PlasmaTherm

Recipes for etch selectivity and sidewall verticality

Stevan Djordjevic

Of interest to those patterning Silicon Nitride or Silicon Oxide, CNM2's plasma etch system, The PlasmaTherm, will serve as a new tool in your arsenal.

Please forward your questions or training requests to:
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PlasmaTherm vs. Technics

Advantages

- More vertical sidewalls
- Faster Silicon Nitride etch rate than technics
- Greater etch reproducibility

Disadvantages

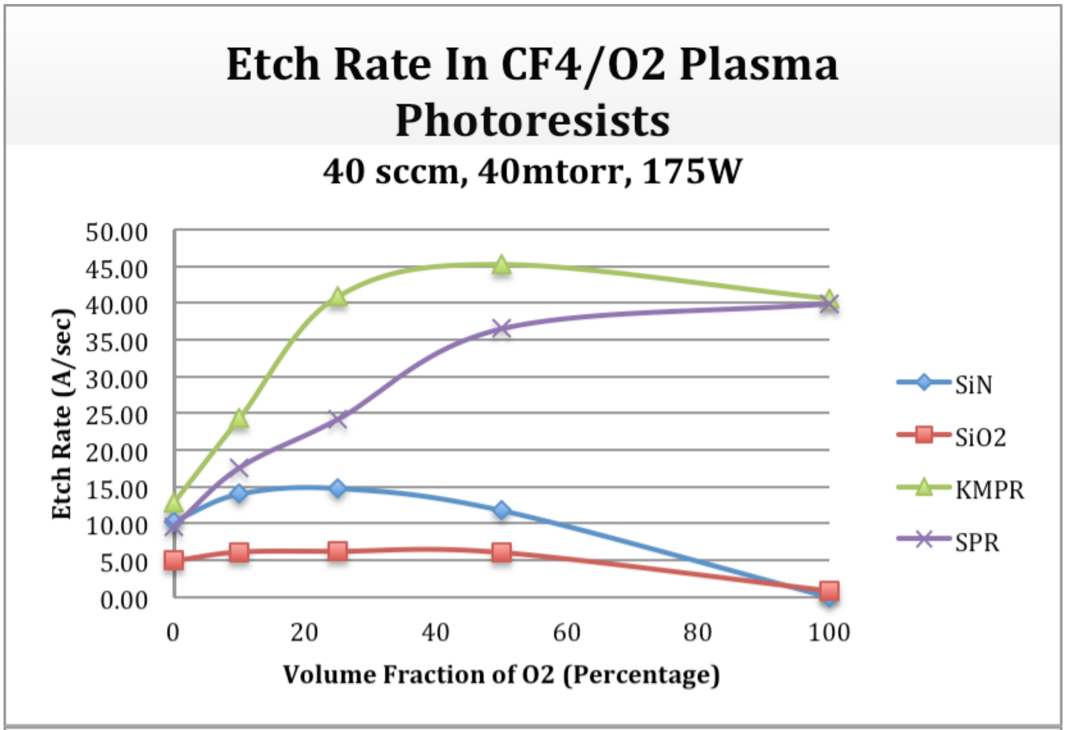
- Slower Silicon and Silicon Oxide etch rate
- No photoresist bulk etching, stripping or ashing allowed
- No 3-5 or similar compounds (eg GaAs, InP, CdTe) allowed

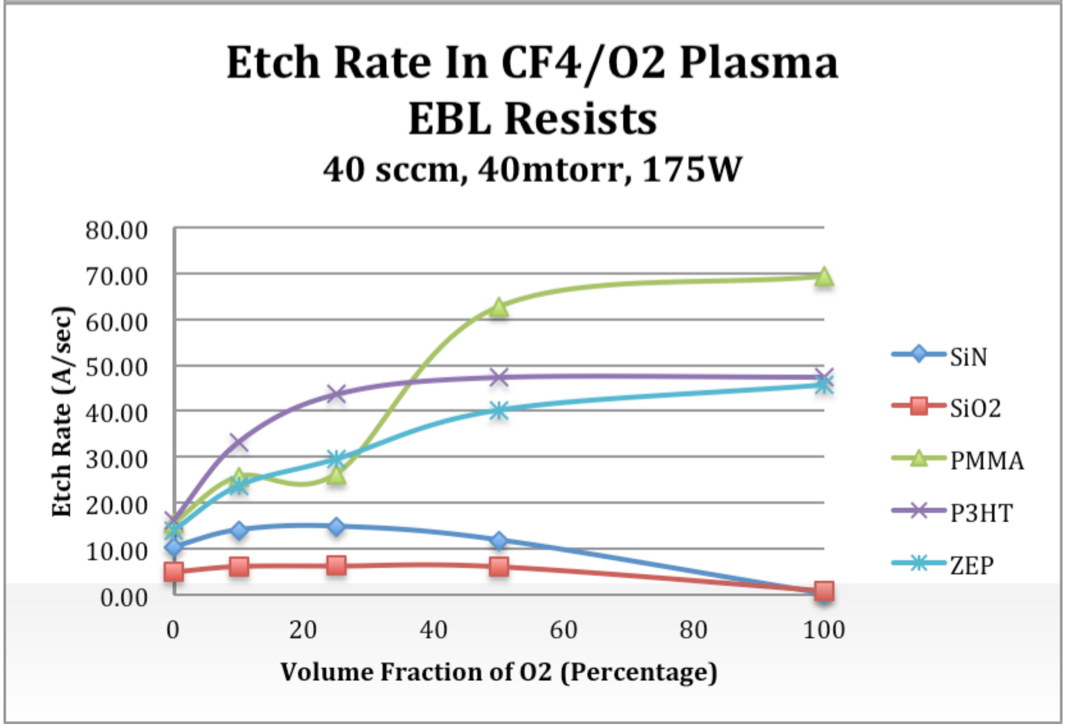
The following three pages of line graphs provide information on the effect of plasma composition and power on the etch rate of several thin films.

