MSc Thesis Project

BCP Lithography Defined Arrays of InAs NWs Grown Using MOVPE with Au Seeds

APPENDIX

2015-11-30

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APPENDIX A0

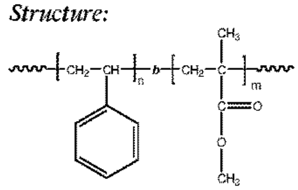
Polymer Characterization Data Supplied By *Polymer Source Inc.*

B82 Data Sheet – Directly From *Polymer Source Inc.*

Sample Name: **Poly(styrene-b-methyl methacrylate)**
(polymethylmethacrylate rich in syndiotactic contents > 78%)

Sample #: **P8269-SMMA**

Structure:



Composition:

Mn x 10^3 S-b-MMA	PDI
57.0-b-25.0	1.07
T_g for PS block: 106°C	T_g for PMMA block: 127°C

Synthesis Procedure:

Poly(styrene-b-methyl methacrylate) is prepared by living anionic polymerization in THF at –78 °C using cumyl potassium initiator in the presence of LiCl. Polystyrene macroanions were end capped with a unit of diphenyl ethylene (DPE) before adding methylmethacrylate (MMA) monomer. For further details please see our published articles.[1-5]

Characterization:

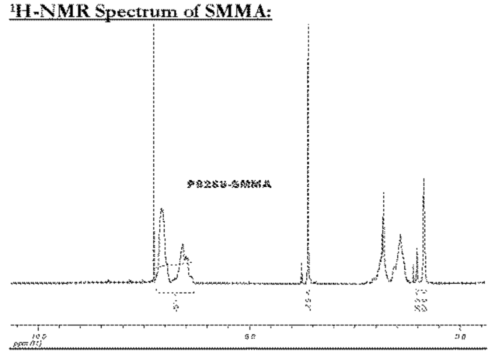
An aliquot of the anionic polystyrene block was terminated before addition of MMA and analyzed by size exclusion chromatography (SEC) to obtain the molecular weight and polydispersity index (PDI). The final block copolymer composition was calculated from ^{1}H-NMR spectroscopy by comparing the peak area of the poly(methyl methacrylate) protons (eg. $–OCH_3$ at 3.6ppm) with the of aromatic protons of polystyrene at 6.3-7.2 ppm. Copolymer PDI is determined by SEC.

Thermal analysis of the samples was carried out using a differential scanning calorimeter (TA Q100) at a heating rate of 15°C/min. The inflection glass transition temperature (T_g) of the sample has been considered.

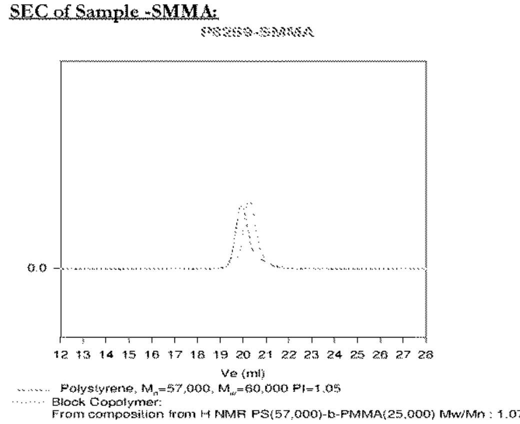
Solubility:

Poly(styrene-b-methyl methacrylate) is soluble in THF, toluene, dioxane and $CHCl_3$. This polymer readily precipitates from methanol, ethanol, hexanes and water.

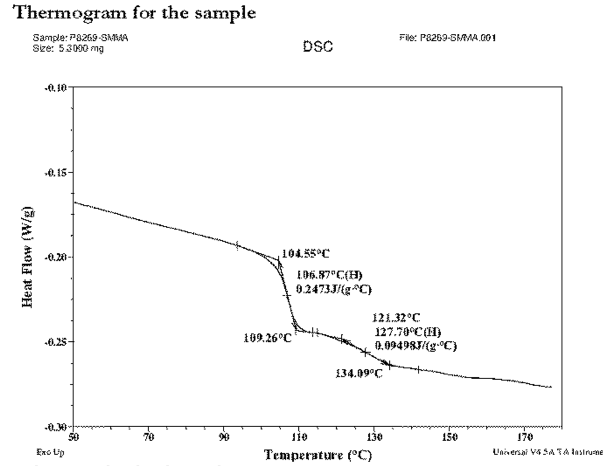
^{1}H-NMR Spectrum of SMMA:



SEC of Sample -SMMA:



Thermogram for the sample



References for further information:

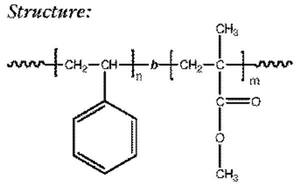
1. S. K. Varshney, R. Fayt, Ph. Teyssie, and J.P. Hautekeer US Patent 5,264,527 (1993)
2. Ph. Teyssie, Ph. Bayard, R. Jerome, S. K. Varshney, and J. S. Wang, *35th IUPAC International Union of Pure & Applied Chemistry International Symposium on Macromolecules" 1994, 67.*
3. Ph. Teyssie, R. Fayt, J. P. Hautekeer, C. Jacobs, R. Jerome, L. Leemans and S. K. Varshney *Makromolekular Chemie, Macromol. Symp., 1990, 32,61-73.*
4. S. K. Varshney, J. P. Hautekeer, R. Fayt, R. Jerome, and Ph.Teyssie *Macromolecules, 1990, 23, 2618-2622.*
5. R. Jerome, R. Forte, S. K. Varshney, R. Fayt, and Ph. Teyssie "The Anionic Polymerization of Alkylacrylates:A Challenge" in the Recent Advances in Mechanistic and Synthetic Aspects of Polymerization. M. Fontanaille and A. Guyot Ed., NATO ASI Series *C 215,101 (1987), CA Vol. 108, 12, 094992.*

B67 Data Sheet – Directly From *Polymer Source Inc.*

Sample Name: **Poly(styrene-b-methyl methacrylate)** ***(polymethylmethacrylate rich in syndiotactic contents > 80%)***

Sample #: **P2400-SMMA**

Structure:



Composition:

Mn x 10^3 S-b-MMA	PDI
46.1-b-21.0	1.09
T_g for PS block: 105C	T_g for PMMA block: 128°C

Synthesis Procedure:

Poly(styrene-b-methyl methacrylate) is prepared by living anionic polymerization in THF at –78 °C using sec.BuLi initiator in the presence of LiCl. Polystyrene macroanions were end capped with a unit of diphenyl ethylene (DPE) before adding methylmethacrylate (MMA) monomer.

Characterization:

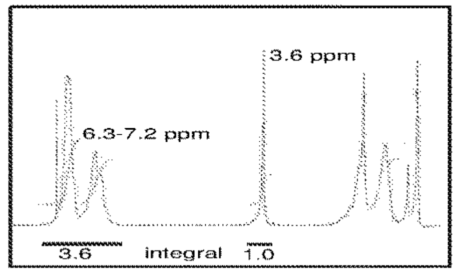
An aliquot of the anionic polystyrene block was terminated before addition of MMA and analyzed by size exclusion chromatography (SEC) to obtain the molecular weight and polydispersity index (PDI). The final block copolymer composition was calculated from ^{1}H-NMR spectroscopy by comparing the peak area of the poly(methyl methacrylate) protons (eg. –OCH_3 at 3.6ppm) with the of aromatic protons of polystyrene at 6.3-7.2 ppm. Copolymer PDI is determined by SEC.

Thermal analysis of the samples was carried out using a differential scanning calorimeter (TA Q100) at a heating rate of 15°C/min. The inflection glass transition temperature (T_g) of the sample has been considered.

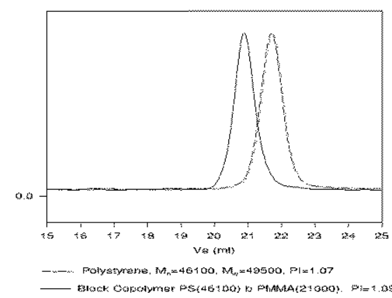
Solubility:

Poly(methyl methacrylate) is soluble in THF, $CHCl_3$, toluene and dioxane. The polymer precipitates from hexanes, methanol and ethanol.

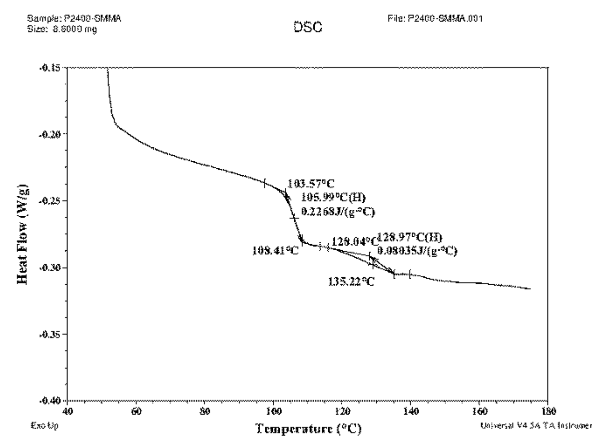
^{1}H-NMR Spectrum of P2400-SMMA:



SEC of Sample P2400-SMMA:



Thermograms of sample



References for further information:

1. S. K. Varshney, R. Fayt, Ph. Teyssie, and J.P. Hautekeer US Patent 5,264,527 (1993)
2. Ph. Teyssie, Ph. Bayard, R. Jerome, S. K. Varshney, and J. S. Wang, *35th IUPAC International Union of Pure & Applied Chemistry International Symposium on Macromolecules" 1994, 67.*
3. Ph. Teyssie, R. Fayt, J. P. Hautekeer, C. Jacobs, R. Jerome, L. Leemans and S. K. Varshney *Makromolekular Chemie, Macromol. Symp., 1990, 32,61-73.*
4. S. K. Varshney, J. P. Hautekeer, R. Fayt, R. Jerome, and Ph.Teyssie *Macromolecules, 1990, 23, 2618-2622.*
5. R. Jerome, R. Forte, S. K. Varshney, R. Fayt, and Ph. Teyssie "The Anionic Polymerization of Alkylacrylates:A Challenge" in the Recent Advances in Mechanistic and Synthetic Aspects of Polymerization: M. Fontanaille and A. Guyot Ed., NATO ASI Series *C 215,101 (1987), CA Vol. 108, 12, 094992.*

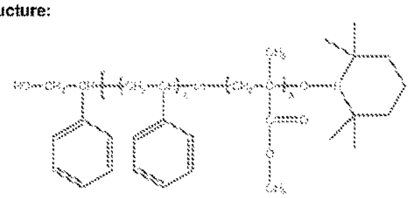
R10.5 Data Sheet – Directly From *Polymer Source Inc.*

Sample Name:

Random Copolymer Poly(styrene-co-methyl methacrylate), α-Hydroxyl-ω-Tempo moiety Terminated

Sample #: **P18984B-SMMAranOHT**

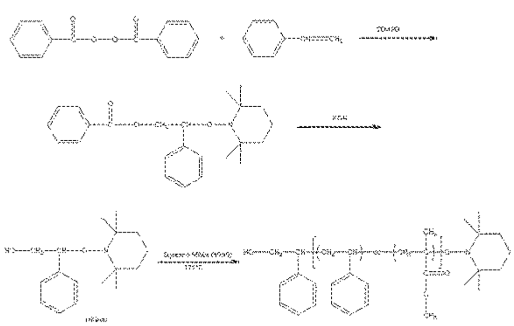
Structure:



Composition:

Mn x 10^3 (Styrene content mol%)	Mw/Mn (PDI)
10.5 (66 %)	1.15

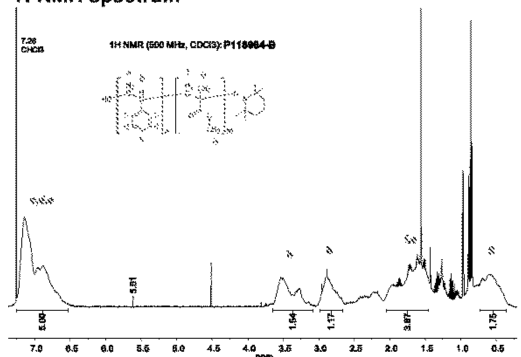
Synthesis Procedure:
Hydroxy terminated poly(styrene-co-methyl methacrylate) is prepared by stable free radical polymerization at 135°C. The reaction scheme is shown below:



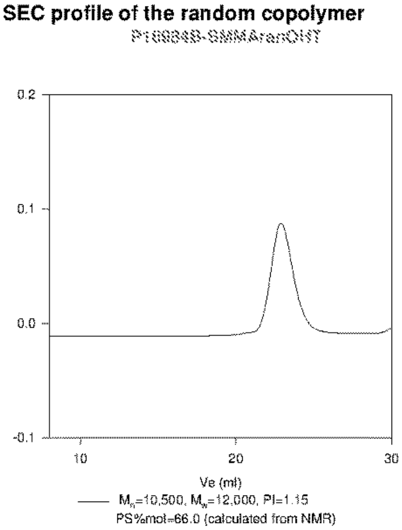
Characterization:
An aliquot of the copolymer was analyzed by size exclusion chromatography (SEC) to obtain the molecular weight and polydispersity index (PDI), the instrument calibrated by Polystyrene standards. The chemical composition was calculated from ^{1}H-NMR spectroscopy by comparing the peak area of the phenyl protons at 6.8-7.4 ppm with the peak area of methyl methacrylate at 2.6-3.6 ppm.

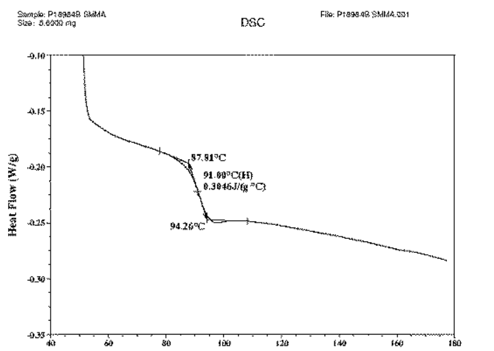
Solubility:
Poly(styrene-co-methyl methacrylate) is soluble in THF, DMF, Toluene and chloroform. Precipitate from methanol and Hexanes.

^{1}H NMR spectrum



SEC profile of the random copolymer





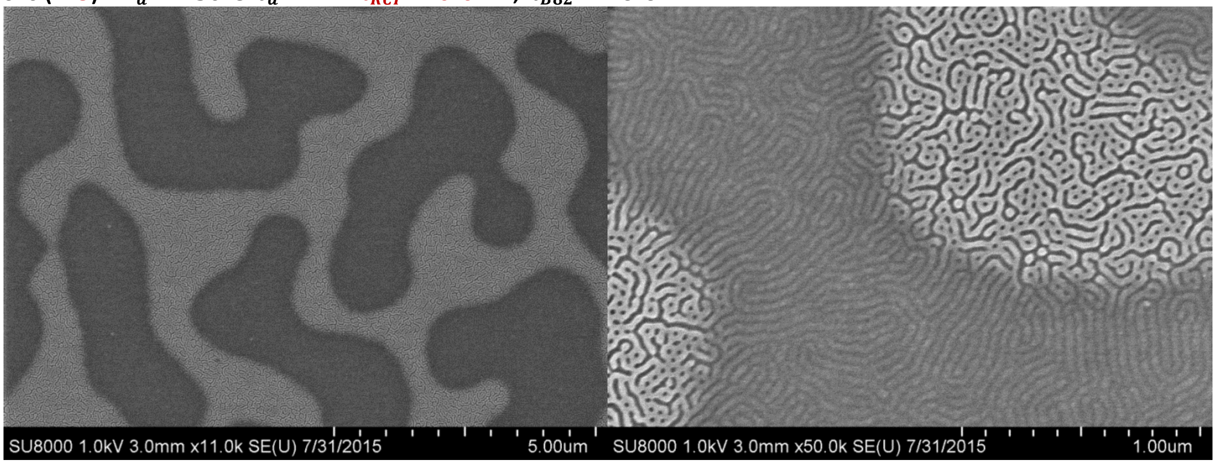
v.A-2

APPENDIX A1

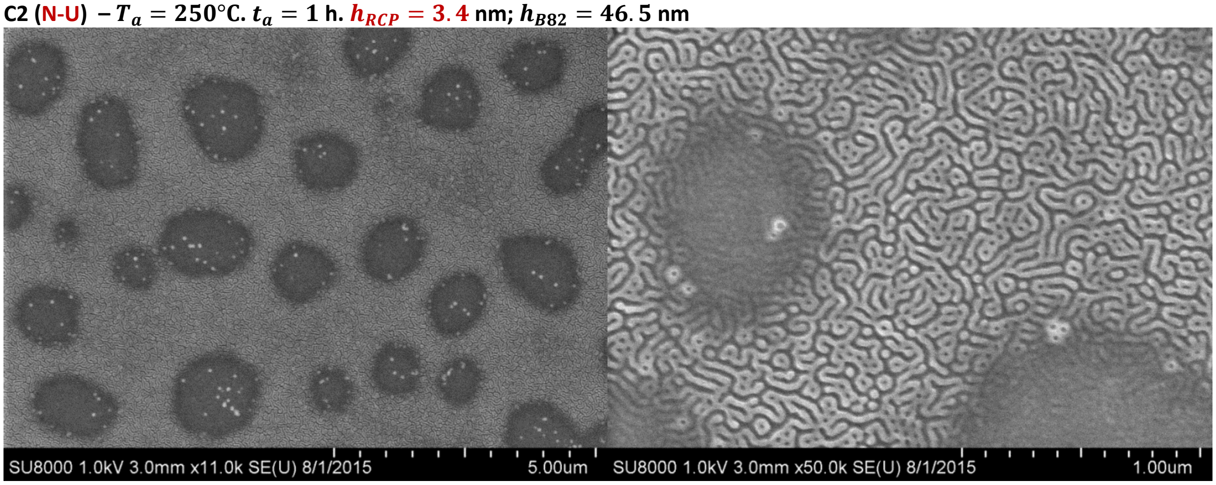
R10.5 Grafting

A1.1 The influence of $h_{R10.5}$ on orientation and ordering of the subsequent B82 layer

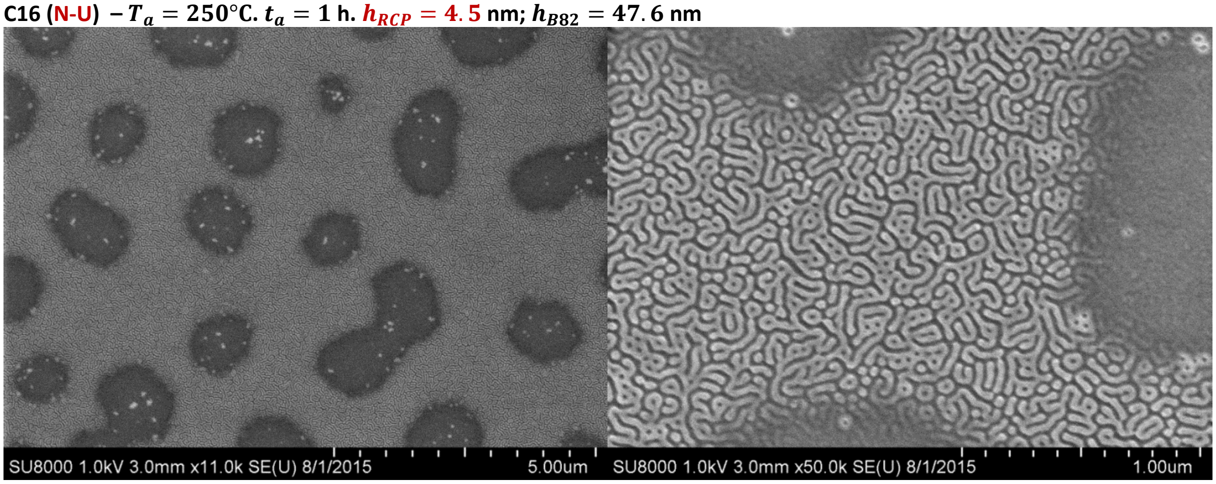
S20 (N-U) – $T_a = 250°\text{C}$. $t_a = 1$ h. $h_{RCP} = 0.0$ nm; $h_{B82} = 46.6$ nm



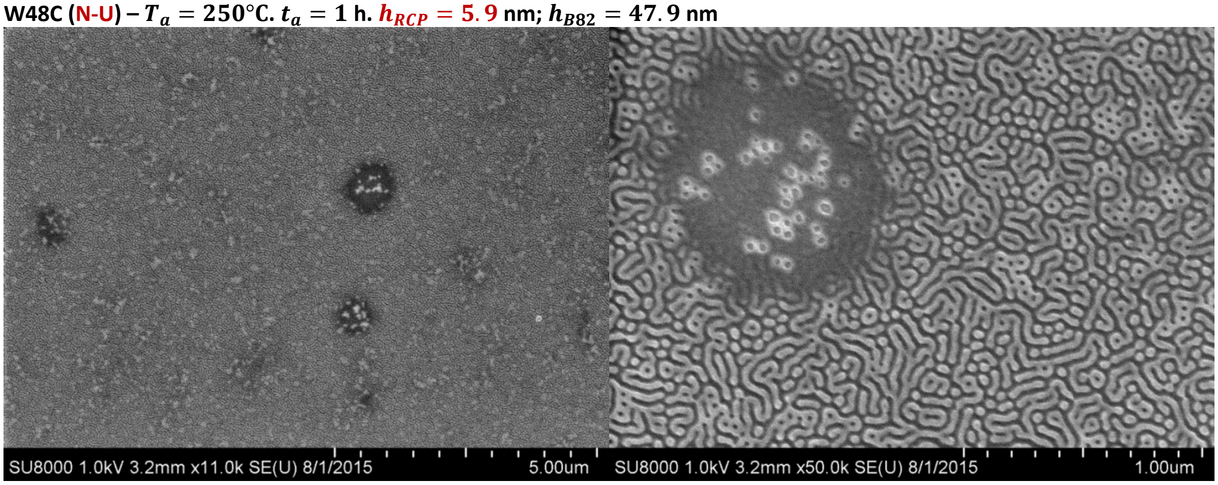
C2 (N-U) – $T_a = 250°\text{C}$. $t_a = 1$ h. $h_{RCP} = 3.4$ nm; $h_{B82} = 46.5$ nm



