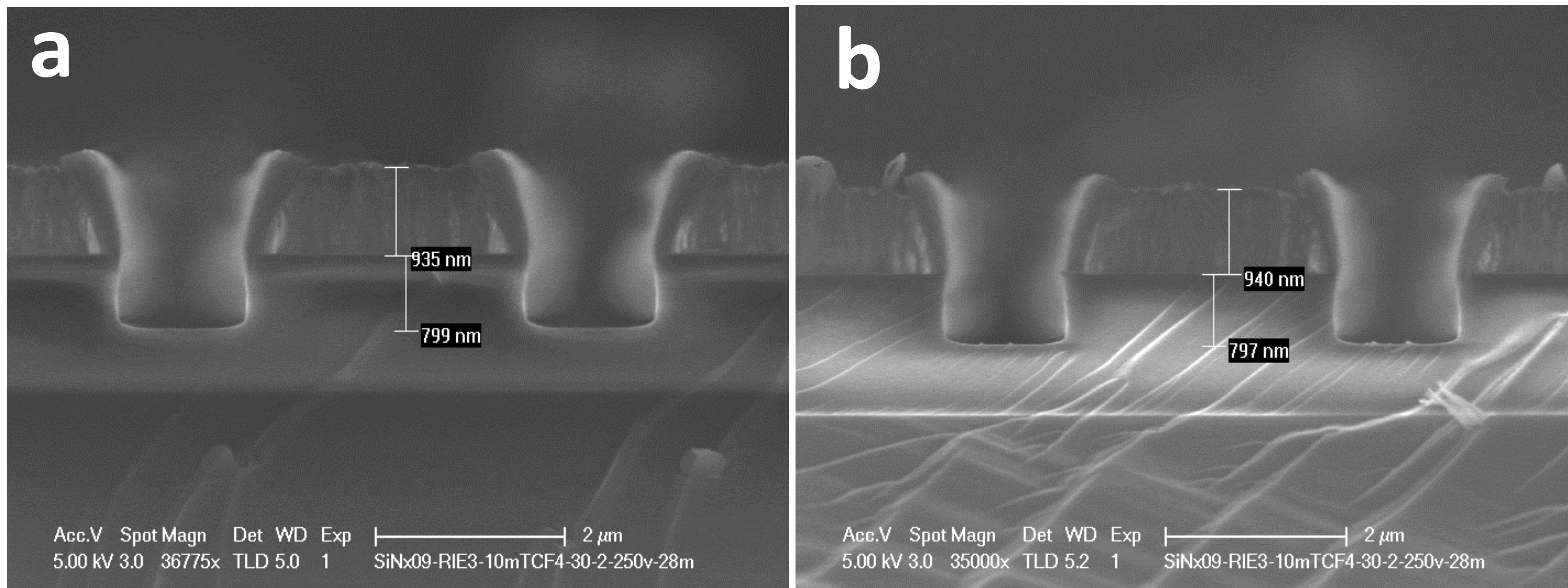
8) Recipe#7 (sample#9): 10 mT, $CF_4/O_2$=30/2 sccm, bias voltage=250 V [Note: etch every 7 minutes, then, do the $O_2$ plasma descum (see the descum parameters below) with the sample inside of chamber to remove the built-up polymer].

Etch Rate=796/28≈28.4 nm/min (for the PR patterned ridge, see Figure 1 above).

Etch Selectivity ($SiN_x$/PR) =796/ (1540-924) ≈1.3

(Prior to the $SiN_x$ etch, do $O_2$ plasma chamber clean: 50mT, $O_2$=20sccm, bias voltage=500 V, and time=30 minutes. After an each 7-minute $CF_4/CHF_3/O_2$ etch, do the $O_2$ plasma descum with 10 mT, $O_2$=20sccm, bias voltage=250 V, and time=5 minutes)

Figure 6 a)-b) $SiN_x$ etch profile of sample#9 using RIE#3 with 10 mT, $CF_4/O_2$ flow-rate=30/2 sccm, bias voltage=250 V, and etch time=28 minutes (7mx4). Note: the PR etch mask is still remained on the top of nitride ridge.



9) Recipe#8 (sample#10): 10 mT, $CF_4/O_2$=10/2 sccm, bias voltage=250 V [Note: etch every 7 minutes, then, do the $O_2$ plasma descum (see the descum parameters below) with the sample inside of chamber to remove the built-up polymer].

Etch Rate=1070/28≈38.1 nm/min (for the PR patterned ridge, see Figure 1 above).

Etch Selectivity ($SiN_x$/PR) =1070/ (1540-870) ≈1.6

(Prior to the $SiN_x$ etch, do $O_2$ plasma chamber clean: 50mT, $O_2$=20sccm, bias voltage=500 V, and time=30 minutes. After an each 7-minute $CF_4/CHF_3/O_2$ etch, do the $O_2$ plasma descum with 10 mT, $O_2$=20sccm, bias voltage=250 V, and time=5 minutes)

Figure 6 a)-b) $SiN_x$ etch profile of sample#10 using RIE#3 with 10 mT, $CF_4/O_2$ flow-rate=10/2 sccm, bias voltage=250 V, and etch time=28 minutes (7mx4). Note: the PR etch mask is still remained on the top of nitride ridge.