Data on sidewall verticality will be coming soon.

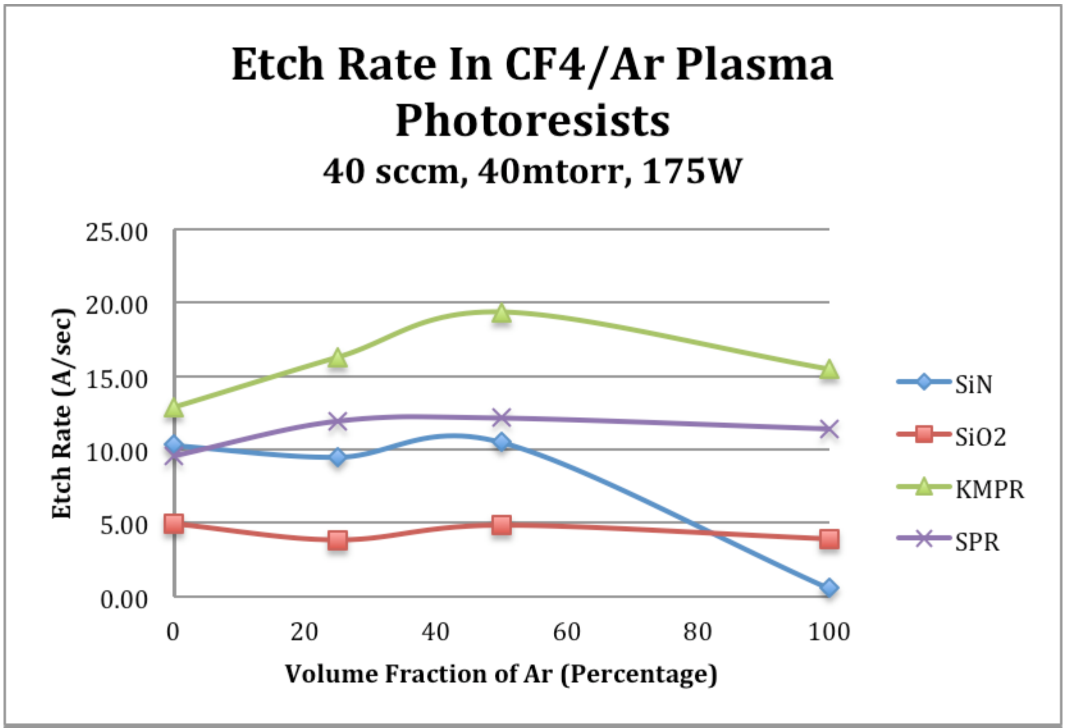
All recipes for pages 2 - 4 were run at 40mTorr pressure and 40sccm total flow rate. Graphs showing the effect of plasma composition were run at 175W. Graphs showing the effect of power were run with a composition of 10:9:1 Ar/CF_4/O_2. A 5-minute plasma clean was run between each etch. All recipes were run on 1cm x 1cm chips of 550um thick Si. Etch rates were determined using a combination of reflectometry and stylus profilometry.

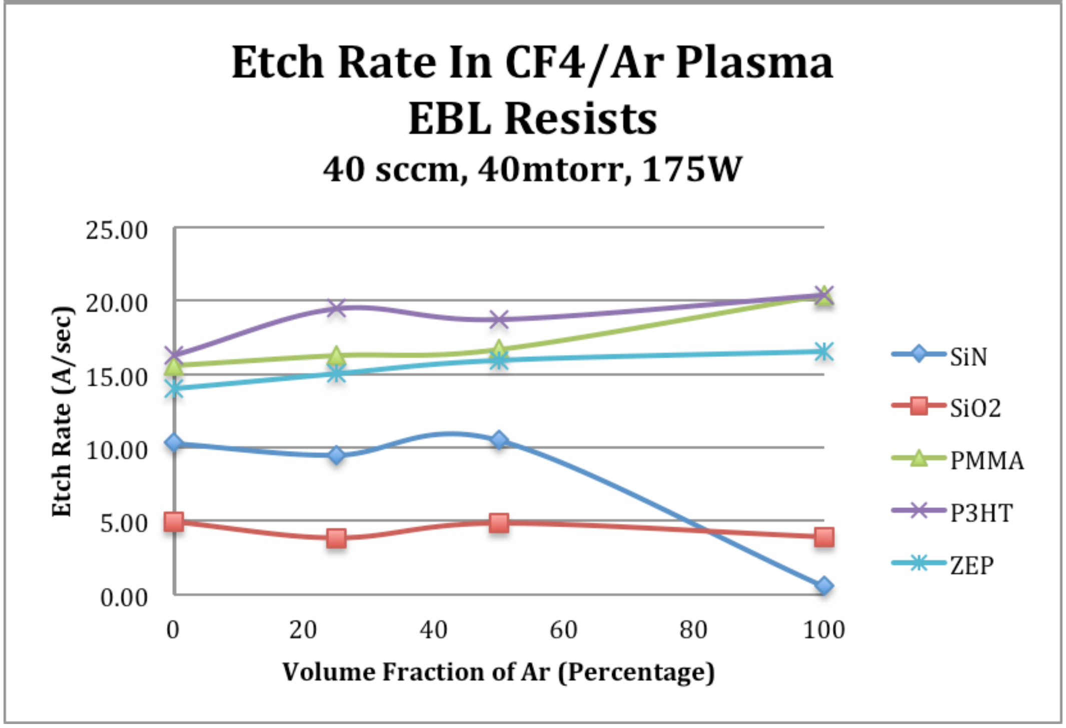
Please give thanks to Stevan Djordjevic of the Yoo group who provided documentation of his experiments to optimize the PlasmaTherm's etch verticality and sidewall roughness on stoichiometric Silicon Nitride coated chips, seen on pages 5 and on.