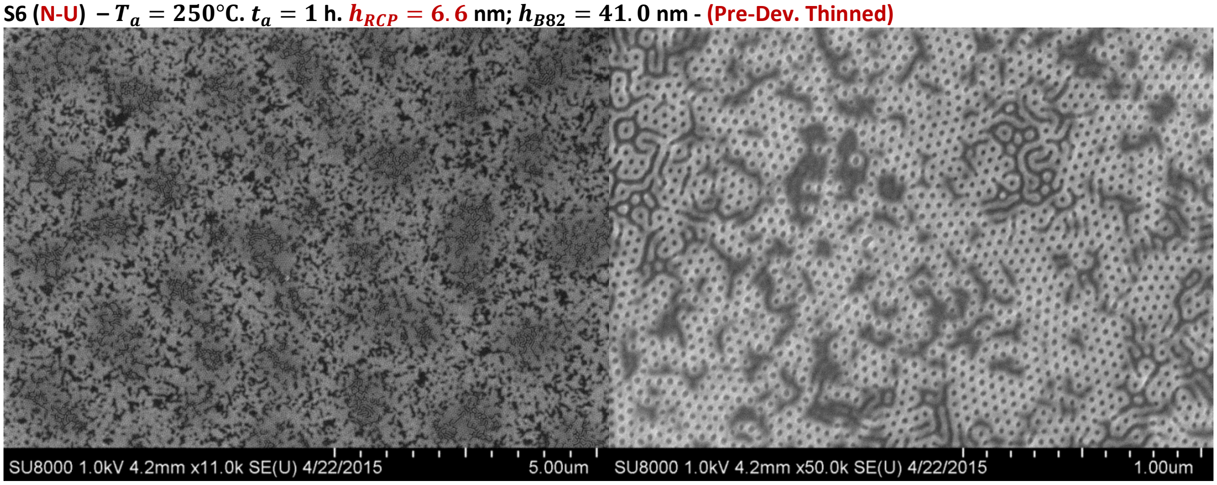
C16 (N-U) – $T_a = 250°\text{C}$. $t_a = 1$ h. $h_{RCP} = 4.5$ nm; $h_{B82} = 47.6$ nm



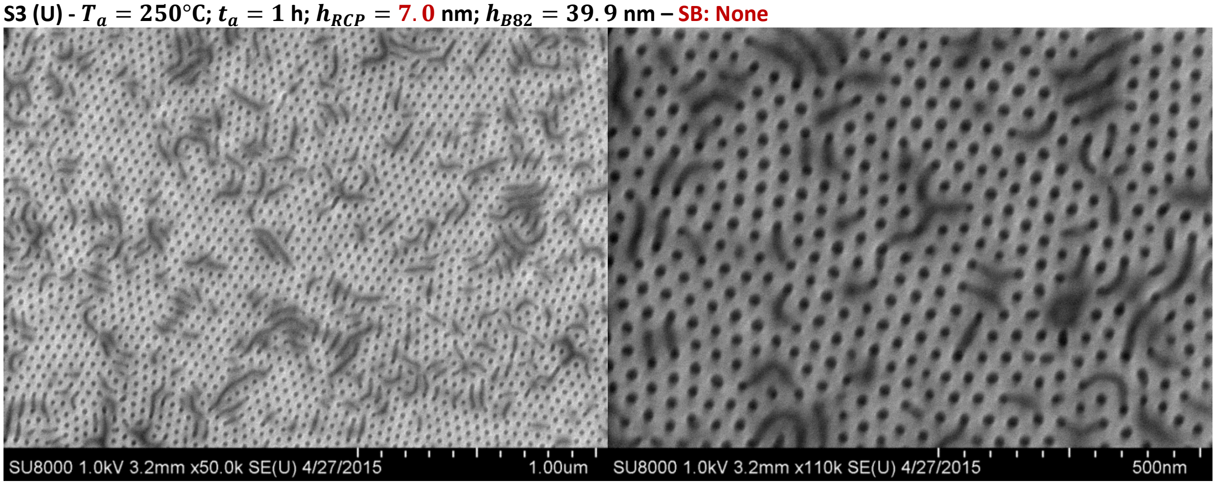
W48C (N-U) – $T_a = 250°\text{C}$. $t_a = 1$ h. $h_{RCP} = 5.9$ nm; $h_{B82} = 47.9$ nm



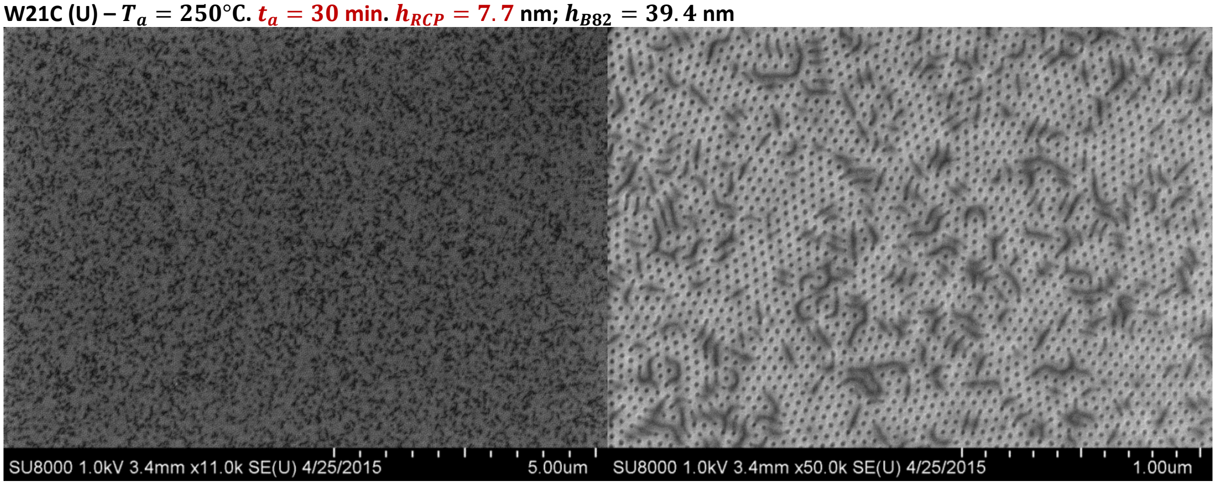
S6 (N-U) – $T_a = 250°\text{C}$. $t_a = 1$ h. $h_{RCP} = 6.6$ nm; $h_{B82} = 41.0$ nm - (Pre-Dev. Thinned)



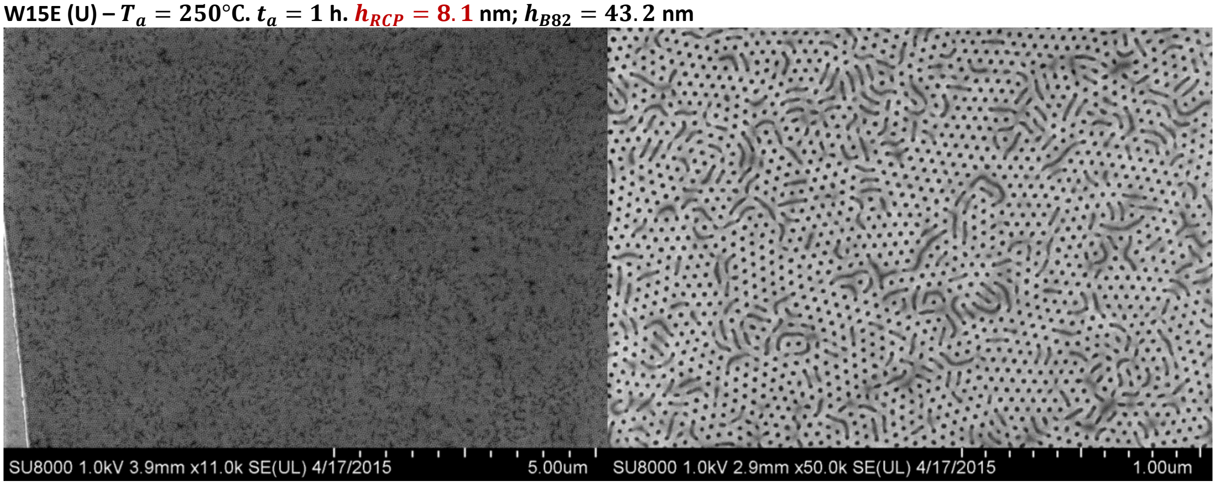
S3 (U) - $T_a = 250°\text{C}$; $t_a = 1$ h; $h_{RCP} = 7.0$ nm; $h_{B82} = 39.9$ nm – SB: None



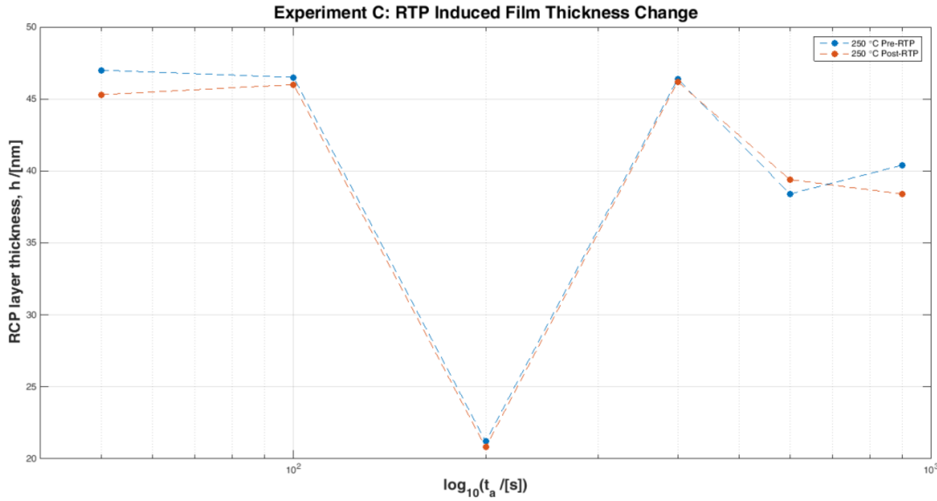
W21C (U) – $T_a = 250°\text{C}$. $t_a = 30$ min. $h_{RCP} = 7.7$ nm; $h_{B82} = 39.4$ nm

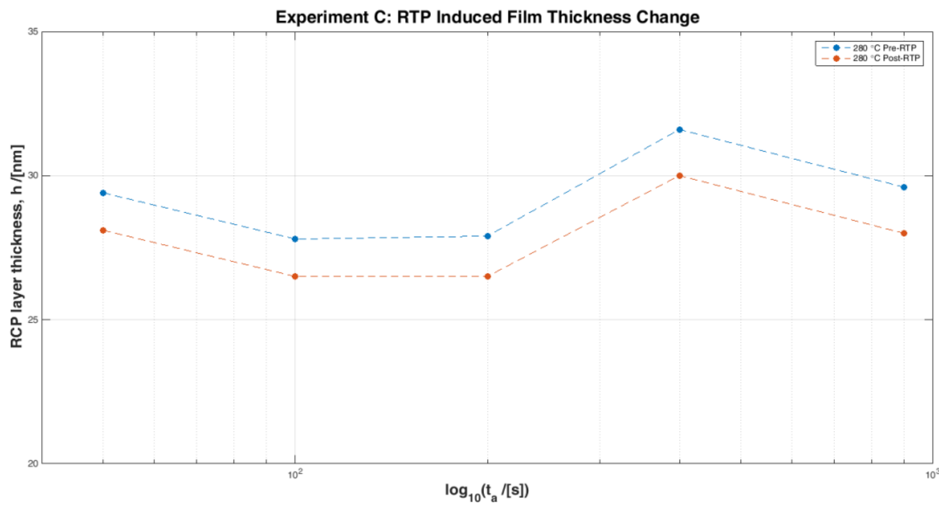


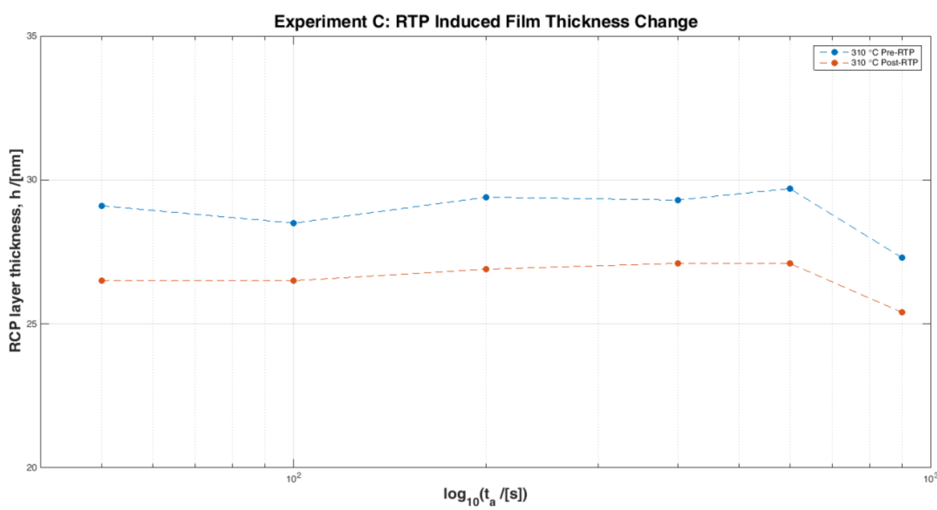
W15E (U) – $T_a = 250°\text{C}$. $t_a = 1$ h. $h_{RCP} = 8.1$ nm; $h_{B82} = 43.2$ nm



A1.2 RTP Induced R10.5 layer thickness reduction







A1.3 Identification of RTP t_{Graft} and T_{Graft} combinations conducive to the grafting of R10.5

	Piranha Treatment		RTP Graft		R10.5 Ellips.					
Sample #	**$t_{Piranha}$ /[min]**	**$T_{Piranha}$ /[°C]**	**T_{Graft} /[°C]**	**t_{Graft} /[s]**	**MSE**	**h_{SiOx} /[Å]**	**$h_{R10.5}$ /[nm]**	**Age_1 /[days]**	**Age_2 /[days]**	**Comments**
C13	40	80	250	50	4.259	15	6.2	0	**1**	
C14	40	80	250	100	3.948	15	6.5	0	**1**	
C12	40	80	250	200	4.113	15	6.3	**1**	0	
C15	40	80	250	400	4.532	15	6.6	**1**	0	
C17	40	80	250	600	3.992	15	6.4	**1**	0	
C16	40	80	250	900	3.808	15	6.5	**1**	0	
C11 (I)	40	80	280	50	3.365	15	6.1	**3**	**3**	
C10	40	80	280	100	3.428	15	7.0	**2**	**3**	
C9	40	80	280	200	3.37	15	7.2	**2**	**3**	
C8	40	80	280	400	3.309	15	7.4	**1**	**4**	
A1	30	80	280	600	4.364	15	6.4	**1**	0	Unfiltered R10.5; **Patch (center)**
A2	30	80	280	600	4.31	15	8.0	**1**	0	Unfiltered R10.5
A3	30	80	280	600	4.273	15	7.9	**1**	0	Unfiltered R10.5
A4	30	80	280	600	4.441	15	7.7	**1**	0	Unfiltered R10.5
B1	30	80	280	600	4.416	15	8.3	**1**	0	Unfiltered R10.5
B2	30	80	280	600	4.74	15	8.3	**1**	0	Unfiltered R10.5
B3	30	80	280	600	4.347	15	7.9	**1**	0	Unfiltered R10.5
B4	30	80	280	600	4.292	15	7.6	**1**	0	Unfiltered R10.5
C7	40	80	280	900	3.66	15	7.4	**1**	**4**	
C6	40	80	310	50	3.878	15	5.1	**1**	**4**	
C5	40	80	310	100	3.779	15	5.5	**1**	**4**	
C3	40	80	310	200	3.761	15	5.5	**1**	**4**	
C2	40	80	310	400	3.834	15	5.6	0	**5**	
C4	40	80	310	600	3.805	15	5.7	**1**	**4**	
C1	40	80	310	900	3.986	15	5.2	0	**5**	
D15	40	80	**265**	600	4.278	15	5.9	**16**	**1**	
D16	40	80	**295**	600	4.216	15	7.1	**16**	**1**	
D3	40	80	280	600	4.176	15	5.0	**13**	**1**	**dT/dt = 10° C/s**
D4	40	80	280	600	3.934	15	6.2	**13**	**1**	**dT/dt = 5° C/s**
D5	40	80	280	600	3.973	15	6.1	**13**	**1**	**dT/dt = 5° C/s**

A1.4 The efficacy of different surface activation treatments on Si(100) substrates

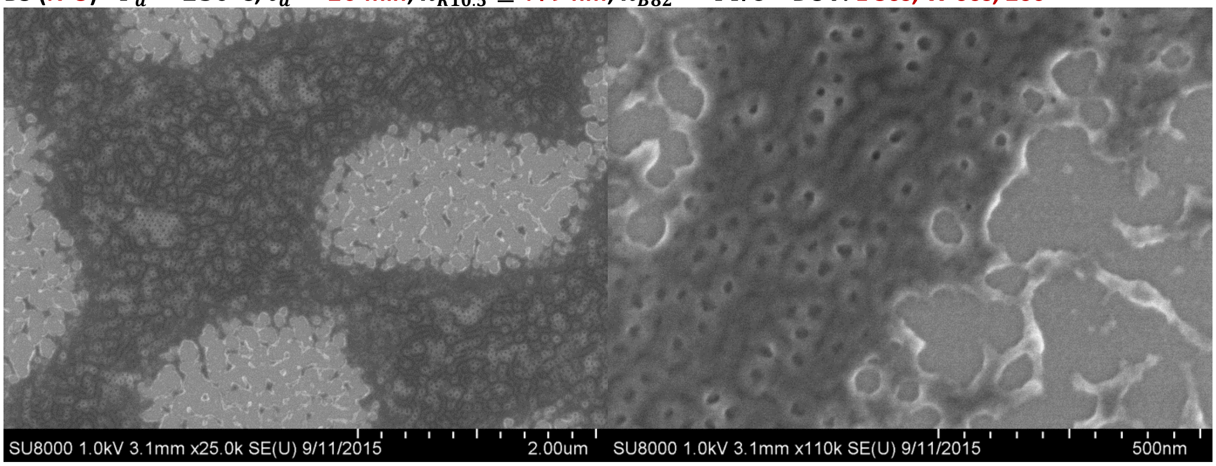
Sample #	Treatment	Before $h_{SiOx.\,1}$ /[Å]	After $h_{SiOx.\,2}$ /[Å]	Diff. Δh_{SiOx} /[Å]	R10.5 Ellips. T_{Graft} /[°C]	t_{Graft} /[min]	$h_{SiOx.\,used}$ /[Å]	$h_{R10.5}$ /[nm]	Age_1 /[days]	Age_2 /[days]
D1	None	NA	NA	NA	280	10	15	6.6	**3**	**1**
D2	None	NA	NA	NA	280	10	15	6.0	**3**	**1**
D10	Ozone	NA	NA	NA	280	10	14.56	7.4	0	0
D11	Ozone	NA	NA	NA	280	10	14.56	7.3	0	0
D14	Ozone	15.57	14.56	**-1.01**	280	10	14.56	6.7	0	0
D17	PP (FC)	14.92	13.88	**-1.04**	280	10	13.88	7.8	0	0
D18	PP (FC)	14.56	13.93	**-0.63**	280	10	13.93	8.0	0	0
D6	PP (No FC)	NA	NA	NA	280	10	15	7.8	**2**	**1**
D7	PP (No FC)	NA	NA	NA	280	10	15	7.6	**2**	**1**
D13	PP (No FC)	14.94	15.3	**0.36**	280	10	15.30	7.6	0	0
D8	RIE	NA	NA	NA	280	10	31.02	5.3	0	0
D9	RIE	NA	NA	NA	280	10	31.02	6.4	0	0
D12	RIE	14.71	31.02	**16.31**	280	10	31.02	5.8	0	0

APPENDIX A2
BCP Annealing

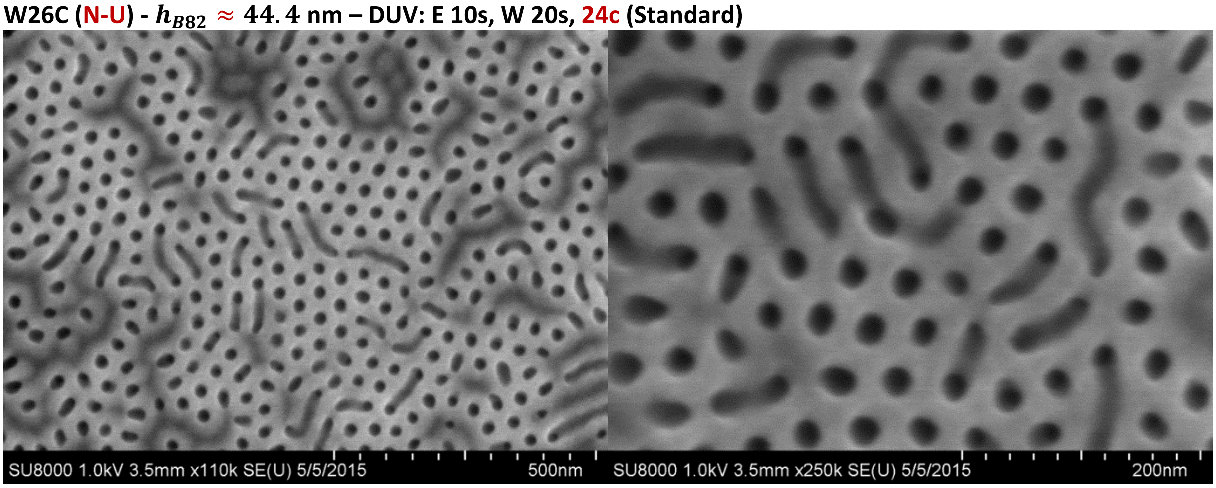
A2.1 DUV exposure dose test

E = cycle exposure time, W = cycle waiting (non-exposure) time, c = number of cycles

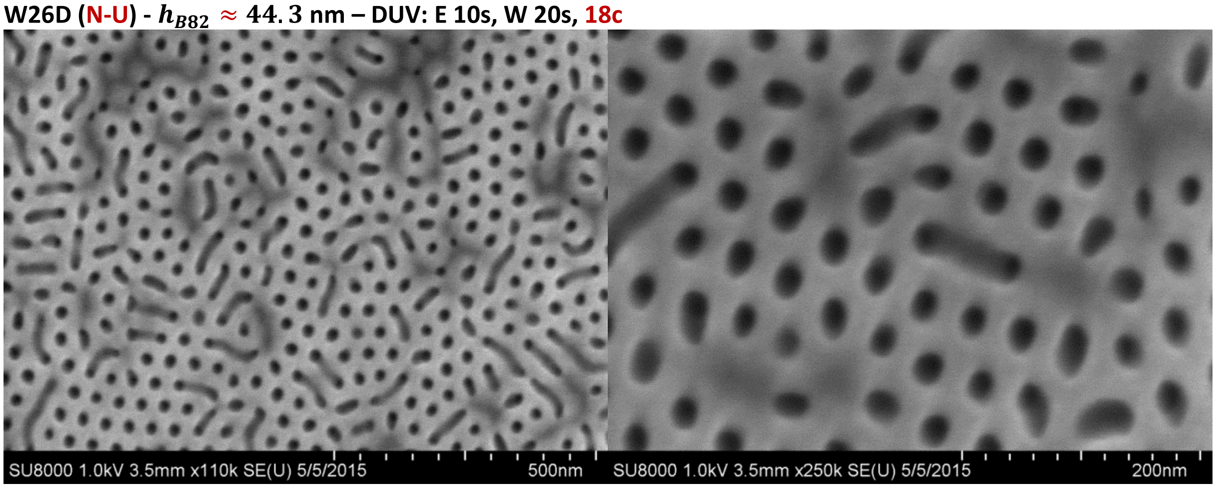
B3 (N-U) - $T_a = 250°C$; $t_a = 10$ min; $h_{R10.5} \leq 7.9$ nm; $h_{B82} = 44.6$ – DUV: E 30s, W 60s, 20c