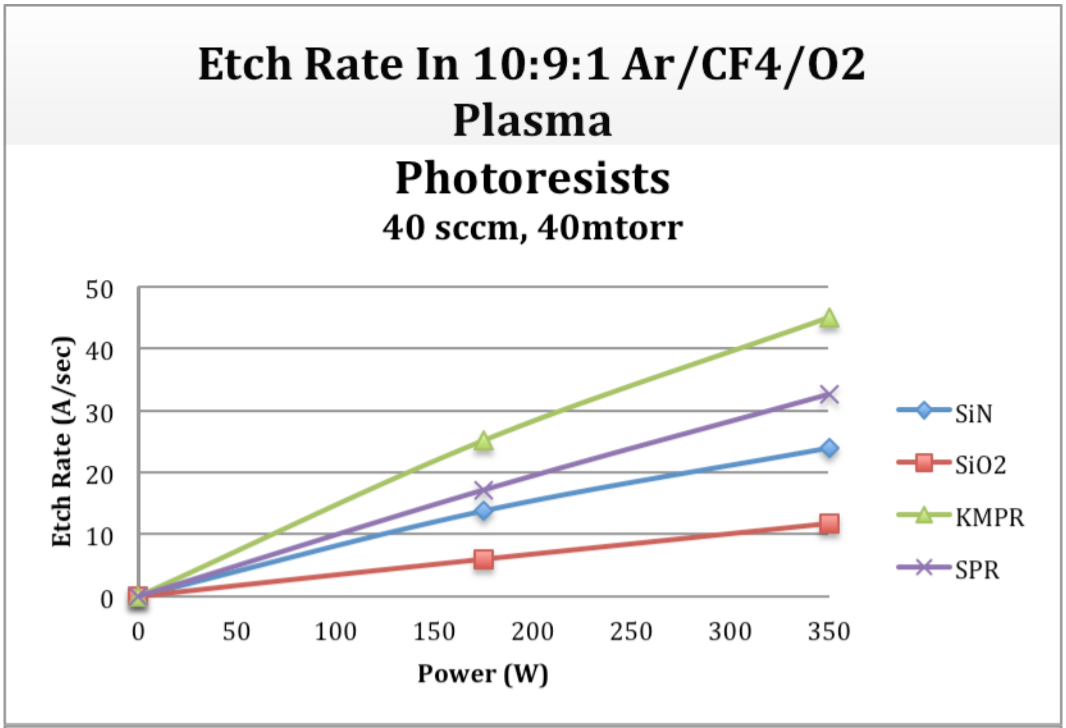


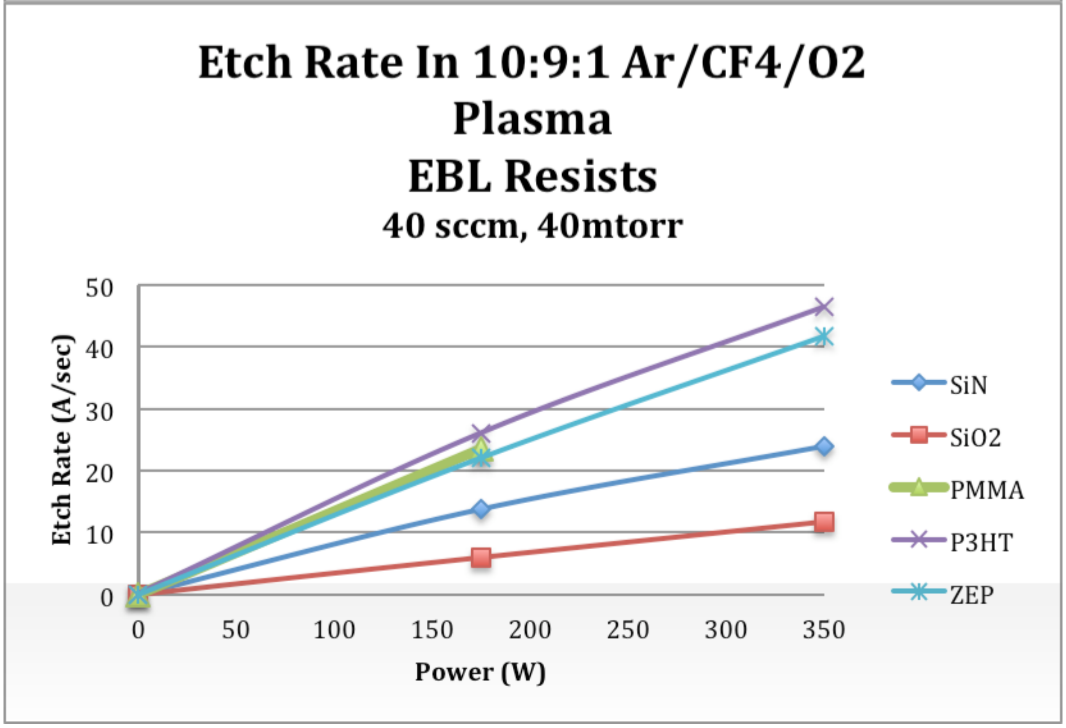
CF4/O2 plasmas find common use in etching Silicon Oxide and Silicon Nitride using a polymeric resist for patterning. Typical recipes utilize 5-15% O2 in the plasma. Though the chart shows data for a pure O2 plasma, please do not ash bulk resists in the PlasmaTherm.