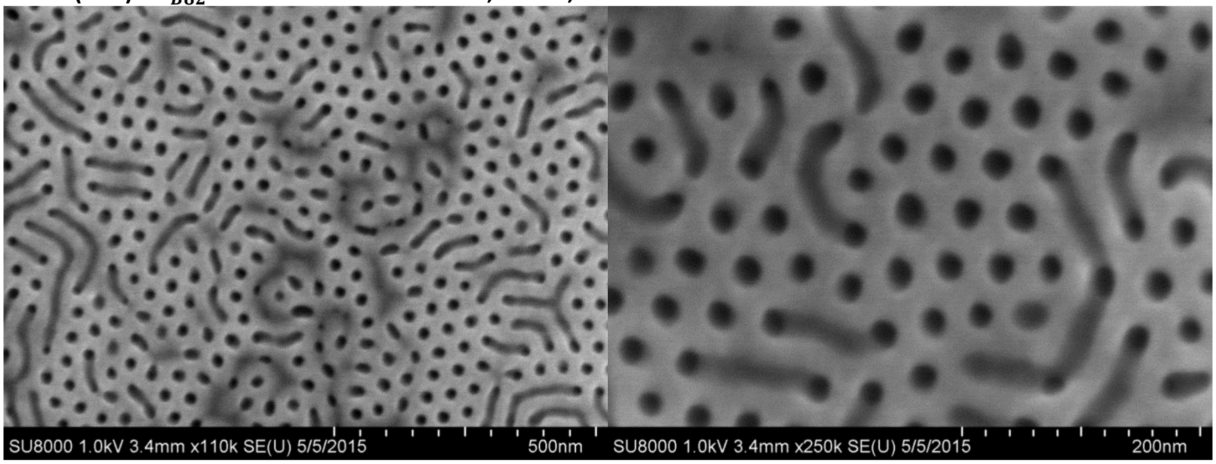
W26C-F: RTP: $T_a = 250°C$; $t_a = 30$ min; $h_{RCP} =$ NA (Guess: 8 nm) (AW)
W26C (N-U) - $h_{B82} \approx 44.4$ nm – DUV: E 10s, W 20s, 24c (Standard)



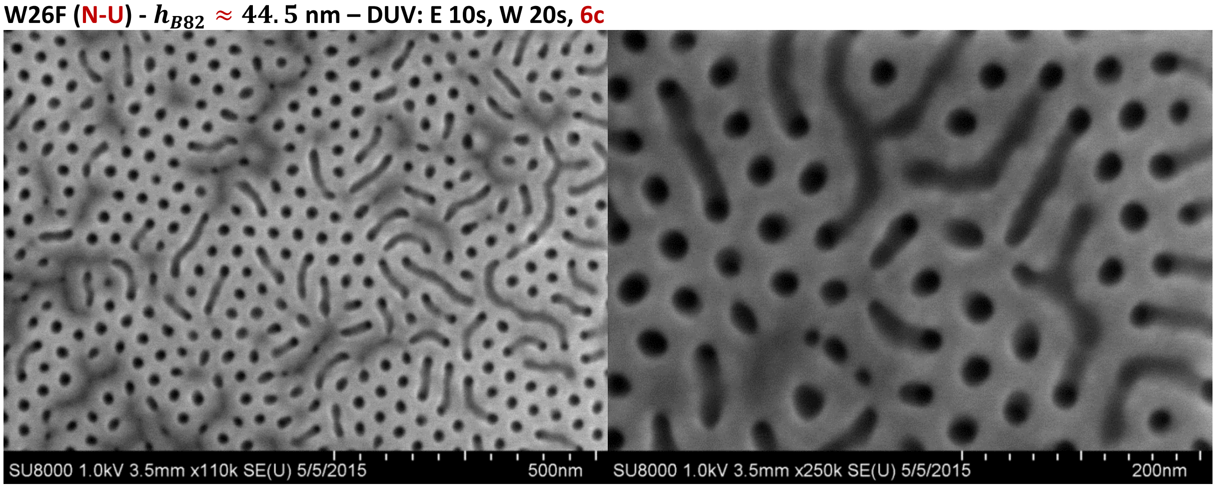
W26D (N-U) - $h_{B82} \approx 44.3$ nm – DUV: E 10s, W 20s, 18c



W26E (N-U) - $h_{B82} \approx 44.4$ nm – DUV: E 10s, W 20s, 12c

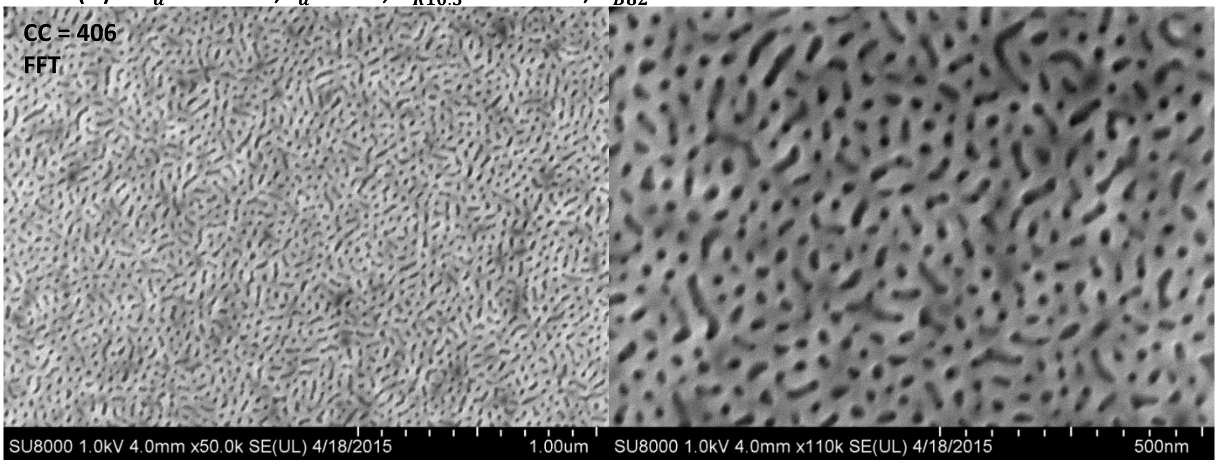


W26F (N-U) - $h_{B82} \approx 44.5$ nm – DUV: E 10s, W 20s, 6c

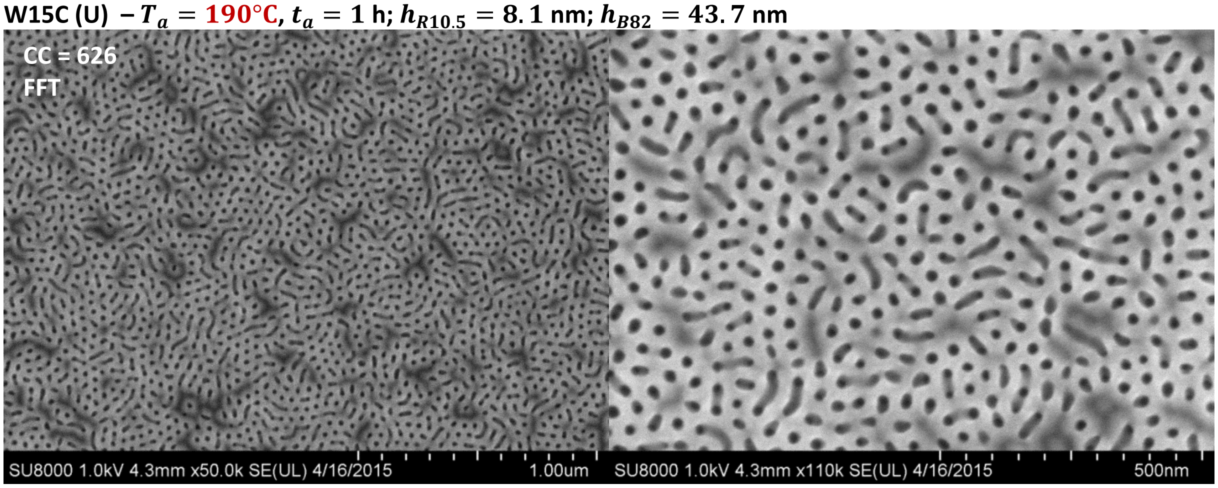


A2.2 Effects of RTP T_a at $t_a = 1$ h for B82 ($h_{B82} \approx L_{0,B82}$) samples

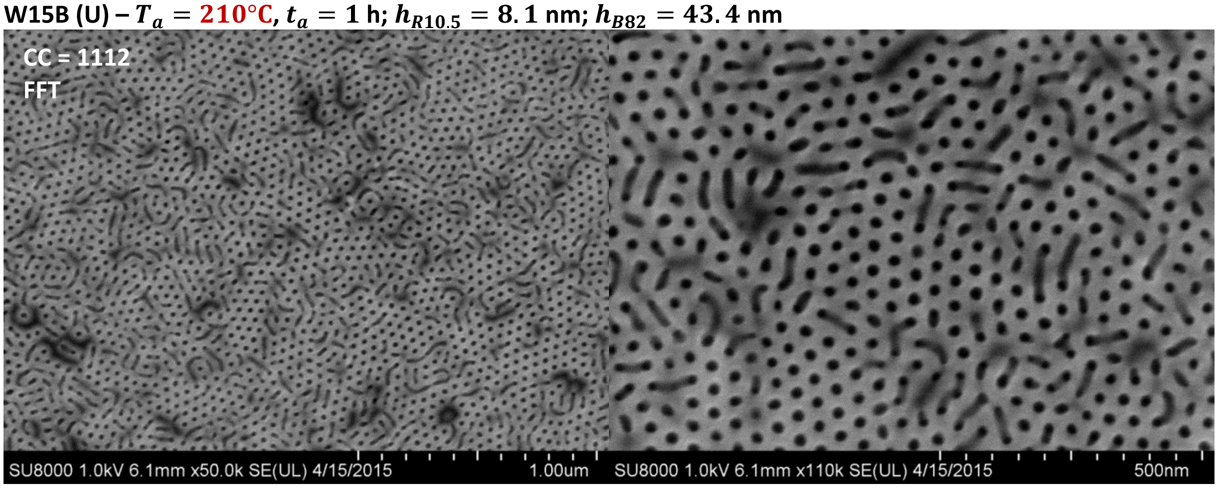
W15A (U) – $T_a = 170°\mathrm{C}$, $t_a = 1$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 43.0$ nm



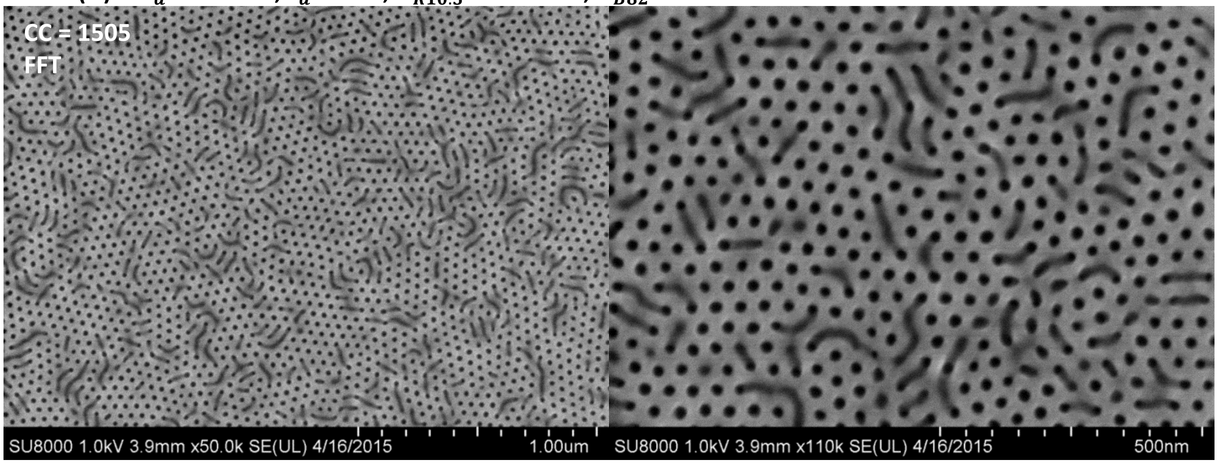
W15C (U) – $T_a = 190°\mathrm{C}$, $t_a = 1$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 43.7$ nm



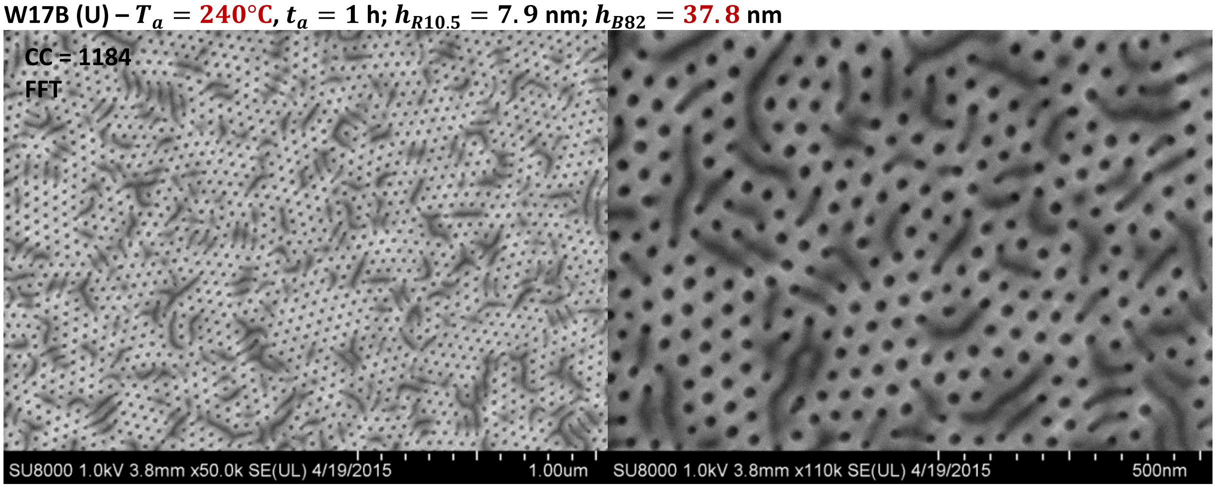
W15B (U) – $T_a = 210°\mathrm{C}$, $t_a = 1$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 43.4$ nm



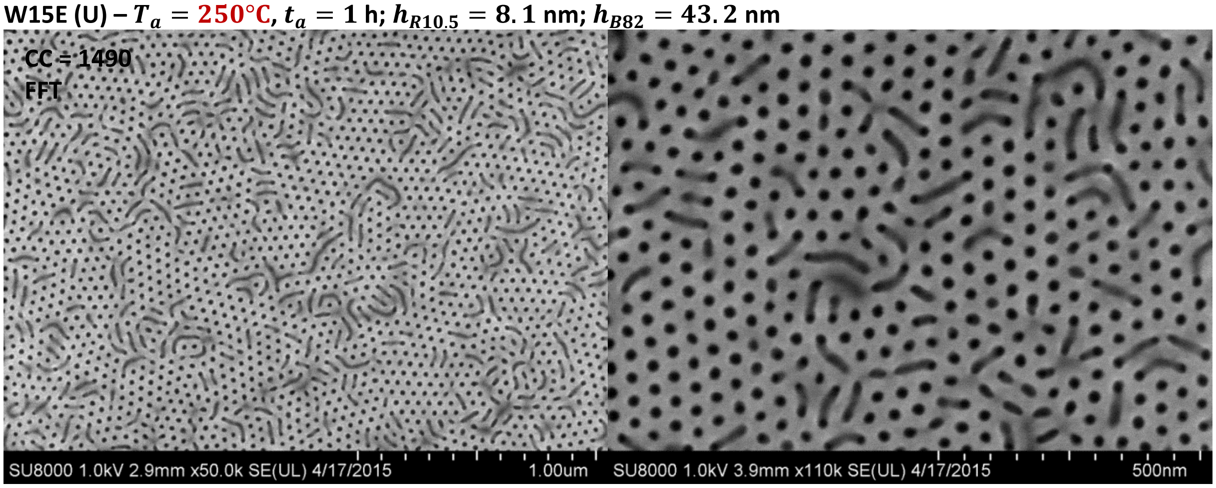
W15D (U) – $T_a = 230°\text{C}$, $t_a = 1$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 43.1$ nm



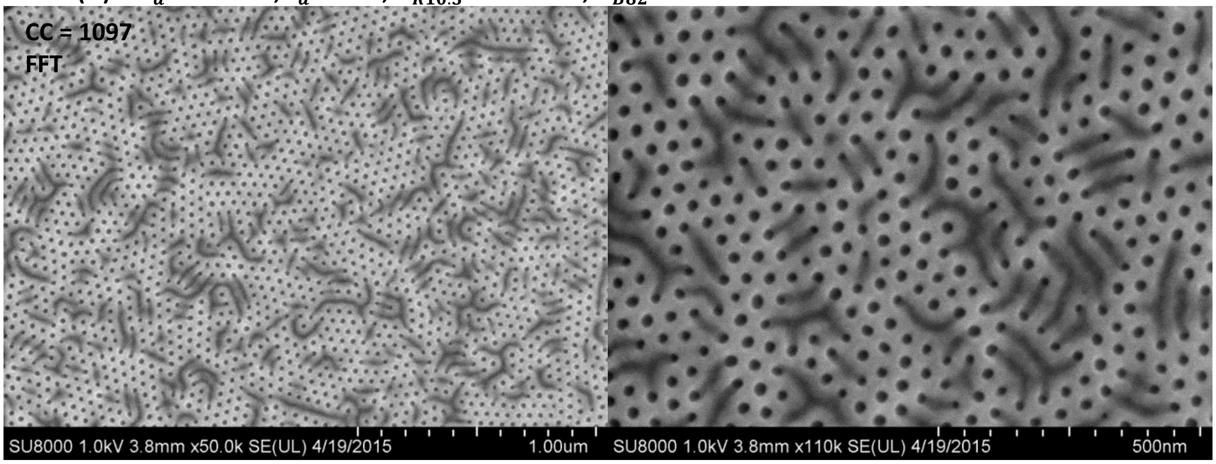
W17B (U) – $T_a = 240°\text{C}$, $t_a = 1$ h; $h_{R10.5} = 7.9$ nm; $h_{B82} = 37.8$ nm



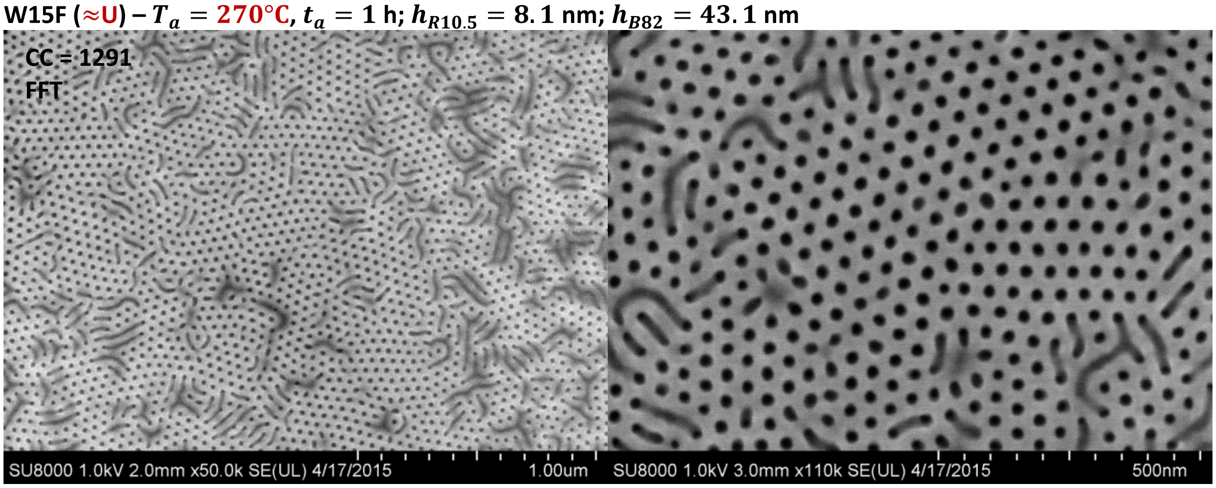
W15E (U) – $T_a = 250°\text{C}$, $t_a = 1$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 43.2$ nm



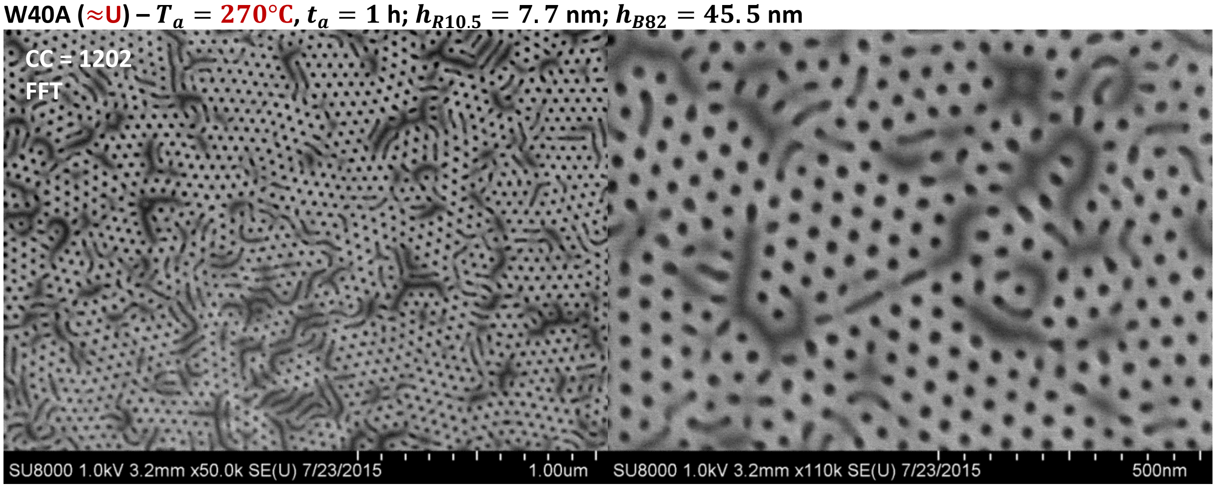
W17A (U) – $T_a = 260°\mathrm{C}$, $t_a = 1$ h; $h_{R10.5} = 7.9$ nm; $h_{B82} = 37.6$ nm



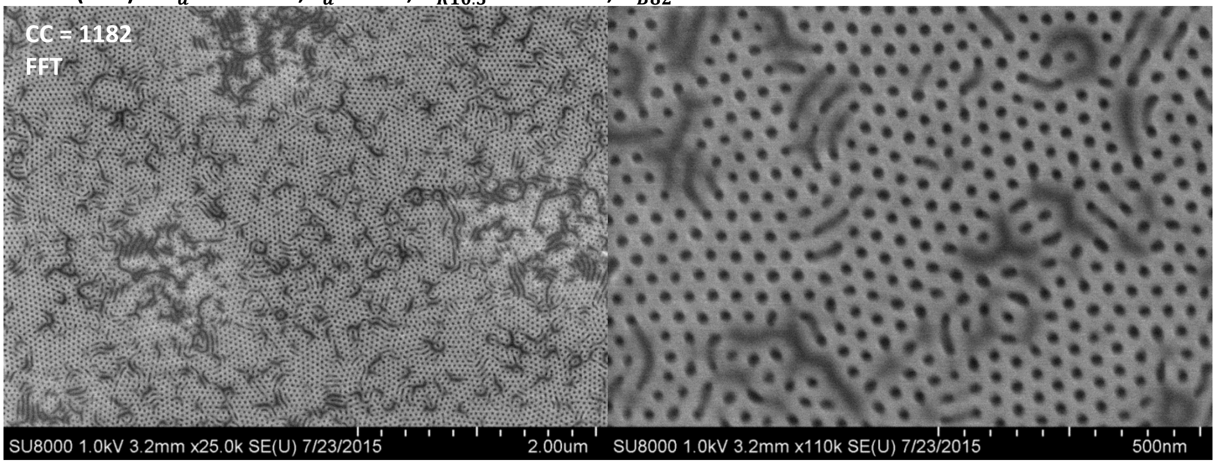
W15F (≈U) – $T_a = 270°\mathrm{C}$, $t_a = 1$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 43.1$ nm



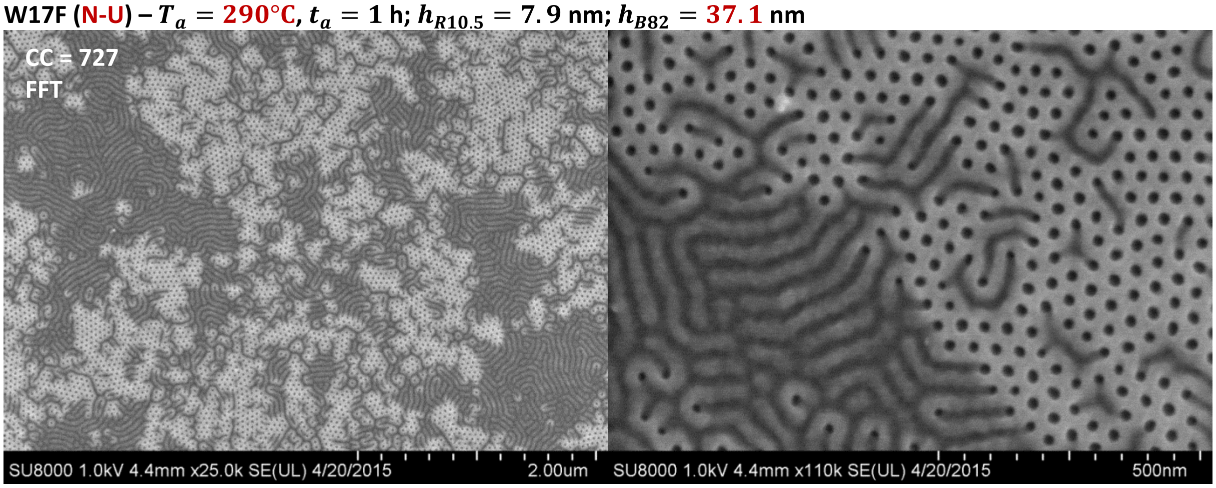
W40A (≈U) – $T_a = 270°\mathrm{C}$, $t_a = 1$ h; $h_{R10.5} = 7.7$ nm; $h_{B82} = 45.5$ nm



W40B (N-U) – $T_a = 280°C$, $t_a = 1$ h; $h_{R10.5} = 7.7$ nm; $h_{B82} = 45.5$ nm

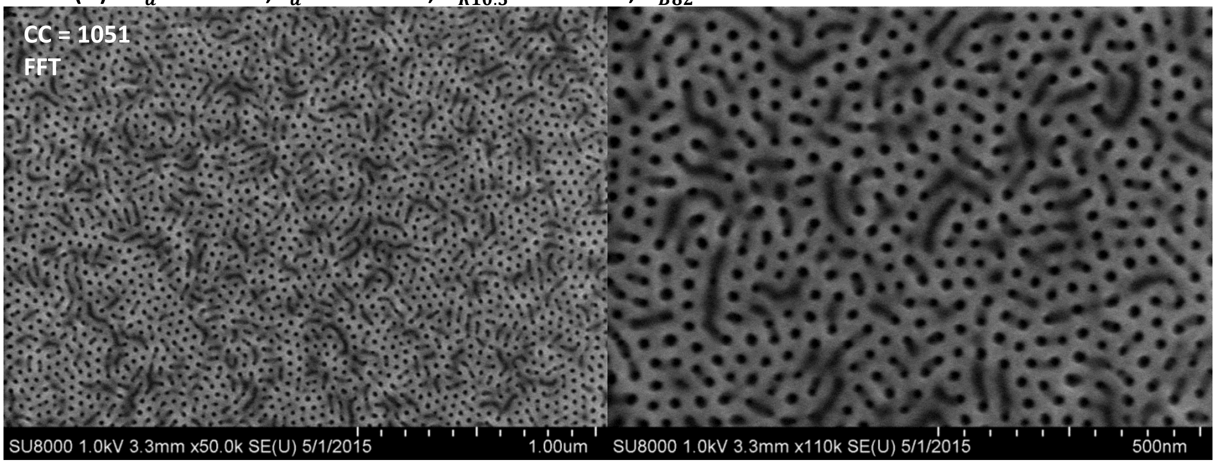


W17F (N-U) – $T_a = 290°C$, $t_a = 1$ h; $h_{R10.5} = 7.9$ nm; $h_{B82} = 37.1$ nm

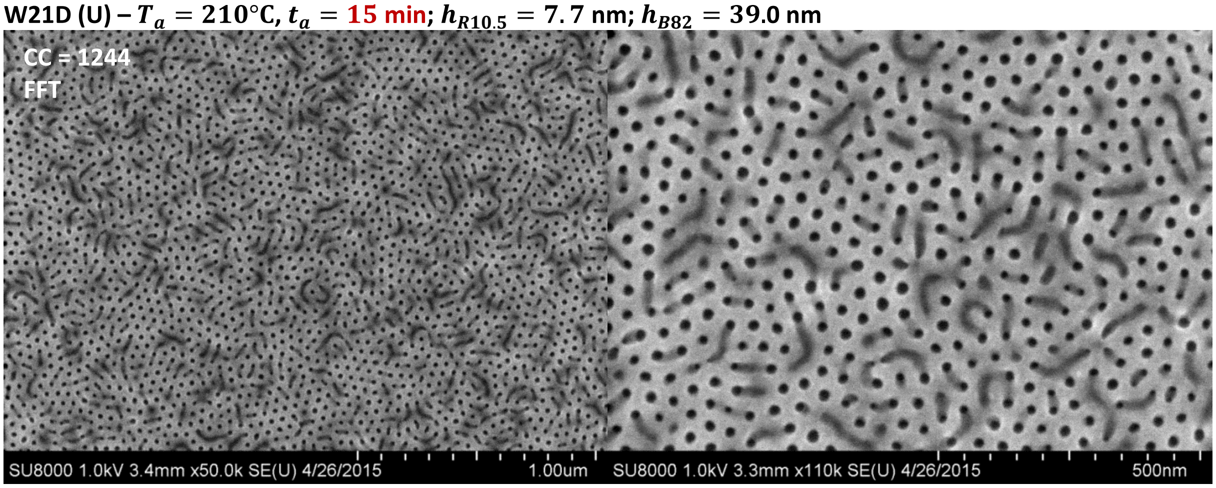


A2.3 Effects of RTP t_a at $T_a = 210°\text{C}$ for B82 ($h_{B82} \approx L_{0,B82}$) samples

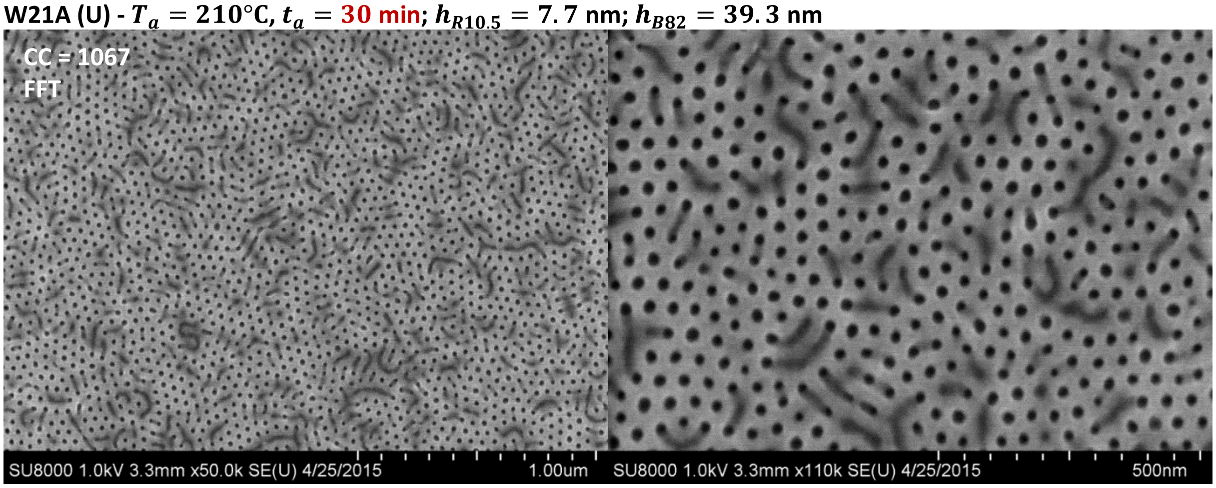
W23E (U) - $T_a = 210°\text{C}$, $t_a = 7.5$ min; $h_{R10.5} = 8.0$ nm; $h_{B82} = 38.5$ nm



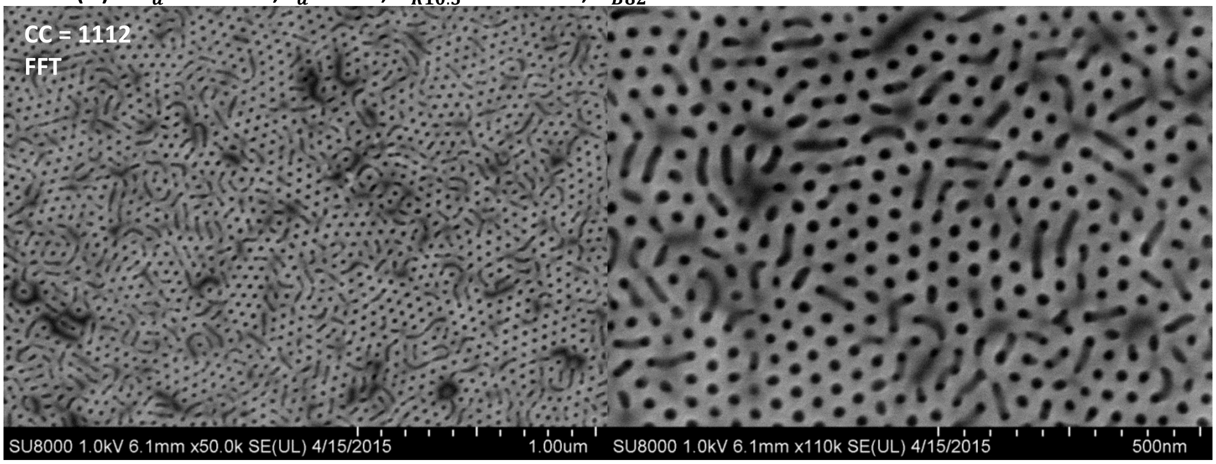
W21D (U) – $T_a = 210°\text{C}$, $t_a = 15$ min; $h_{R10.5} = 7.7$ nm; $h_{B82} = 39.0$ nm



W21A (U) - $T_a = 210°\text{C}$, $t_a = 30$ min; $h_{R10.5} = 7.7$ nm; $h_{B82} = 39.3$ nm

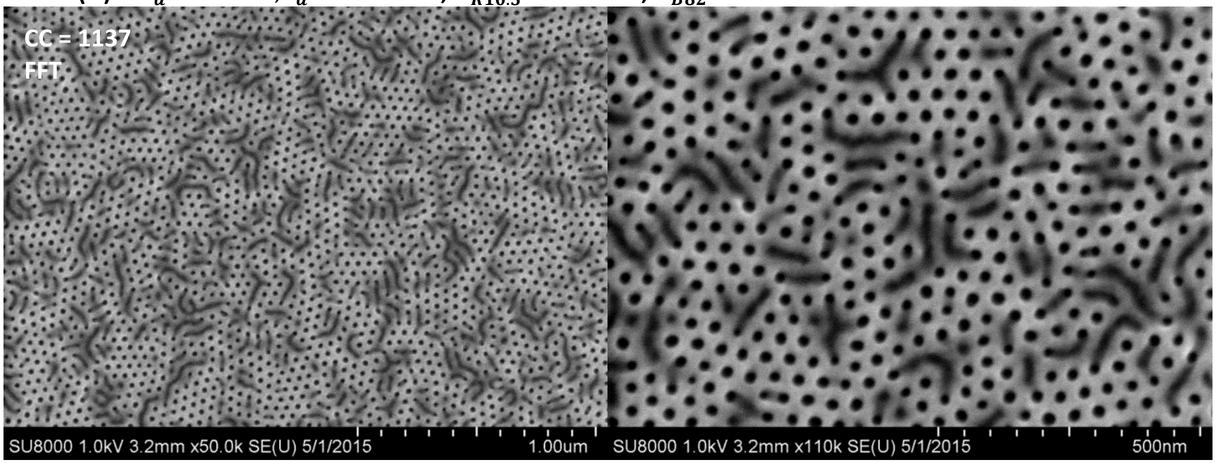


W15B (U) – $T_a = 210°\text{C}$, $t_a = 1$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 43.4$ nm

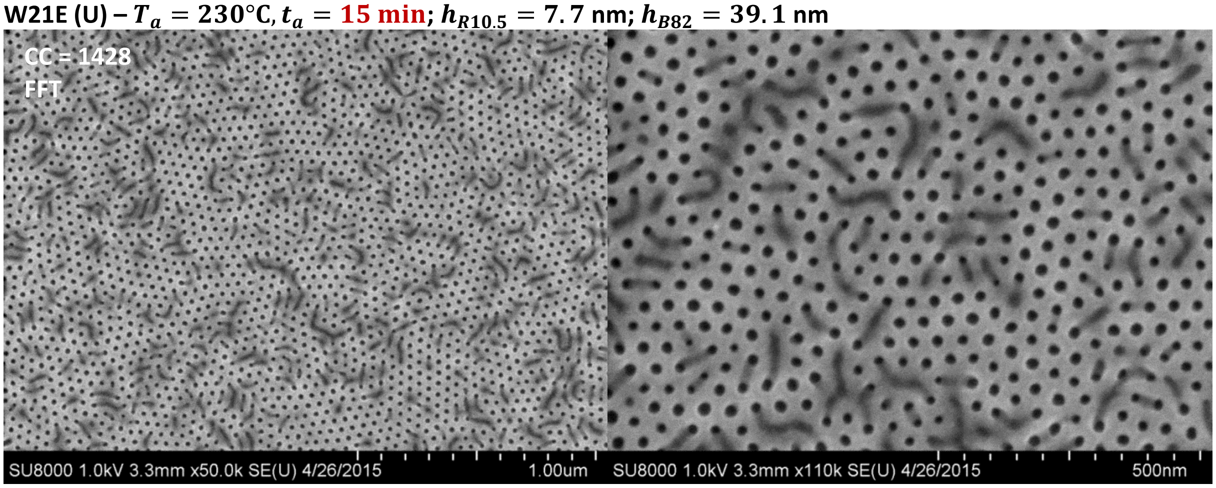


A2.4 Effects of RTP t_a at $T_a = 230°\text{C}$ for B82 ($h_{B82} \approx L_{0,B82}$) samples

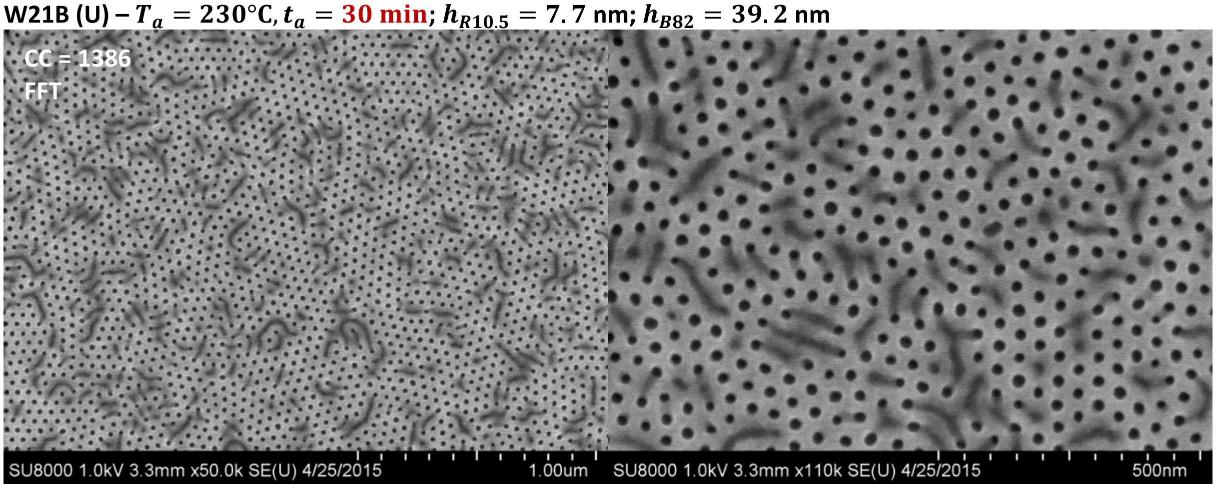
W23D (U) – $T_a = 230°\text{C}, t_a = 7.5\ \text{min}$; $h_{R10.5} = 8.0$ nm; $h_{B82} = 38.6$ nm



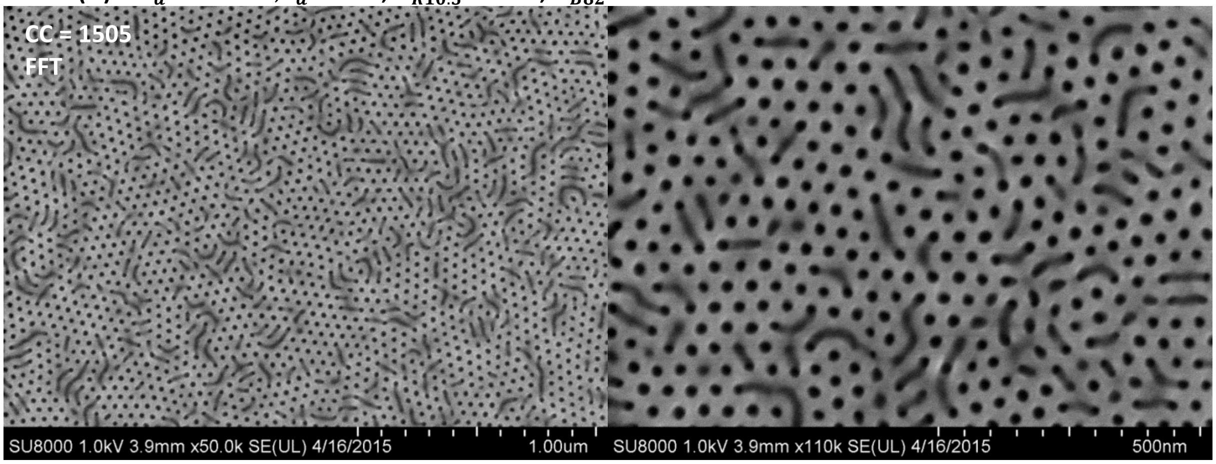
W21E (U) – $T_a = 230°\text{C}, t_a = 15\ \text{min}$; $h_{R10.5} = 7.7$ nm; $h_{B82} = 39.1$ nm



W21B (U) – $T_a = 230°\text{C}, t_a = 30\ \text{min}$; $h_{R10.5} = 7.7$ nm; $h_{B82} = 39.2$ nm

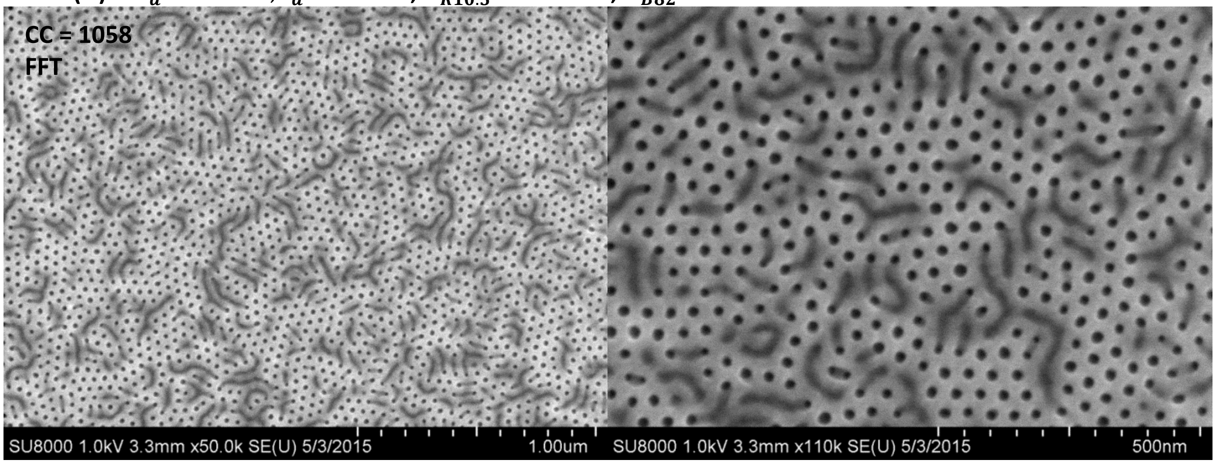


W15D (U) – $T_a = 230°\mathrm{C}, t_a = 1\ \mathrm{h}; h_{R10.5} = 8.1; h_{B82} = 43.1$ nm

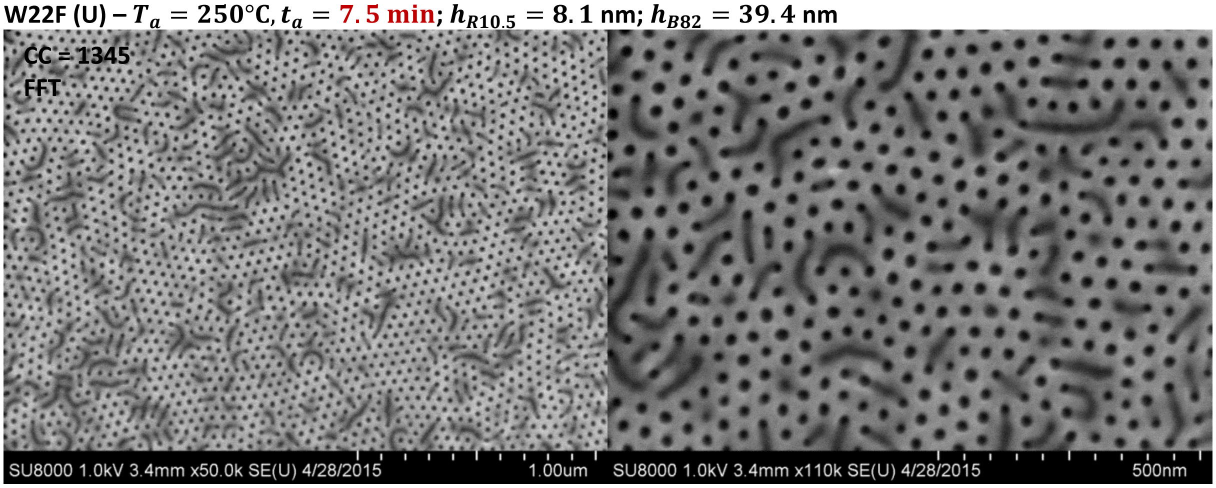


A2.5 Effects of RTP t_a at $T_a = 250°\text{C}$ for B82 ($h_{B82} \approx L_{0,B82}$) samples