Diluting the plasma with Argon reportedly reduces the amount of grass formed while not reducing resist selectivity as much as Oxygen does. Including as much as 50% Argon did not drastically change etch rates for most materials.





The PlasmaTherm controls platen bias with RF power. Etch rates show a linear dependence on RF power at 40mtorr.

Materials of interest – measured deposition parameters on dummy silicon wafers

Material	DCS [sscm]	N20 [sccm]	NH3 [sccm]	Temp [C]	Pressure [mTorr]	Dep. <me [hrs]	Dep. rate [nm/min]	Uniformity on wafer [%]	Tensile stress [GPa]
SSN	25	0	75	800	300	2	3.34*	1.7	1.10
LSN	100	0	25	835	140	2	3.0	2.4	0.31
HTO	180	180	0	920	400	2	5.1	2.8	- 0.16**

SSN = Stoichiometric silicon nitride LSN = Low stress nitride HTO = High temperature oxide

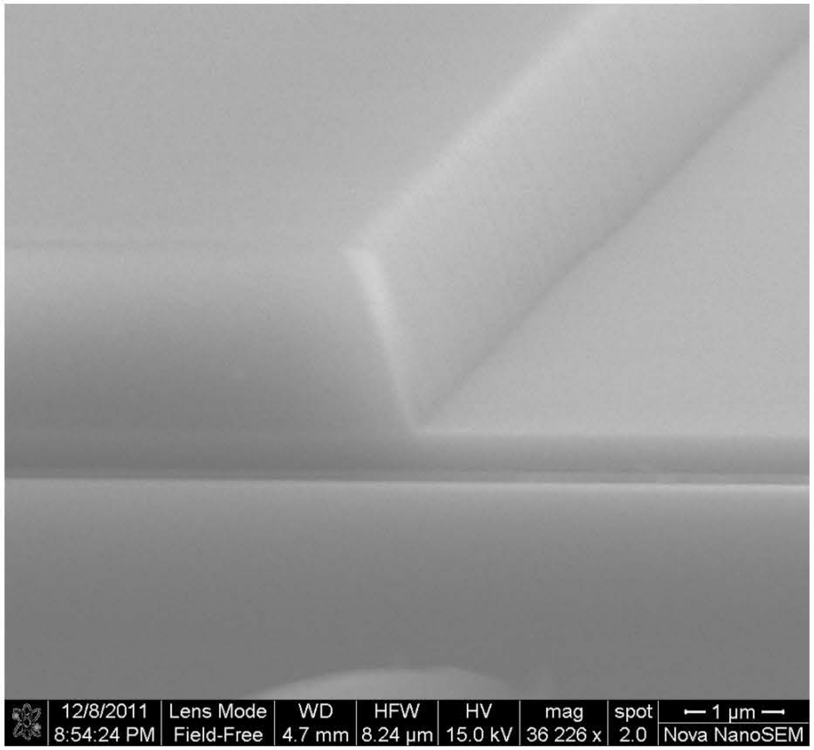
* measurement confirmed by SEM

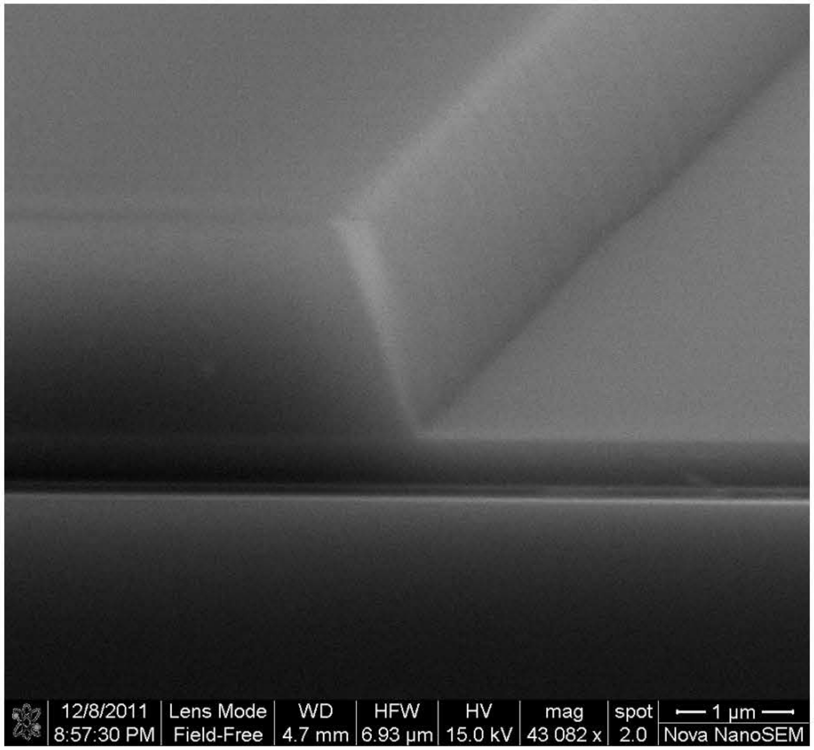
** compressive stress (stress measured on Tencor Flexus -2320 machine)

Rec. #	CF4 [sccm]	O2 [sccm]	Ar [sccm]	Press [mTorr]	RF [W]	DC* [W]	Time [s]	Etch rate [nm/min]	SEM
1	40	0	0	40	200	345	240	53.2	Yes
2	40	0	0	20	200	345	240	50.2	Yes
3	40	0	0	40	400	345	240	96.0	Yes
4	40	0	0	10	150		240		No
5	40	0	0	10	100		240		No
6	30	0	10	10	100		240		No

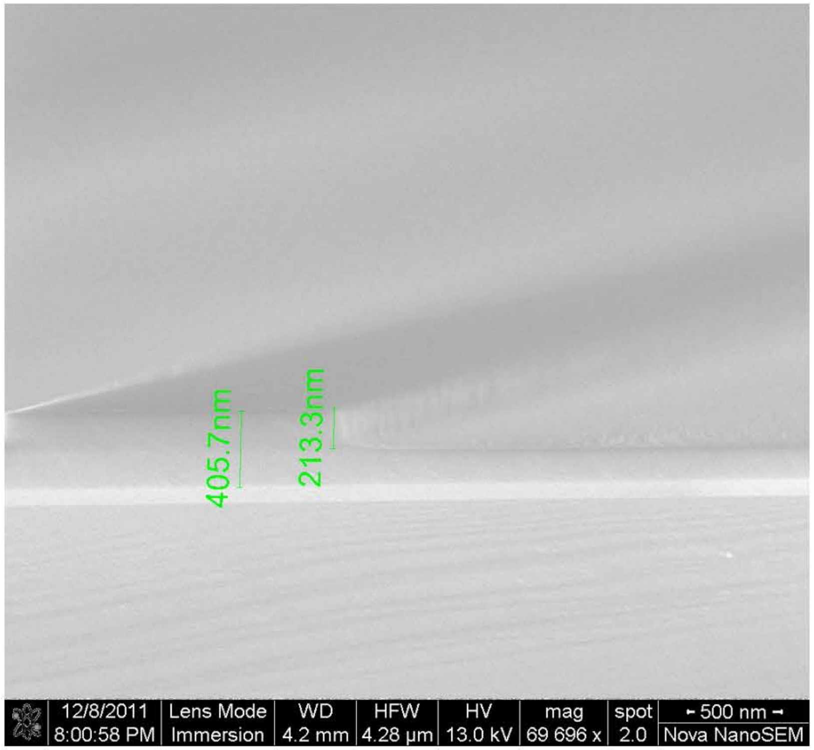
* In the PlasmaTherm etch system DC bias cannot be controlled independently from the RF power (and vice versa).

Photoresist Pattern (AZ1813)





Recipe #1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213.3nm
12/8/2011
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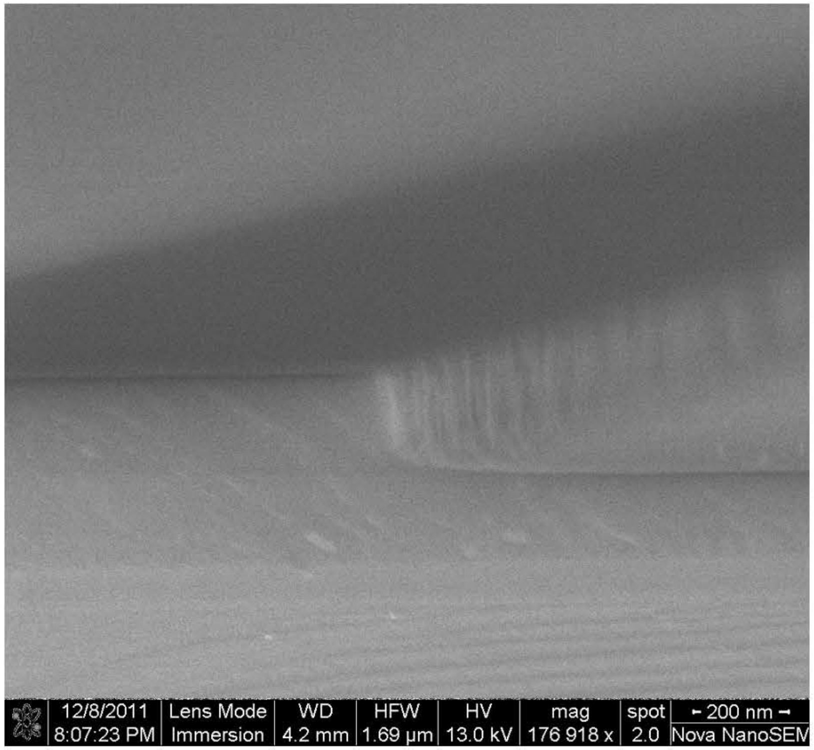
HFW
4.28 µm
HV
13.0 kV
mag
69 696 x
spot
2.0
500 nm
Nova NanoSEM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HV
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mag
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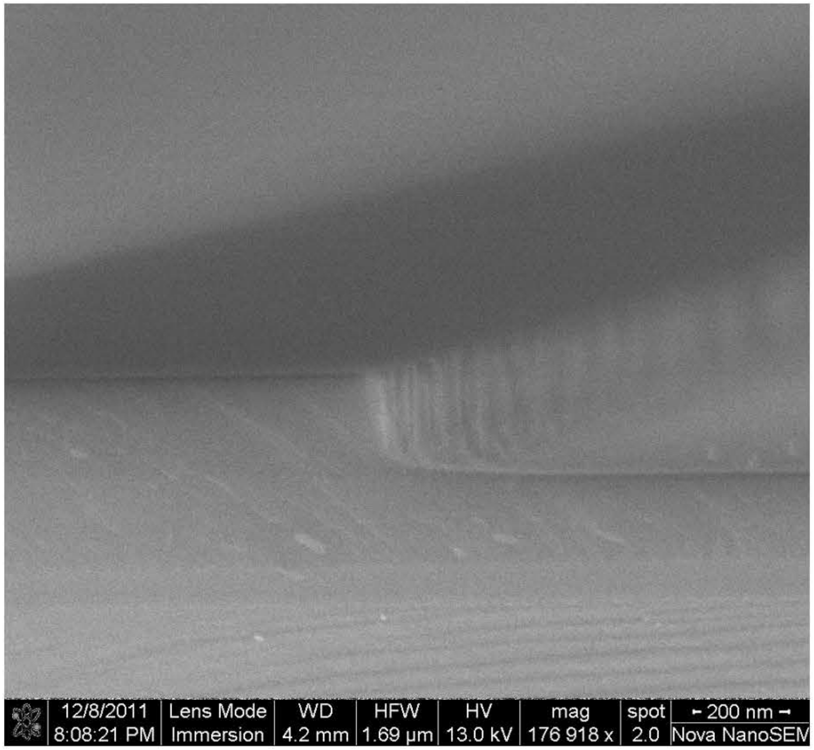
spot
2.0
200 nm
Nova NanoSEM