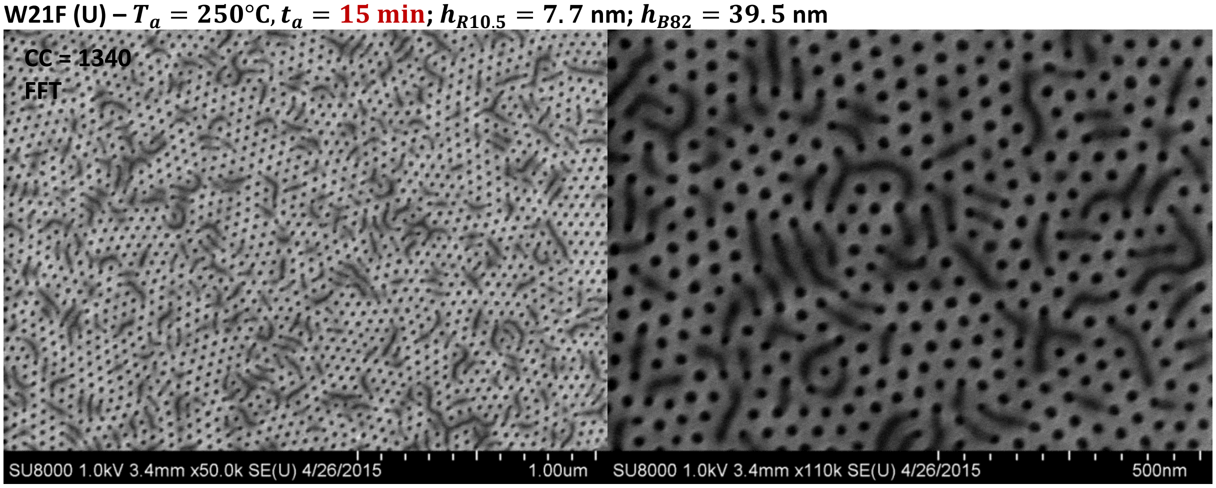
W23F (U) – $T_a = 250°\text{C}$, $t_a = 3$ min; $h_{R10.5} = 8.0$ nm; $h_{B82} = 38.8$ nm



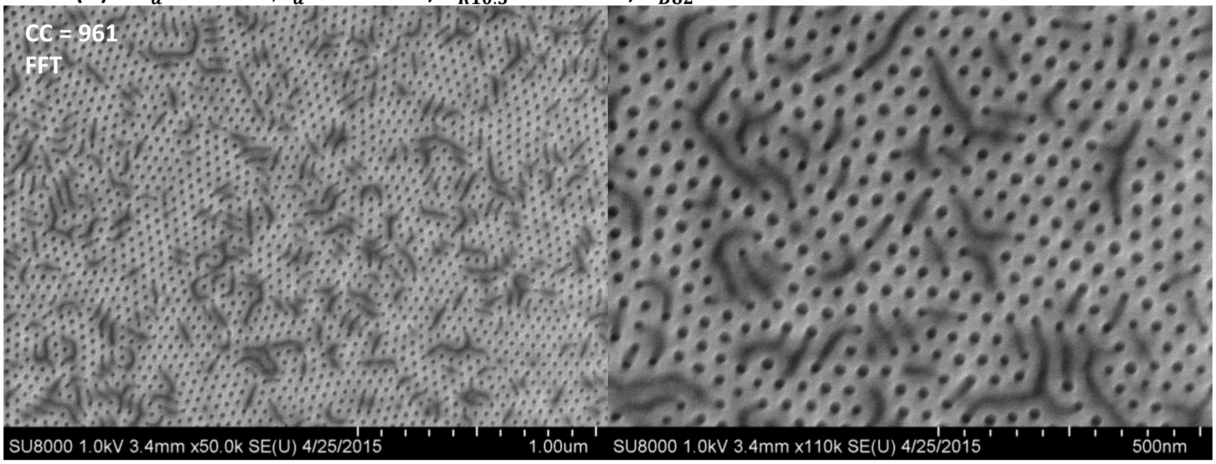
W22F (U) – $T_a = 250°\text{C}$, $t_a = 7.5$ min; $h_{R10.5} = 8.1$ nm; $h_{B82} = 39.4$ nm



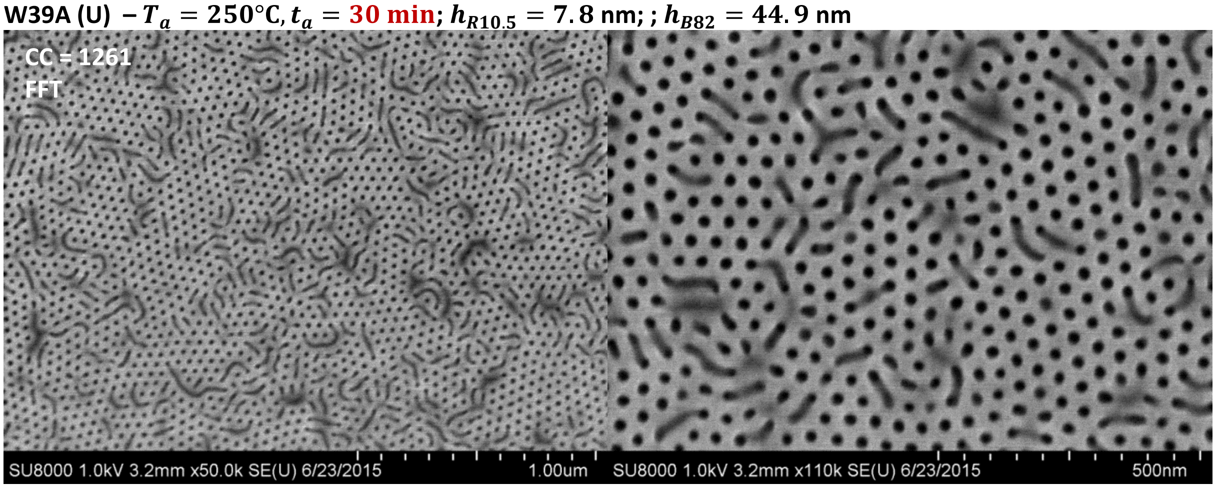
W21F (U) – $T_a = 250°\text{C}$, $t_a = 15$ min; $h_{R10.5} = 7.7$ nm; $h_{B82} = 39.5$ nm



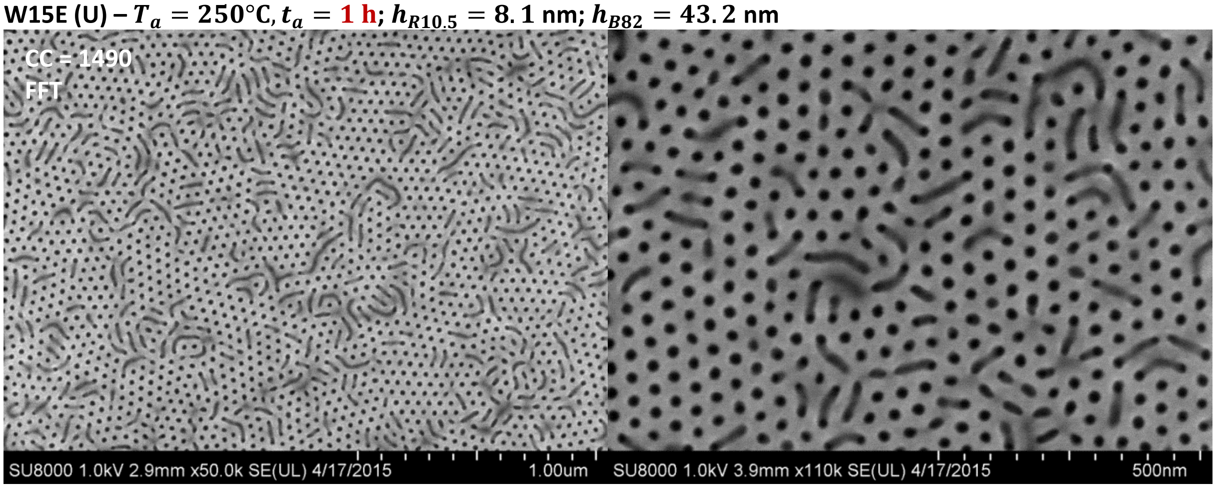
W21C (U) – $T_a = 250°\text{C}, t_a = \mathbf{30\ min}$; $h_{R10.5} = 7.7$ nm; $h_{B82} = 39.4$ nm



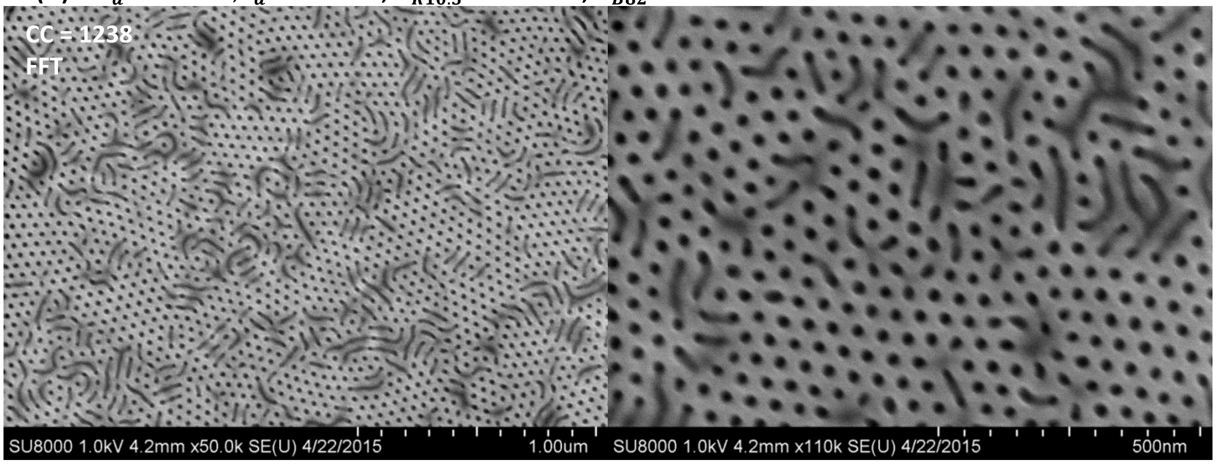
W39A (U) – $T_a = 250°\text{C}, t_a = \mathbf{30\ min}$; $h_{R10.5} = 7.8$ nm; ; $h_{B82} = 44.9$ nm



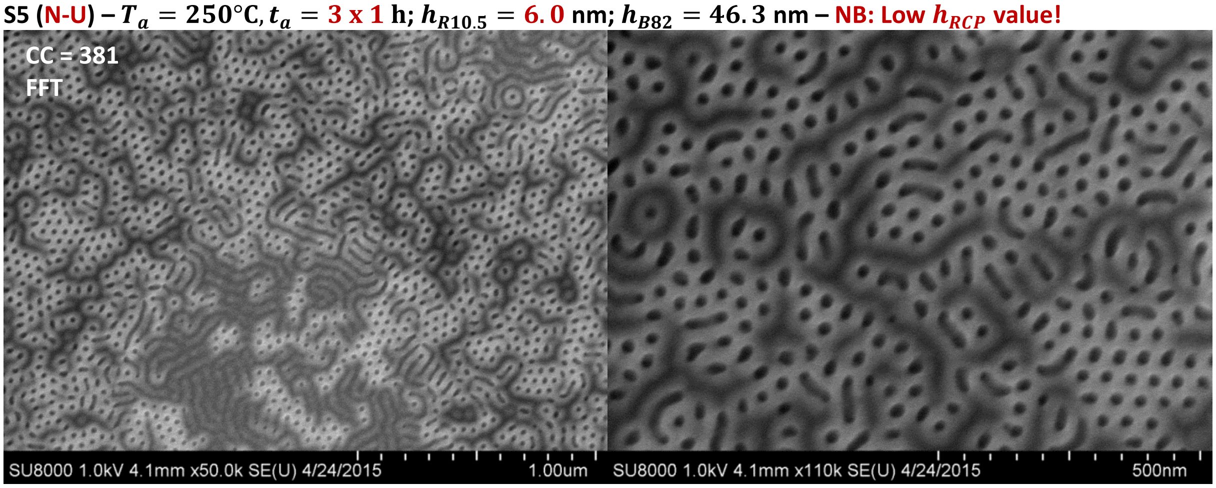
W15E (U) – $T_a = 250°\text{C}, t_a = \mathbf{1\ h}$; $h_{R10.5} = 8.1$ nm; $h_{B82} = 43.2$ nm



S4 (U) – $T_a = 250°\text{C}, t_a = 2 \text{ x } 1$ h; $h_{R10.5} = 6.9$ nm; $h_{B82} = 45.7$ nm

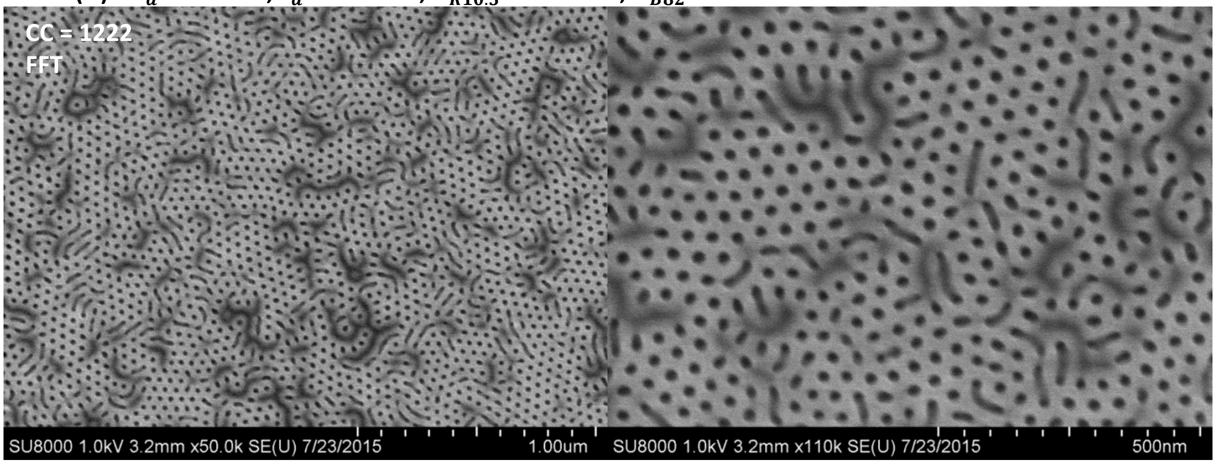


S5 (N-U) – $T_a = 250°\text{C}, t_a = 3 \text{ x } 1$ h; $h_{R10.5} = 6.0$ nm; $h_{B82} = 46.3$ nm – NB: Low h_{RCP} value!

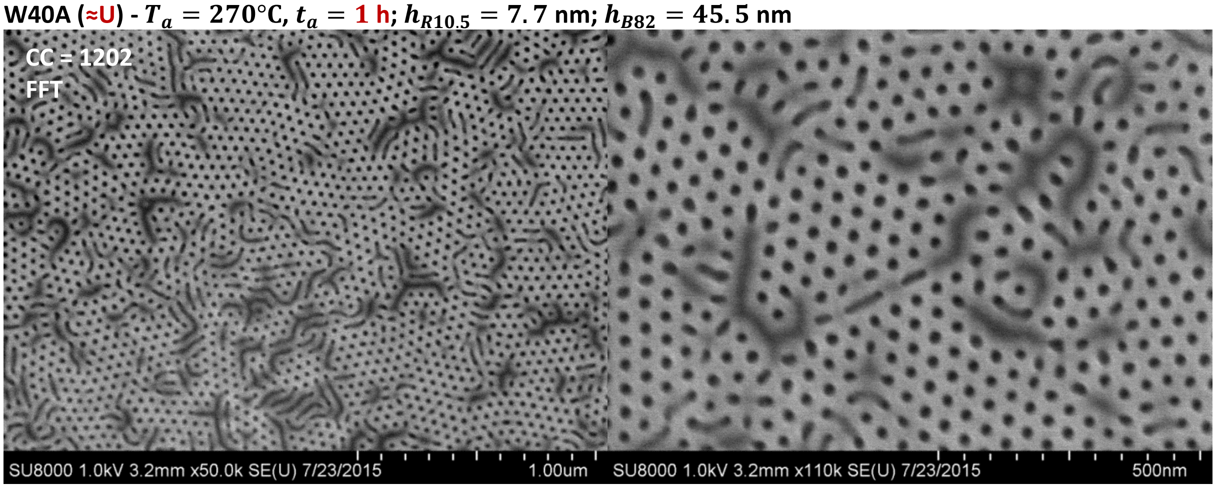


A2.6 Effects of RTP t_a at $T_a = 270°\text{C}$ for B82 ($h_{B82} \approx L_{0,B82}$) samples

W40C (U) - $T_a = 270°\text{C}$, $t_a = $ 15 min; $h_{R10.5} = 7.7$ nm; $h_{B82} = 45.5$ nm

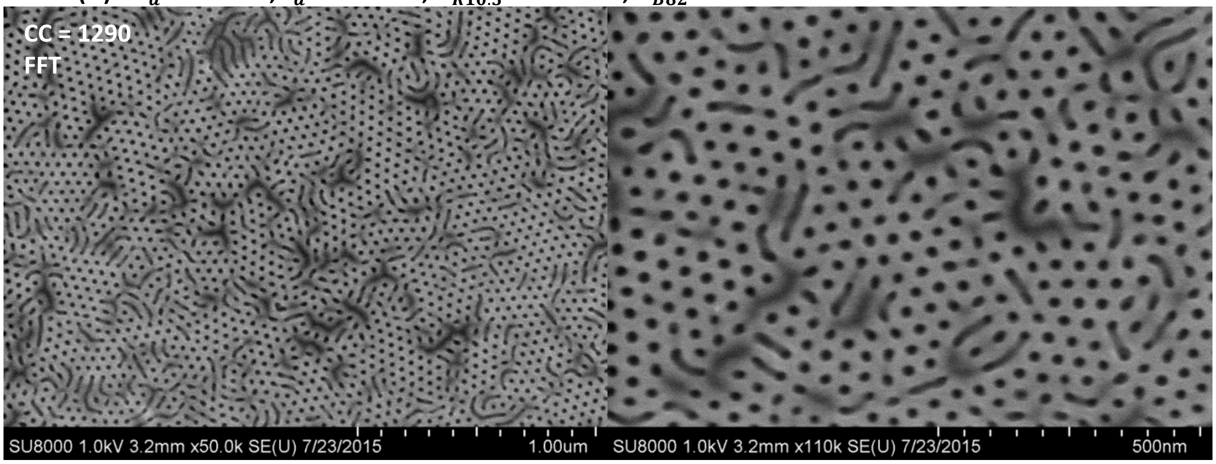


W40A (≈U) - $T_a = 270°\text{C}$, $t_a = $ 1 h; $h_{R10.5} = 7.7$ nm; $h_{B82} = 45.5$ nm

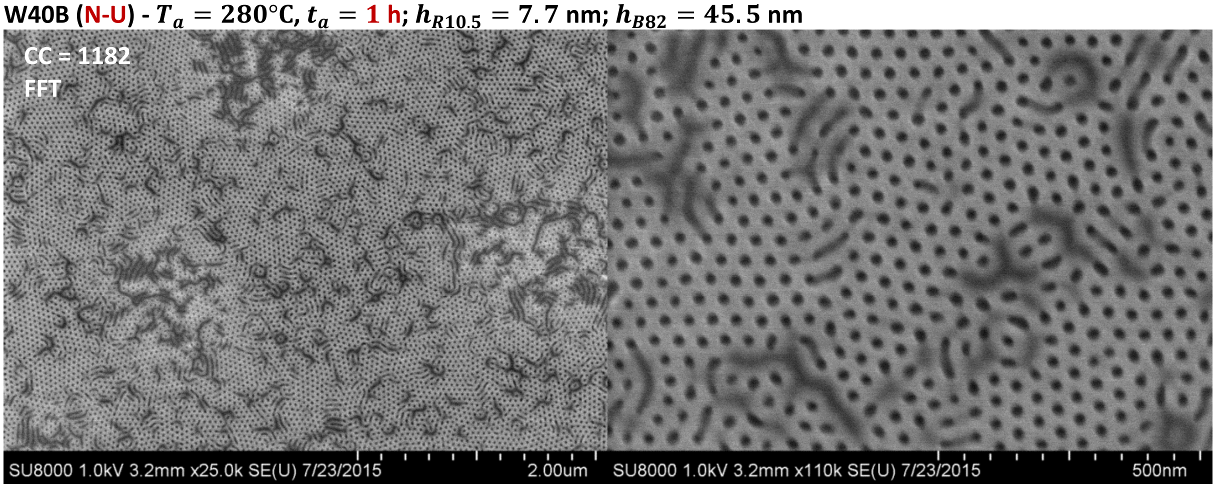


A2.7 Effects of RTP t_a at $T_a = 280°\text{C}$ for B82 ($h_{B82} \approx L_{0,B82}$) samples

W40D (U) - $T_a = 280°\text{C}$, $t_a =$ 15 min; $h_{R10.5} = 7.7$ nm; $h_{B82} = 45.5$ nm

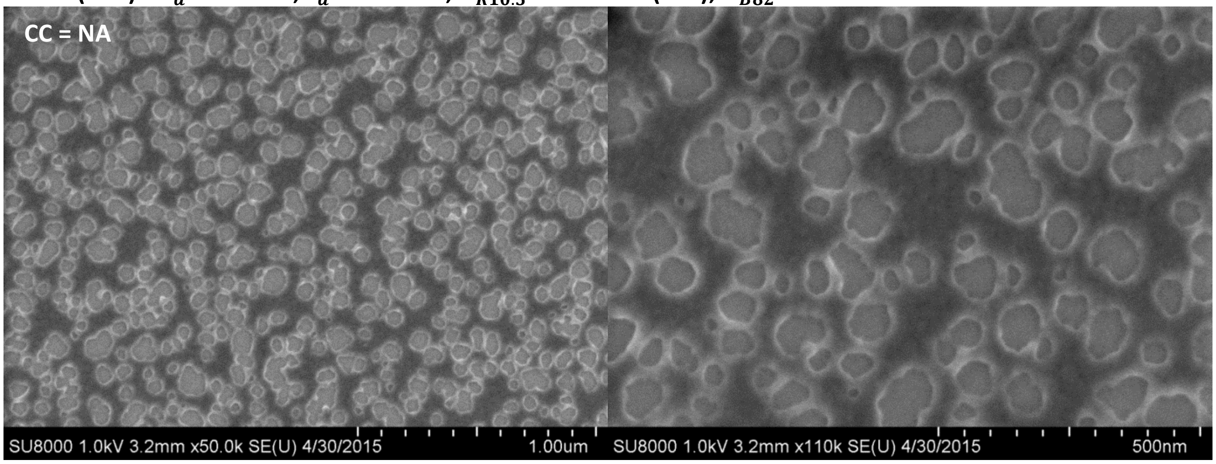


W40B (N-U) - $T_a = 280°\text{C}$, $t_a =$ 1 h; $h_{R10.5} = 7.7$ nm; $h_{B82} = 45.5$ nm