Recipe #1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HFW
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HV
13.0 kV
mag
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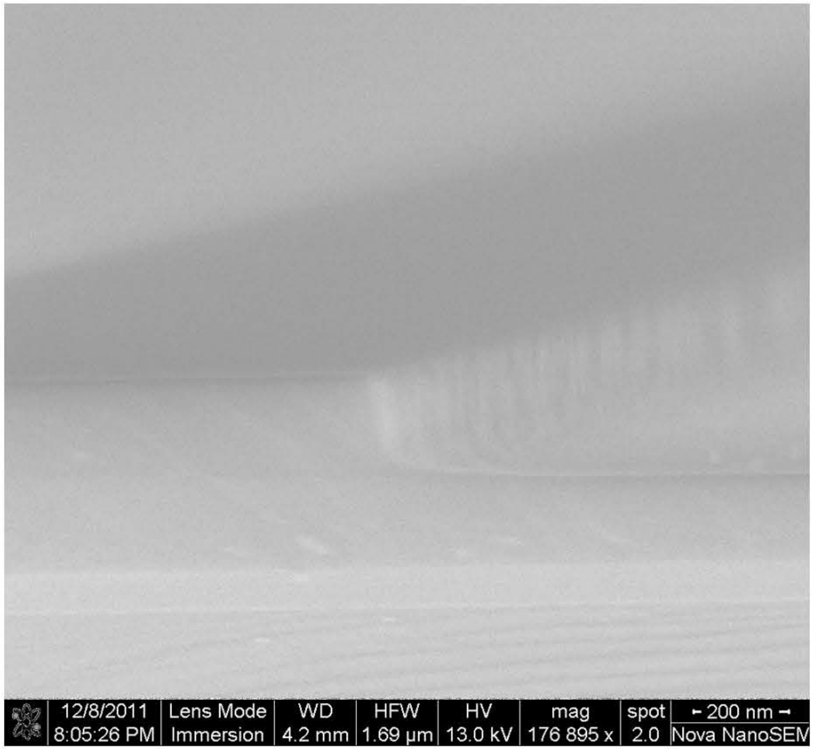
spot
2.0
← 200 nm →
Nova NanoSEM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HV
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mag
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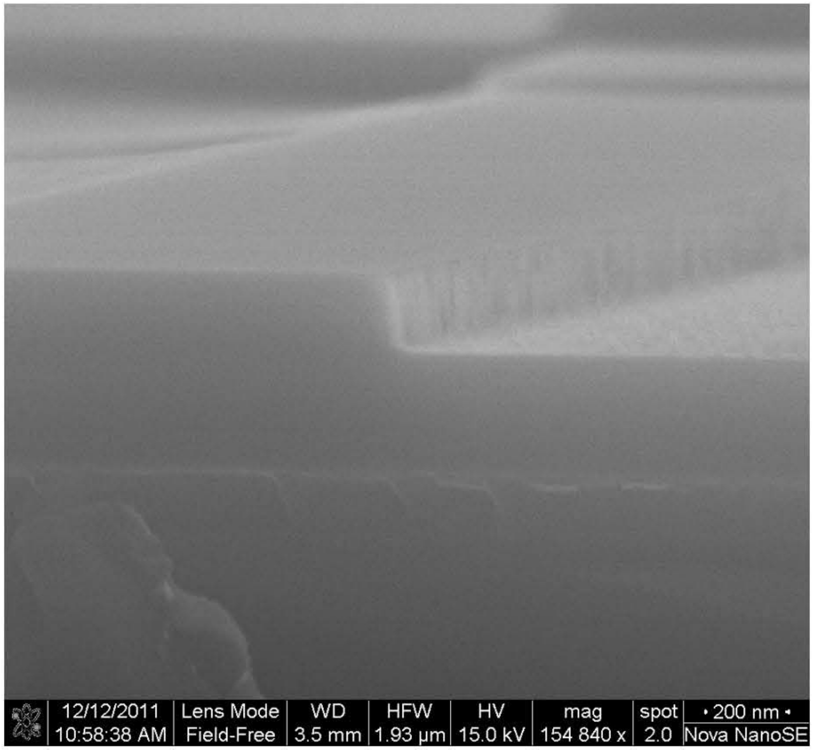
spot
2.0
← 200 nm →
Nova NanoSEM

Recipe #2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HV
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mag
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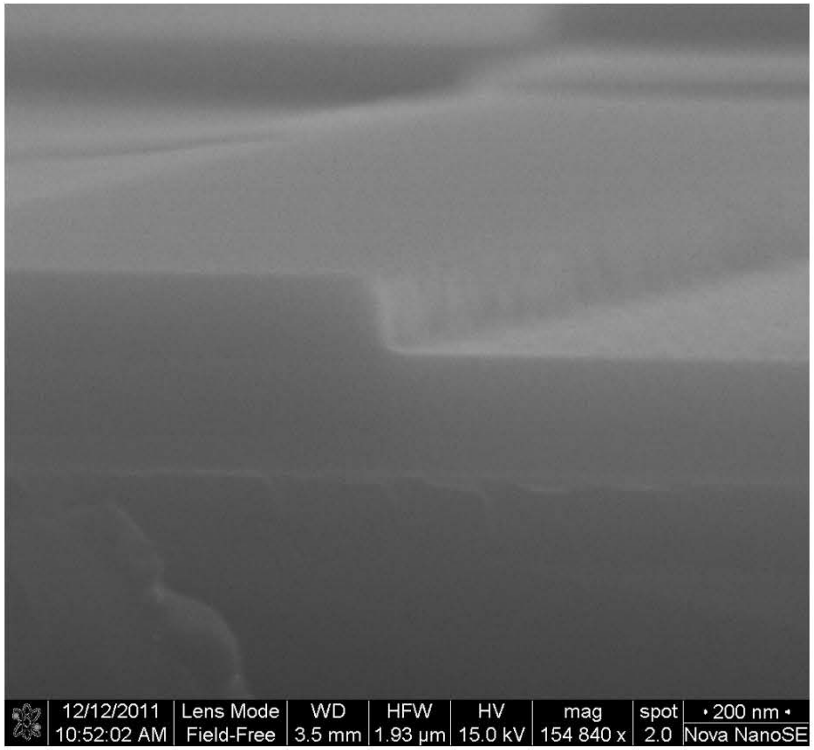
spot
2.0
200 nm
Nova NanoSE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HV
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mag
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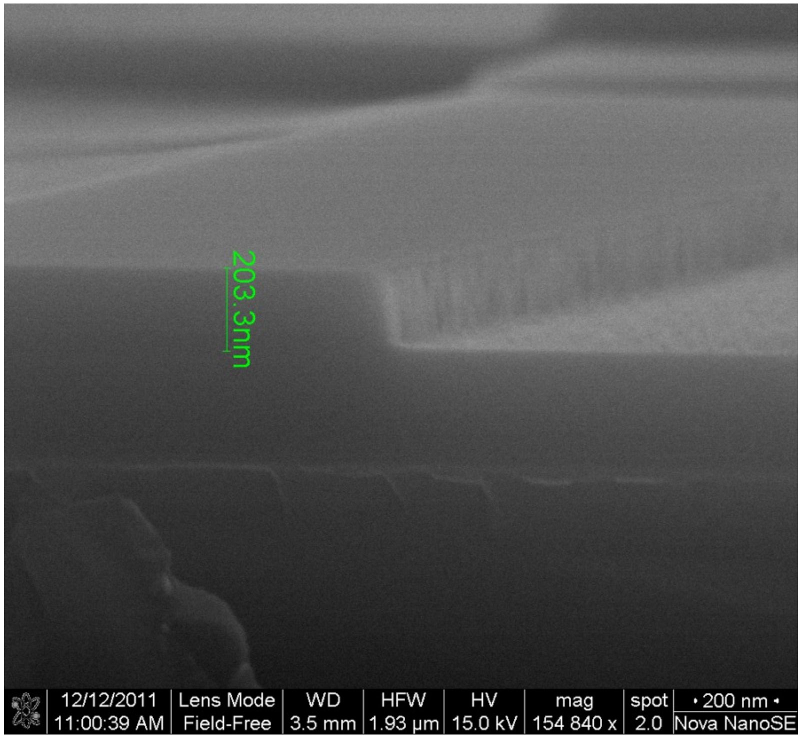
spot
2.0
200 nm
Nova NanoSE