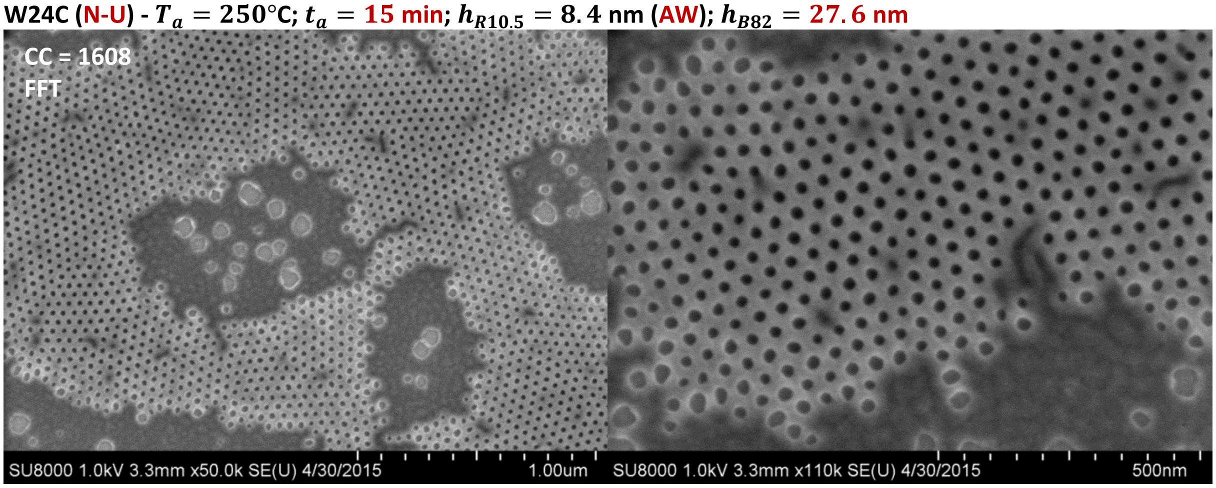


A2.8 Importance of h_{B82} on morphology orientation after **RTP** anneal of **B82** samples

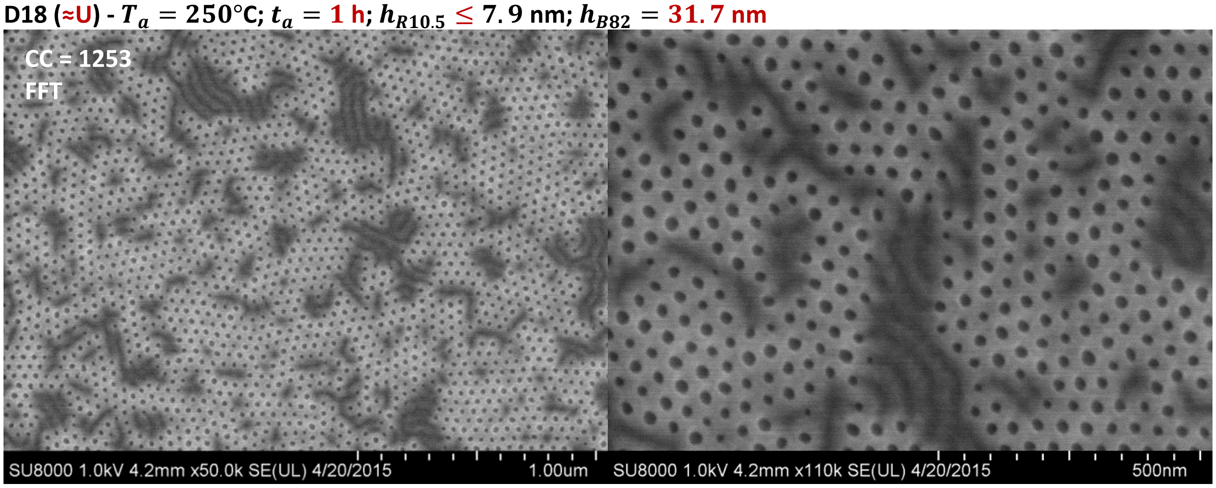
W24A (N-U) - $T_a = 250°C$; $t_a =$ 15 min; $h_{R10.5} = 8.5$ nm (AW); $h_{B82} = 17.8$ nm



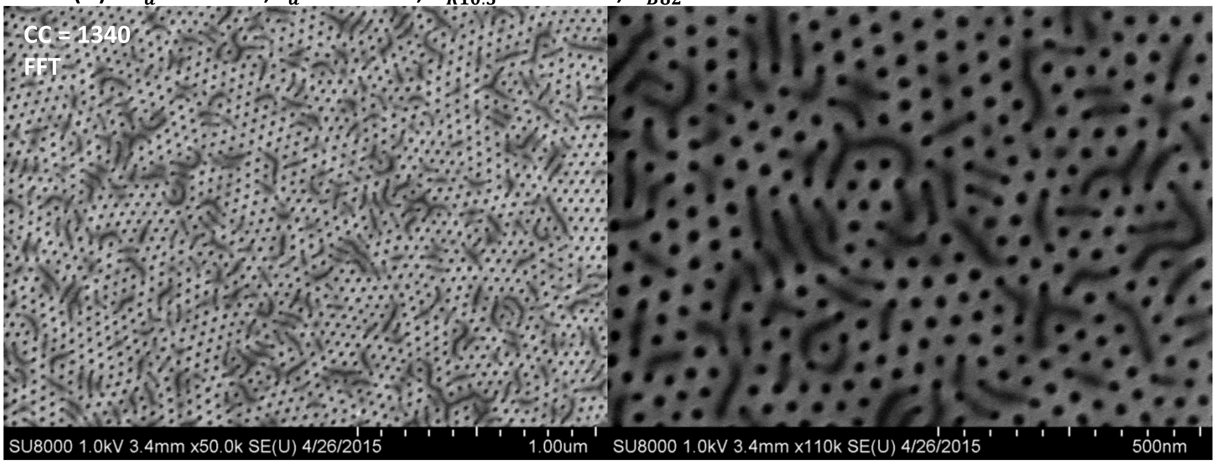
W24C (N-U) - $T_a = 250°C$; $t_a =$ 15 min; $h_{R10.5} = 8.4$ nm (AW); $h_{B82} = 27.6$ nm



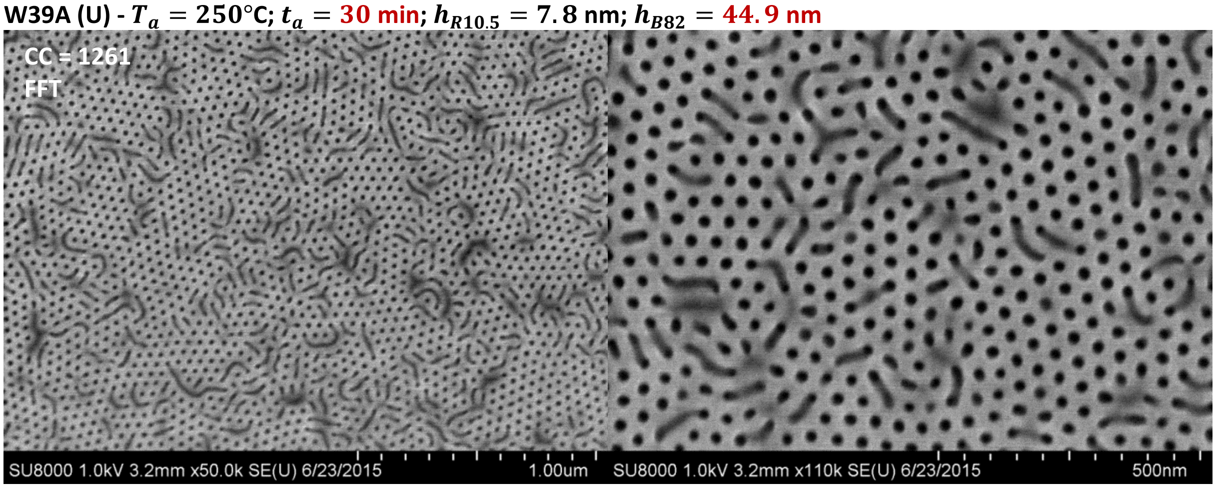
D18 (≈U) - $T_a = 250°C$; $t_a =$ 1 h; $h_{R10.5} \leq 7.9$ nm; $h_{B82} = 31.7$ nm



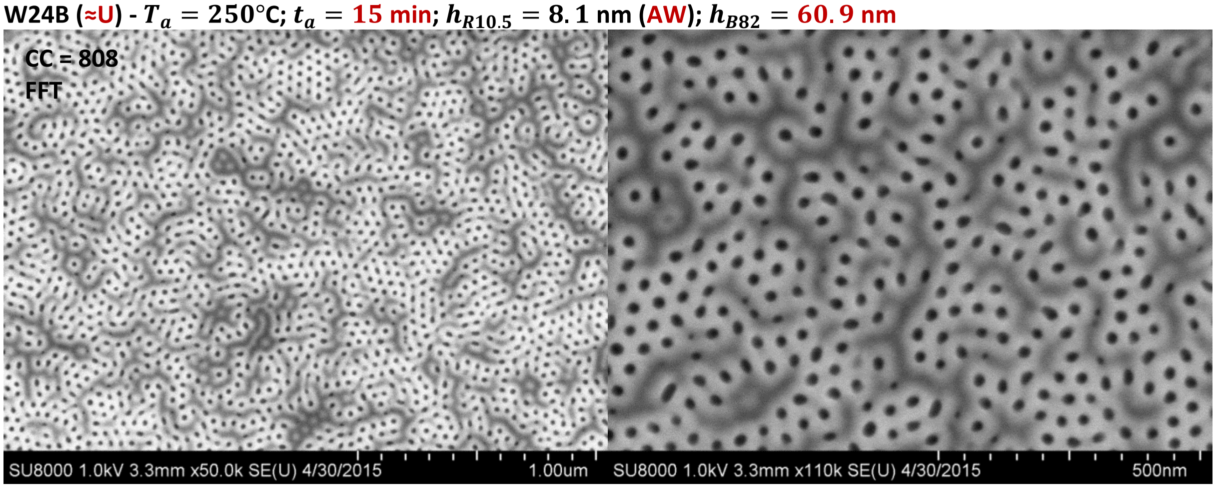
W21F (U) - $T_a = 250$°C; $t_a =$ 15 min; $h_{R10.5} = 7.7$ nm; $h_{B82} = 39.5$ nm



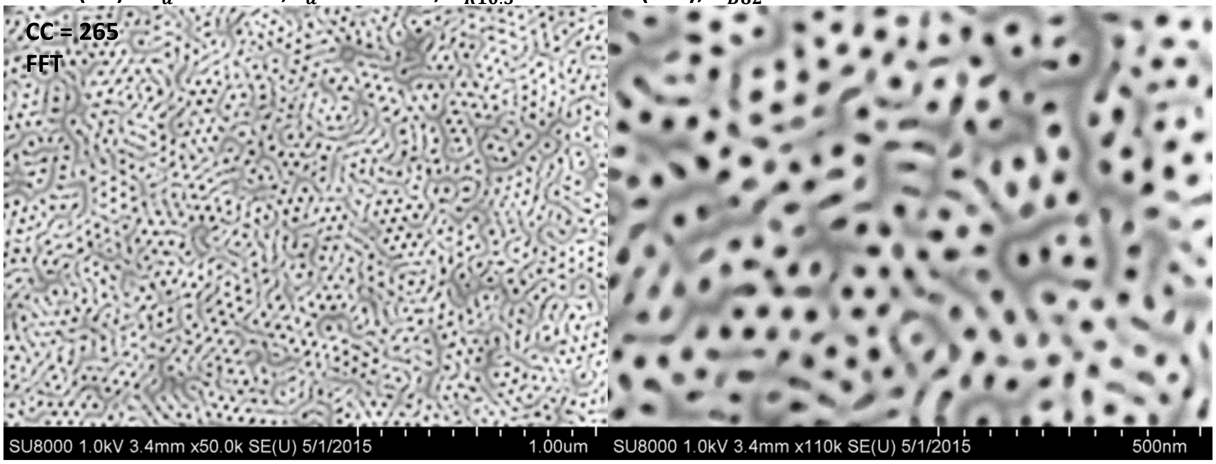
W39A (U) - $T_a = 250$°C; $t_a =$ 30 min; $h_{R10.5} = 7.8$ nm; $h_{B82} = 44.9$ nm



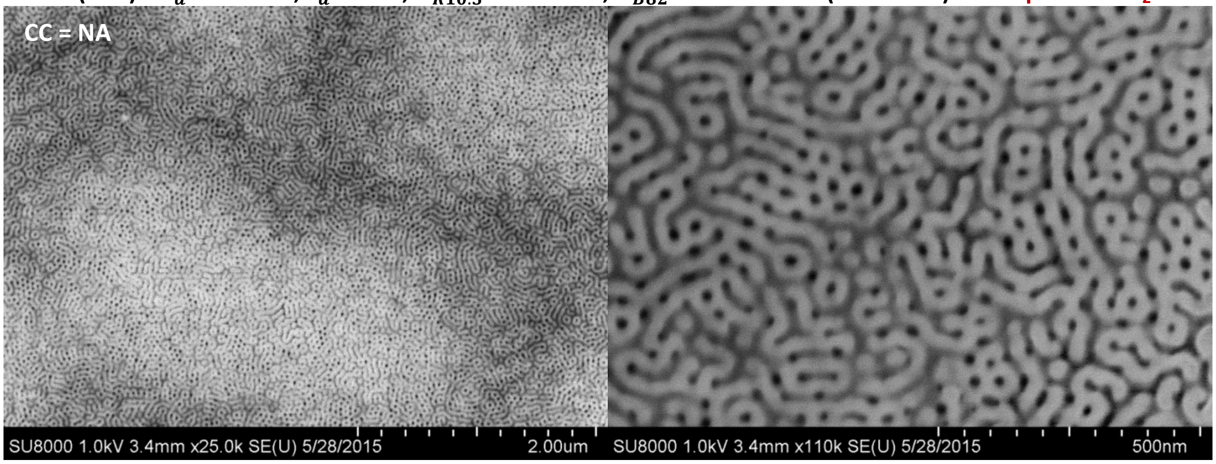
W24B (≈U) - $T_a = 250$°C; $t_a =$ 15 min; $h_{R10.5} = 8.1$ nm (AW); $h_{B82} = 60.9$ nm



W24D (≈U) - $T_a = 250°C$; $t_a = 15$ min; $h_{R10.5} = 8.0$ nm (AW); $h_{B82} = 92.1$nm

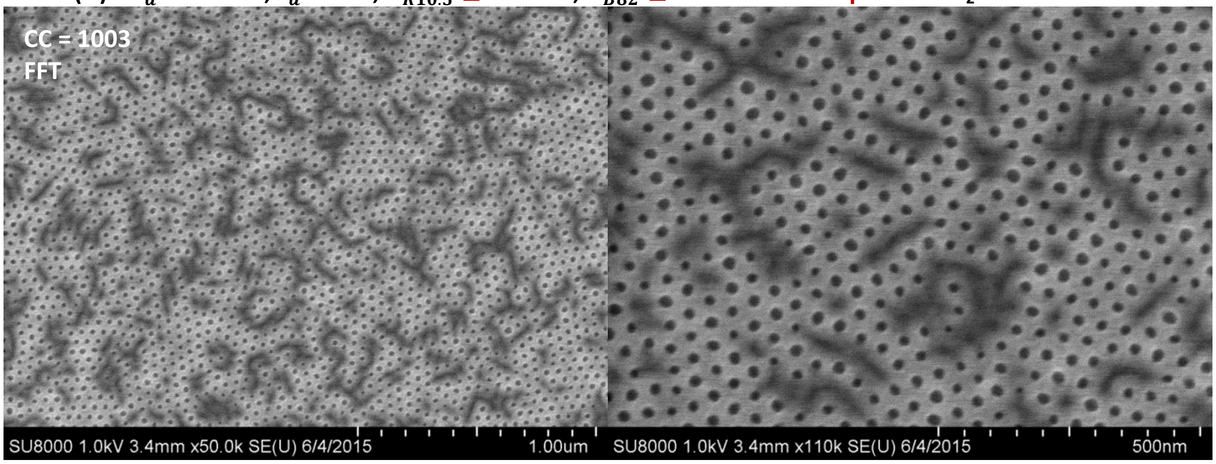


W33D (N-U) - $T_a = 250°C$; $t_a = 1$ h; $h_{R10.5} = 8.7$ nm; $h_{B82} = 126.2$ nm (MSE = 8.1) – 14 s pre-dev. O_2 RIE

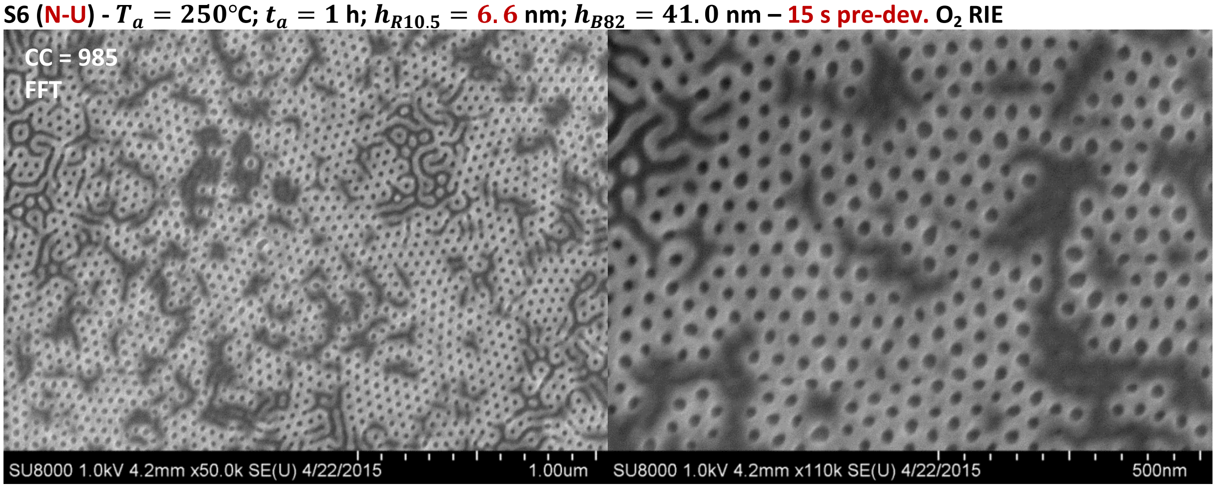


A2.9 Effects of Pre-/Post-development O_2 plasma thinning of B82 samples

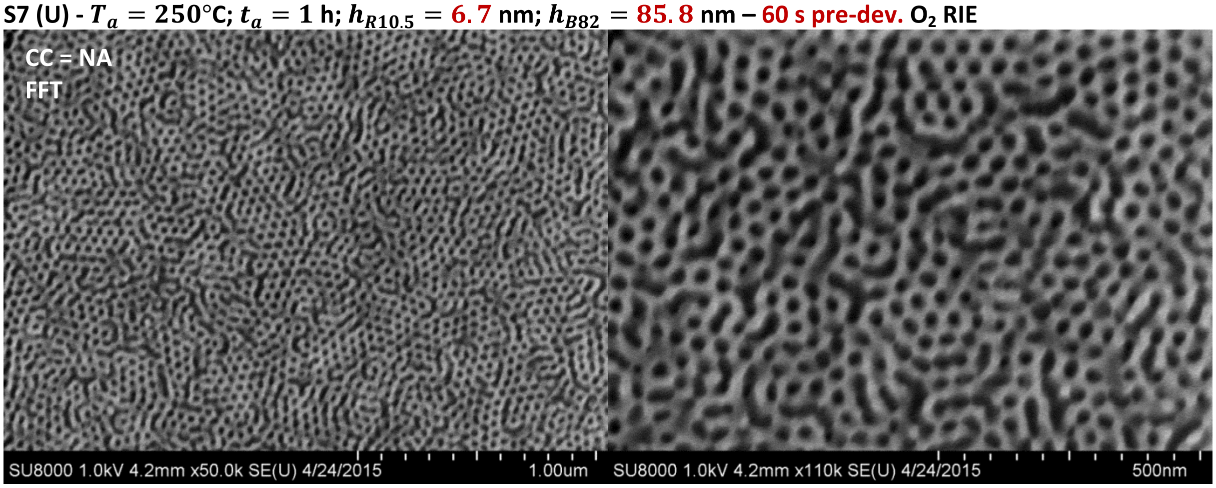
W33E (U) - $T_a = 250°C$; $t_a = 1$ h; $h_{R10.5} \leq 8.7$ nm; $h_{B82} \geq 40.8$ nm – 10 s pre-dev. O_2 RIE



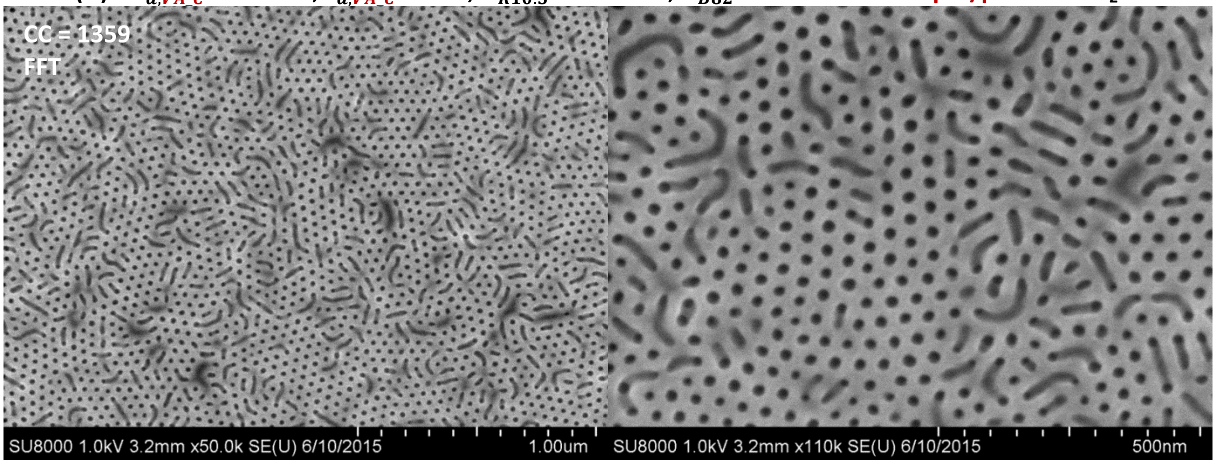
S6 (N-U) - $T_a = 250°C$; $t_a = 1$ h; $h_{R10.5} = 6.6$ nm; $h_{B82} = 41.0$ nm – 15 s pre-dev. O_2 RIE



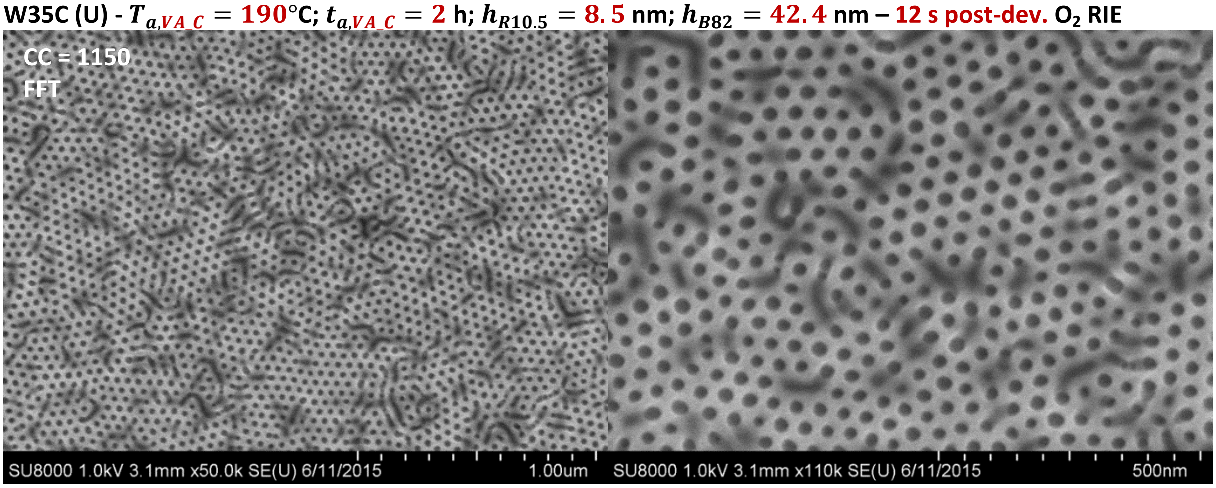
S7 (U) - $T_a = 250°C$; $t_a = 1$ h; $h_{R10.5} = 6.7$ nm; $h_{B82} = 85.8$ nm – 60 s pre-dev. O_2 RIE



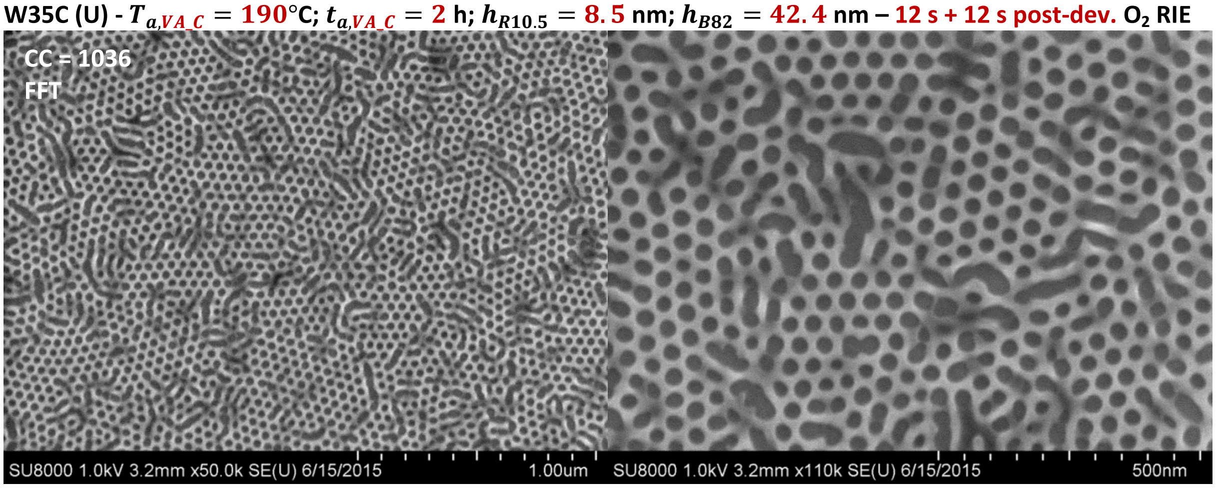
W35C (U) - $T_{a,VA\_C} = 190$°C; $t_{a,VA\_C} = 2$ h; $h_{R10.5} = 8.5$ nm; $h_{B82} = 42.4$ nm – No pre/post-dev. O_2 RIE



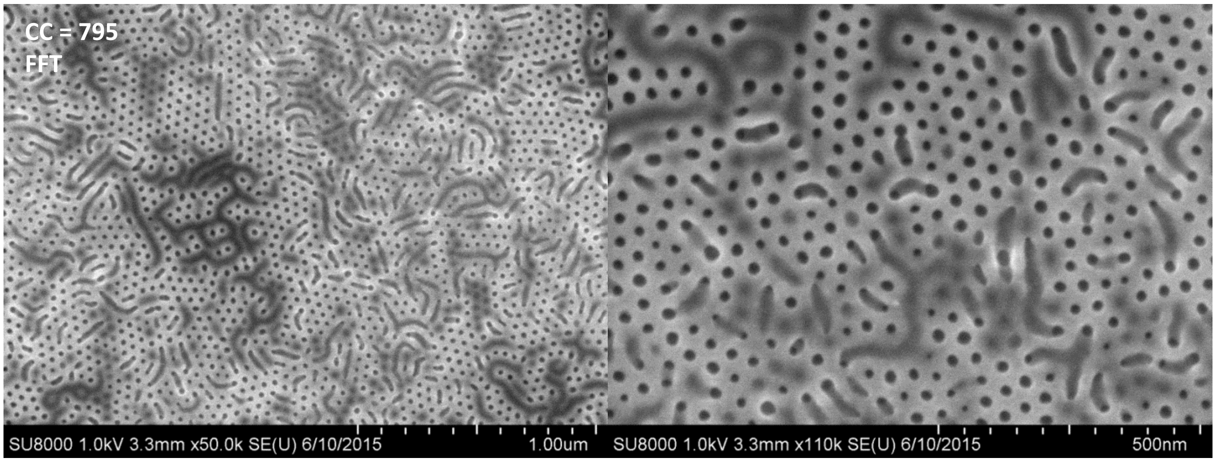
W35C (U) - $T_{a,VA\_C} = 190$°C; $t_{a,VA\_C} = 2$ h; $h_{R10.5} = 8.5$ nm; $h_{B82} = 42.4$ nm – 12 s post-dev. O_2 RIE



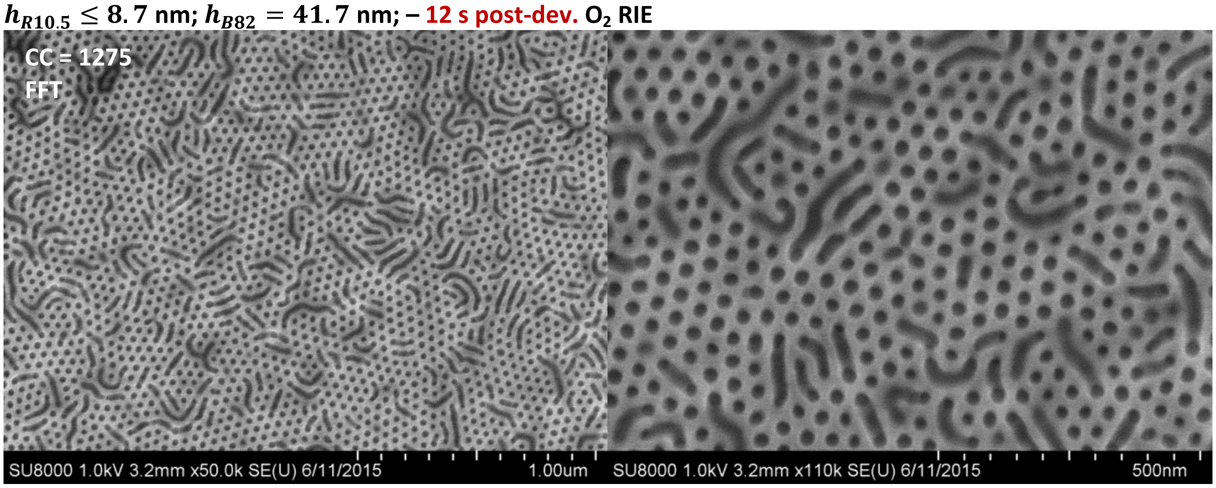
W35C (U) - $T_{a,VA\_C} = 190$°C; $t_{a,VA\_C} = 2$ h; $h_{R10.5} = 8.5$ nm; $h_{B82} = 42.4$ nm – 12 s + 12 s post-dev. O_2 RIE



W33F (N-U) - $T_{a,RTP} = 250°\text{C}$; $t_{a,RTP} = 30\ \text{min}$; $T_{a,VA\_C} = 190°\text{C}$; $t_{a,VA\_C} = 2$ h; $h_{R10.5} \leq 8.7$ nm; $h_{B82} = 41.7$ nm

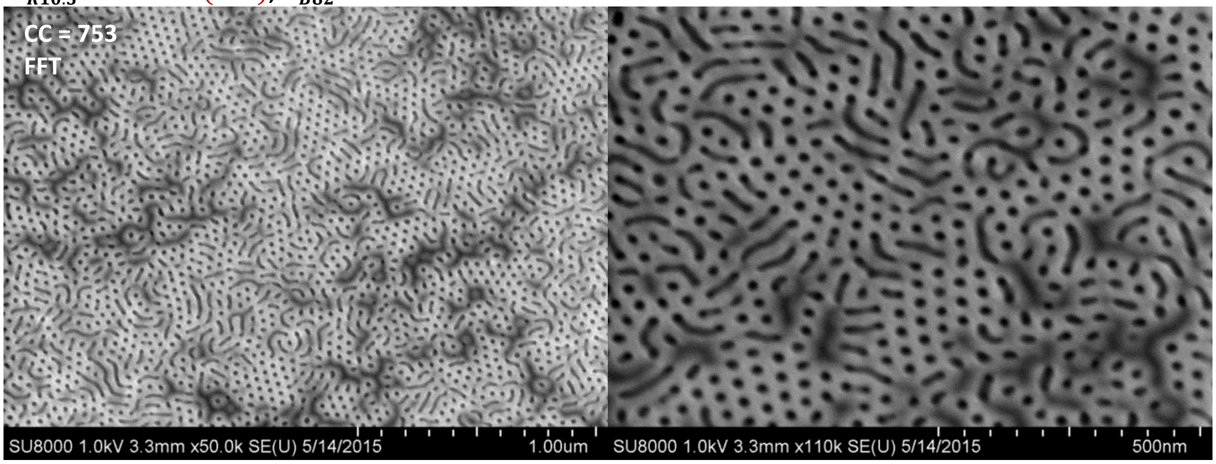


W33F (≈U) - $T_{a,RTP} = 250°\text{C}$; $t_{a,RTP} = 30\ \text{min}$; $T_{a,VA\_C} = 190°\text{C}$; $t_{a,VA\_C} = 2$ h; $h_{R10.5} \leq 8.7$ nm; $h_{B82} = 41.7$ nm; – 12 s post-dev. O_2 RIE

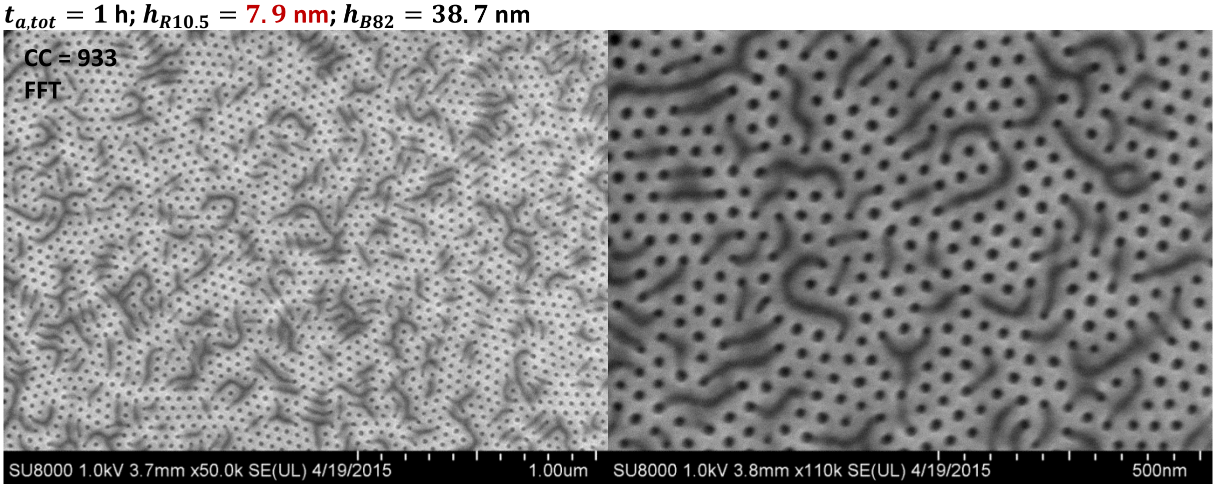


A2.10 Multi-tiered RTP annealing programs for B82 samples

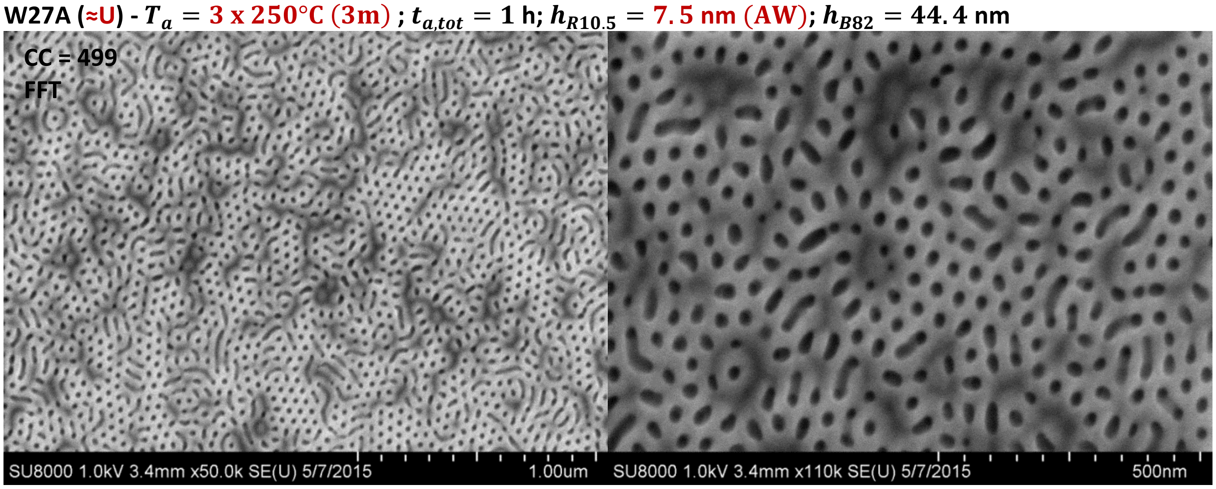
W28F (N-U) - $T_a = 250°\text{C}\ (8\text{m}) \rightarrow 170°\text{C}\ (50\text{m})$; $t_{a,tot} = 1$ h; $h_{R10.5} = 8.6$ nm (AW); $h_{B82} = 44.0$ nm



W17C (U) - $T_a = 280°\text{C}\ (5\text{m}) \rightarrow 250°\text{C}\ (25\text{m}) \rightarrow 220°\text{C}\ (10\text{m}) \rightarrow 190°\text{C}\ (10\text{m})$; $t_{a,tot} = 1$ h; $h_{R10.5} = 7.9$ nm; $h_{B82} = 38.7$ nm

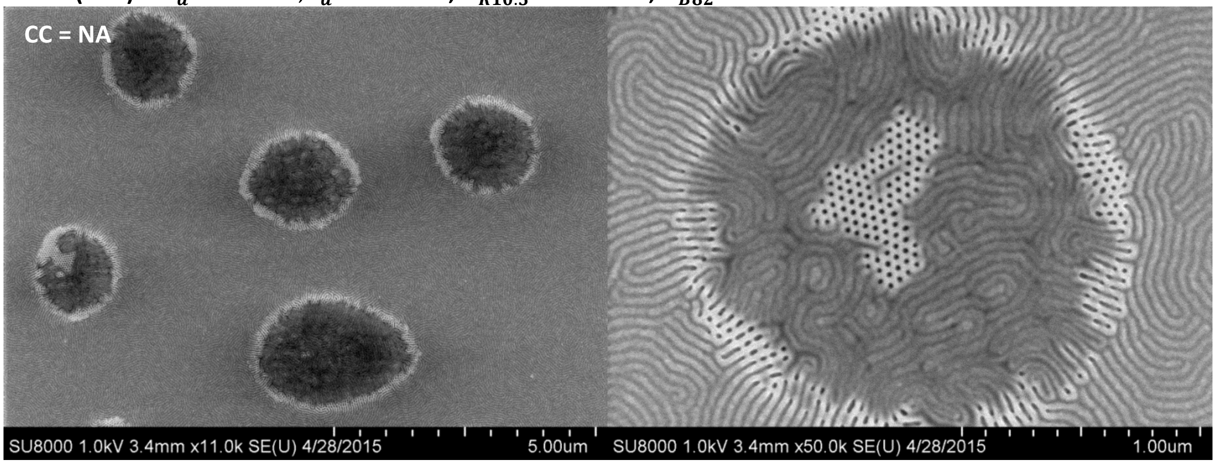


W27A (≈U) - $T_a = 3 \text{ x } 250°\text{C}\ (3\text{m})$; $t_{a,tot} = 1$ h; $h_{R10.5} = 7.5$ nm (AW); $h_{B82} = 44.4$ nm



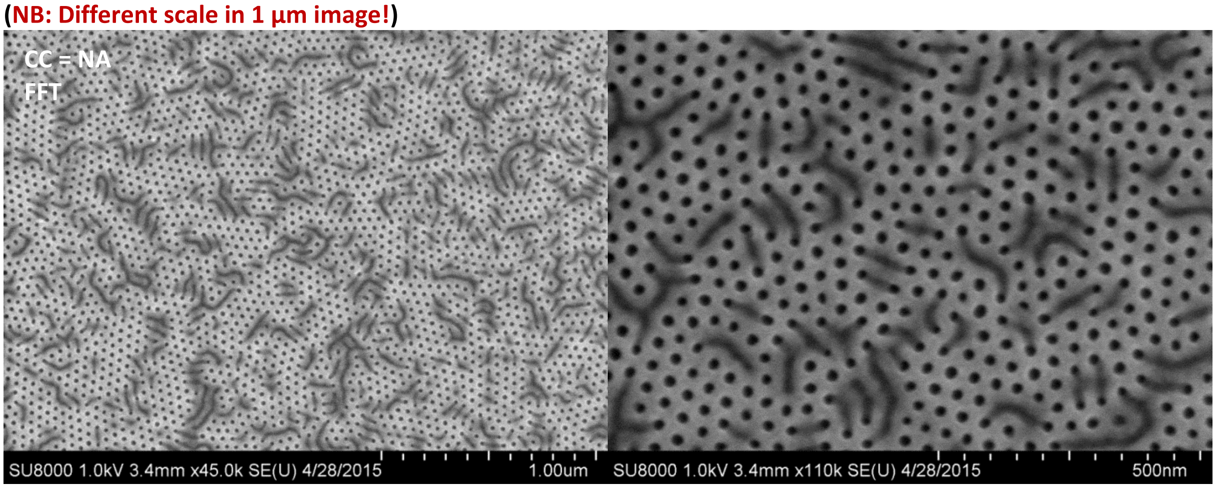
A2.11 Graphite, instead of Si, carrier wafer in the RTP anneal of B82 sample

W23C (N-U) – $T_a = 250°\mathrm{C}$; $t_a = 15$ min; $h_{R10.5} = 8.0$ nm; $h_{B82} = 38.9$ nm

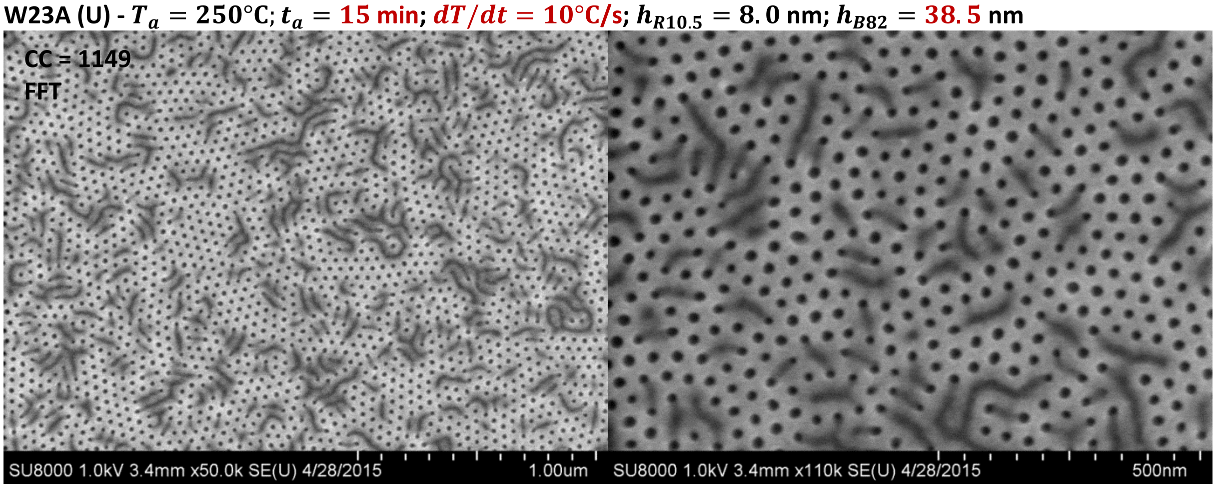


A2.12 Effects of heating rate ($\frac{dT}{dt}$) during the ramp-up of the RTP anneal of B82 samples

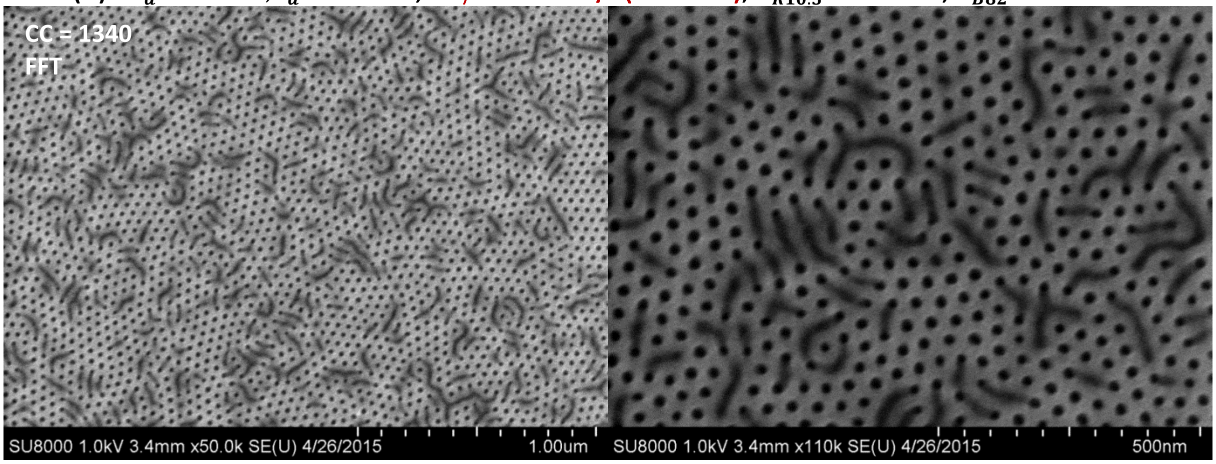
W23B (U) - $T_a = 250°\mathrm{C}$; $t_a = 15$ min; $dT/dt = 5°\mathrm{C/s}$; $h_{R10.5} = 8.0$ nm; $h_{B82} = 38.7$ nm
(NB: Different scale in 1 µm image!)