Recipe #2



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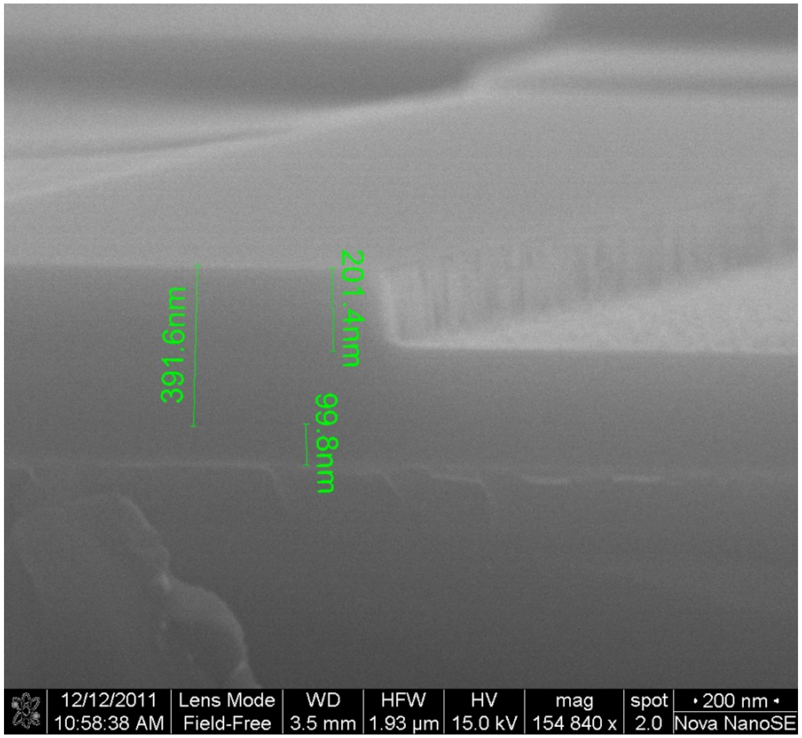
spot
2.0
200 nm
Nova NanoSE



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201.4nm
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HV
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mag
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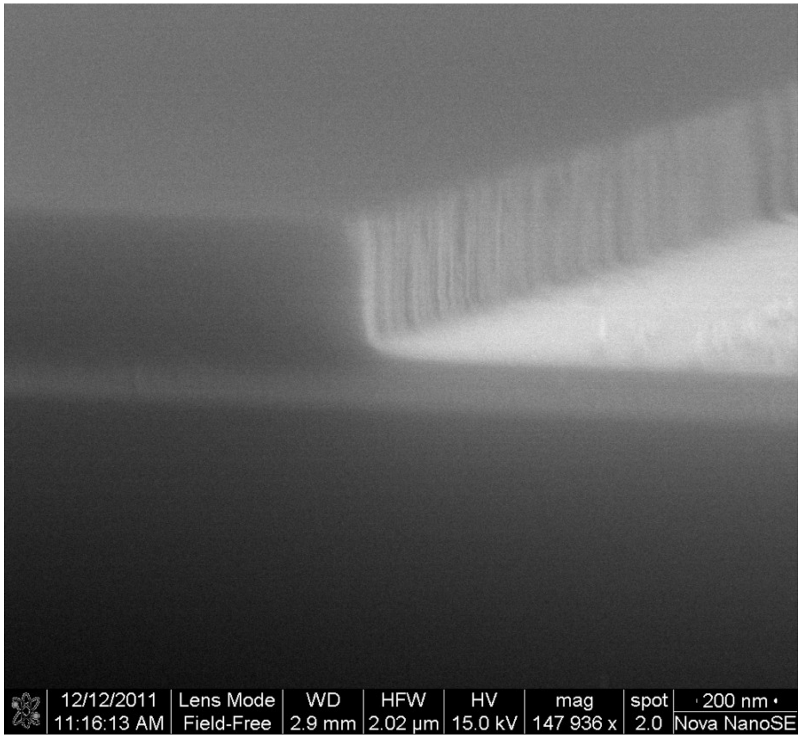
spot
2.0
200 nm
Nova NanoSE

Recipe #3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HFW
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HV
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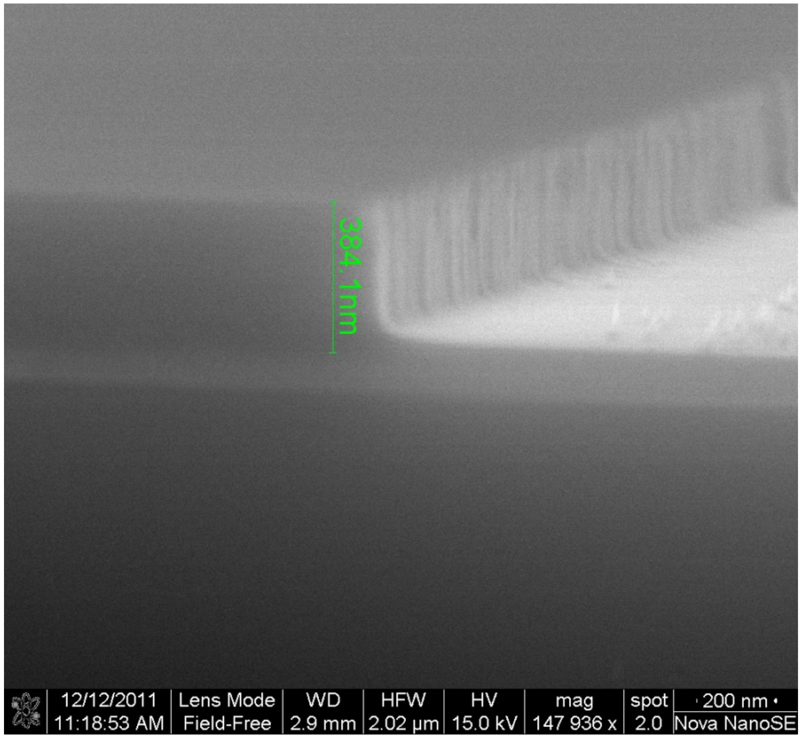
mag
147 936 x
spot
2.0
200 nm
Nova NanoSE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12/12/2011
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WD
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2.02 µm
HV
15.0 kV
mag
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spot
2.0
200 nm
Nova NanoSE