W23A (U) - $T_a = 250°\mathrm{C}$; $t_a = 15$ min; $dT/dt = 10°\mathrm{C/s}$; $h_{R10.5} = 8.0$ nm; $h_{B82} = 38.5$ nm

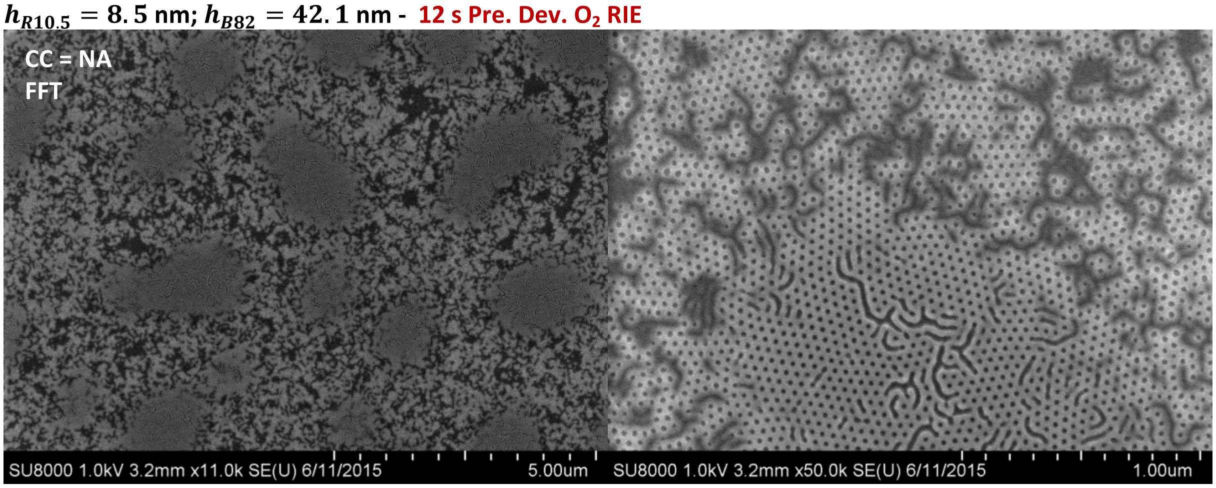


W21F (U) - $T_a = 250°\text{C}$; $t_a = 15$ **min**; $dT/dt = 18°\text{C/s}$ **(Standard)**; $h_{R10.5} = 7.7$ **nm**; $h_{B82} = 39.5$ **nm**

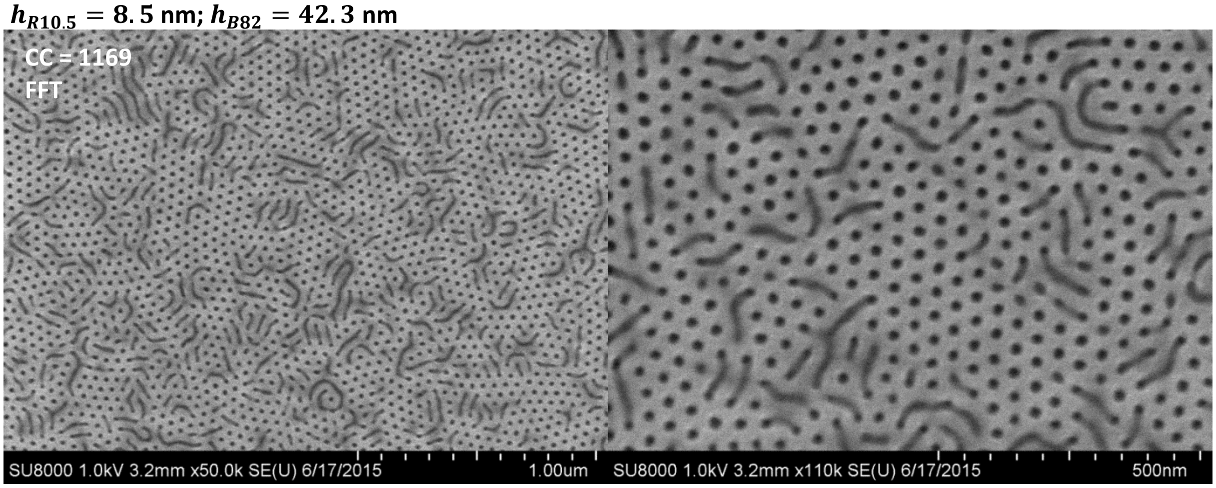


A3.13 TOPHEAT option during RTP anneal of B82 samples

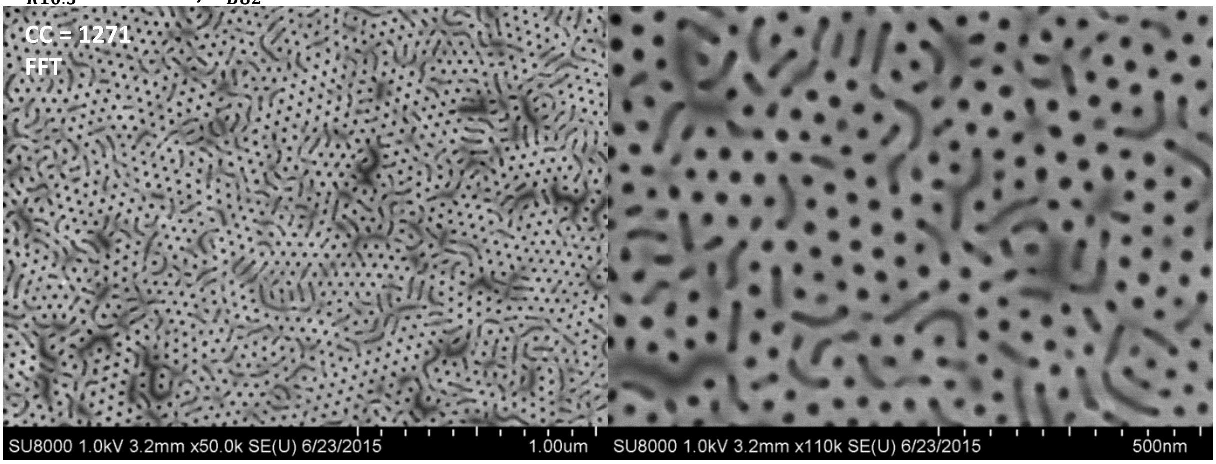
W35A (N-U) - $T_a = 250°\text{C}$; $t_a = 30$ **min**; **TOPHEAT during ramp-up;**
$h_{R10.5} = 8.5$ **nm**; $h_{B82} = 42.1$ **nm - 12 s Pre. Dev.** O_2 **RIE**



W35D (U) - $T_a = 230°\text{C}$; $t_a = 1$ **h**; $dT/dt = 10°\text{C/s}$; **TOPHEAT during entire anneal;**
$h_{R10.5} = 8.5$ **nm**; $h_{B82} = 42.3$ **nm**

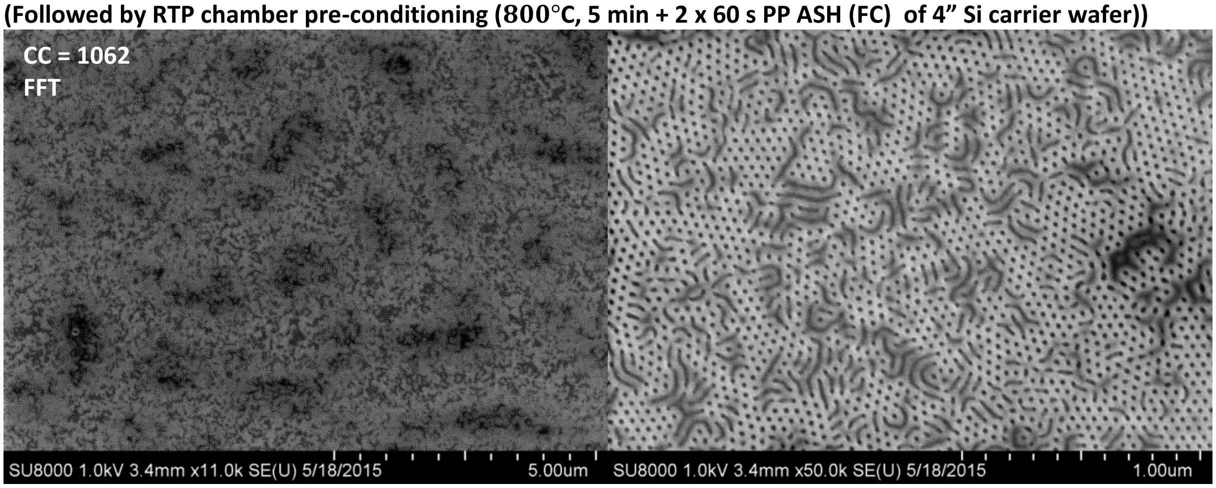


W39C (U) - $T_a = 230°\text{C}$; $t_a = 30\ \text{min}$; $dT/dt = 5°\text{C/s}$; **TOPHEAT during ramp-up;**
$h_{R10.5} = 7.8$ **nm;** $h_{B82} = 44.9$ **nm**

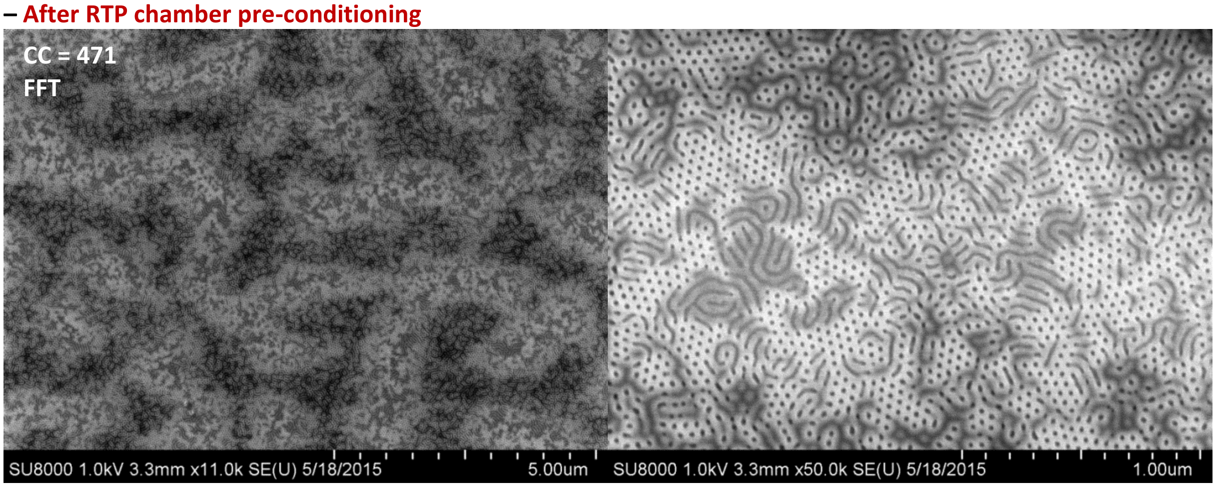


A2.14 Effect of RTP chamber preconditioning prior to anneal of B82 samples

W29B (N-U) - $T_a = 250°\text{C}$; $t_a = 30\ \text{min}$; $h_{R10.5} = 8.6$ **nm;** $h_{B82} = 43.1$ **nm – Reference sample**
(Followed by RTP chamber pre-conditioning ($800°\text{C}$**, 5 min + 2 x 60 s PP ASH (FC) of 4" Si carrier wafer))**

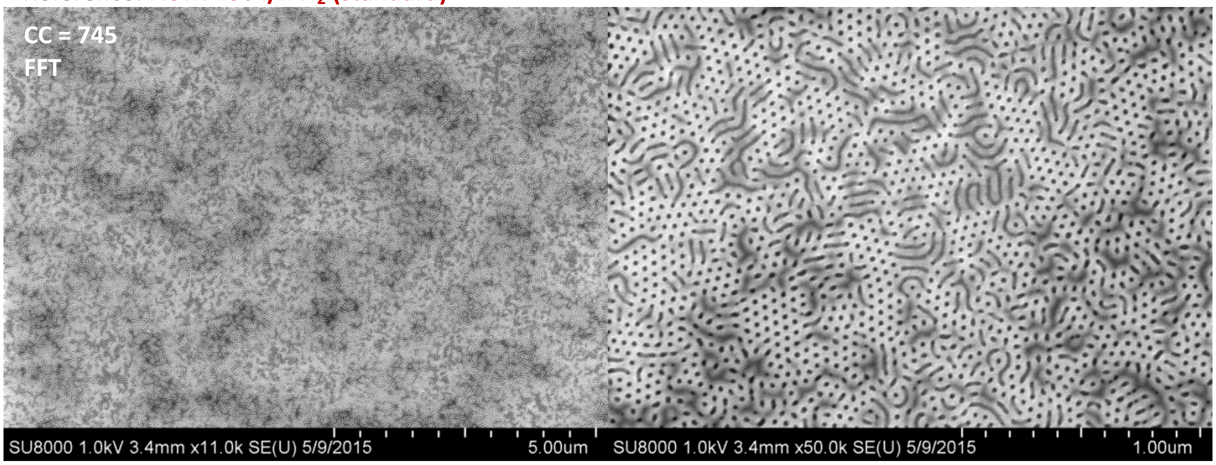


W29C (N-U) - $T_a = 250°\text{C}$; $t_a = 30\ \text{min}$; $h_{R10.5} = 8.6$ **nm;** $h_{B82} = 44.3$ **nm**
– After RTP chamber pre-conditioning

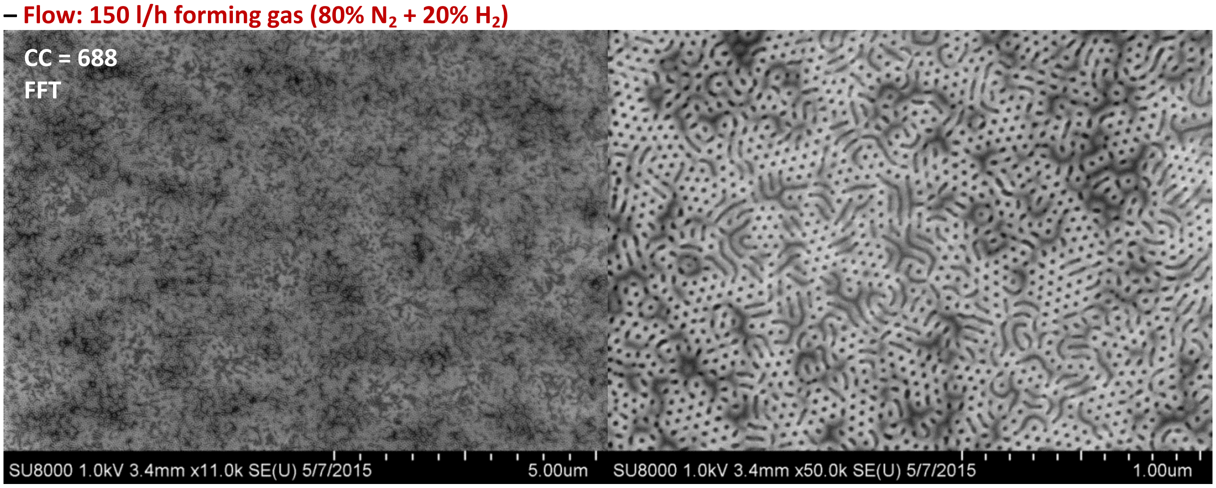


A2.15 Effect of alternative gas flow during RTP anneal of B82 samples

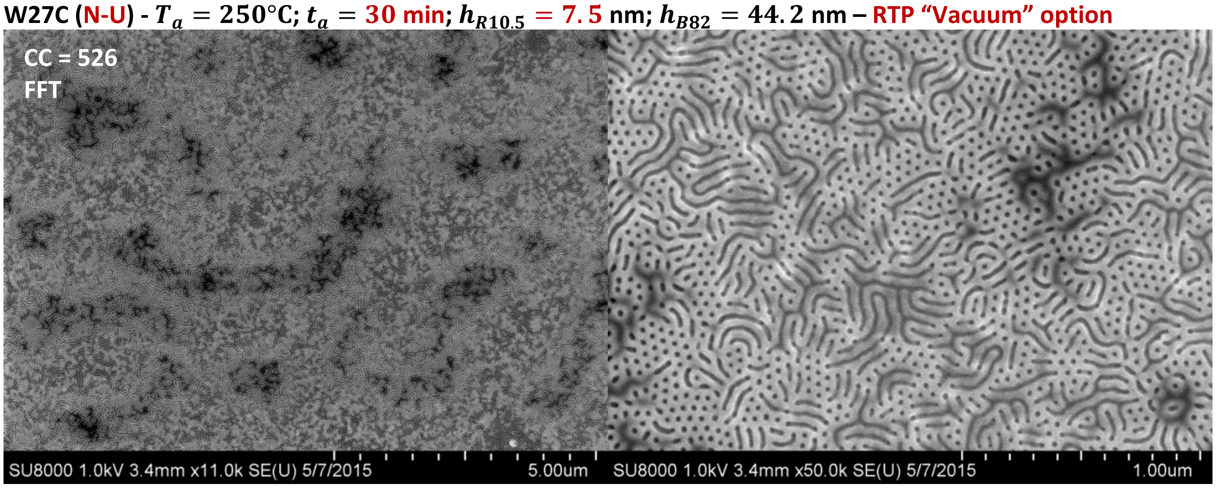
W27F (N-U) - $T_a = 250°\text{C}$; $t_a = 1$ h; $h_{R10.5} = 7.5$ nm; $h_{B82} = 44.3$ nm
– Reference: Flow: 150 l/h N_2 (standard)



W27B (N-U) - $T_a = 250°\text{C}$; $t_a = 30$ min; $h_{R10.5} = 7.5$ nm; $h_{B82} = 44.3$ nm
– Flow: 150 l/h forming gas (80% N_2 + 20% H_2)

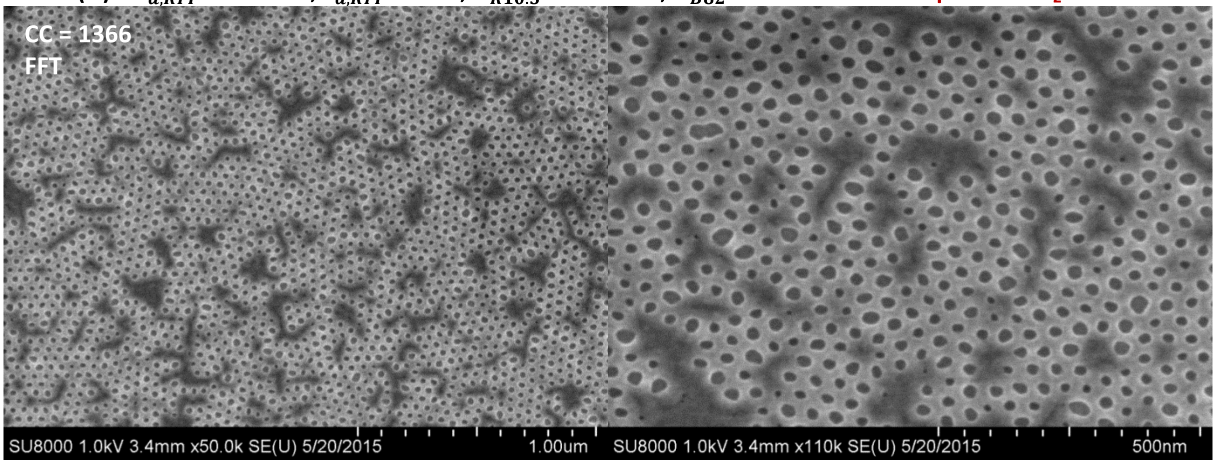


W27C (N-U) - $T_a = 250°\text{C}$; $t_a = 30$ min; $h_{R10.5} = 7.5$ nm; $h_{B82} = 44.2$ nm – RTP "Vacuum" option

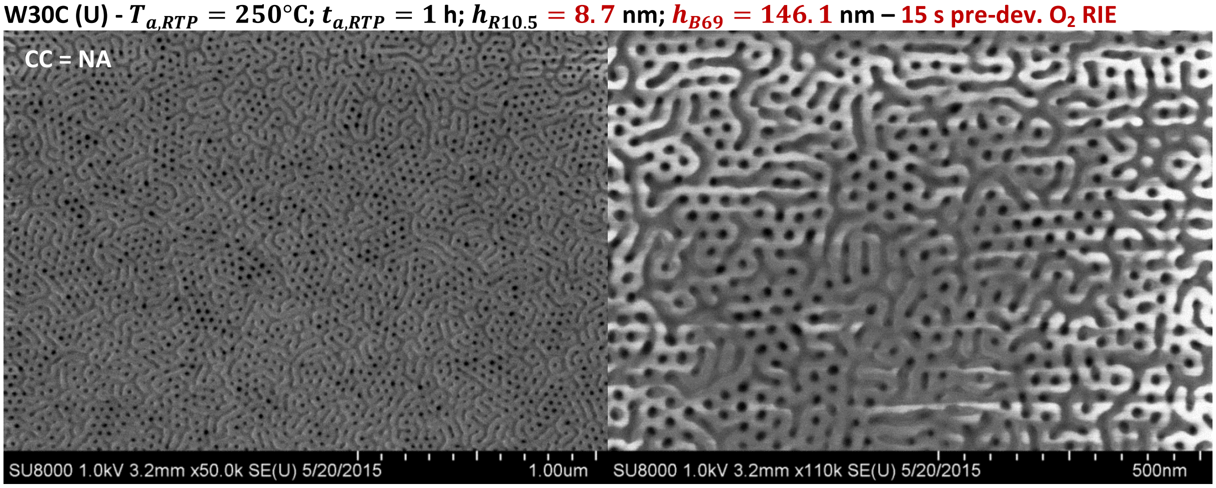


A2.16 Double layered Al foil as an O_2 barrier during anneal of B82/B67 samples

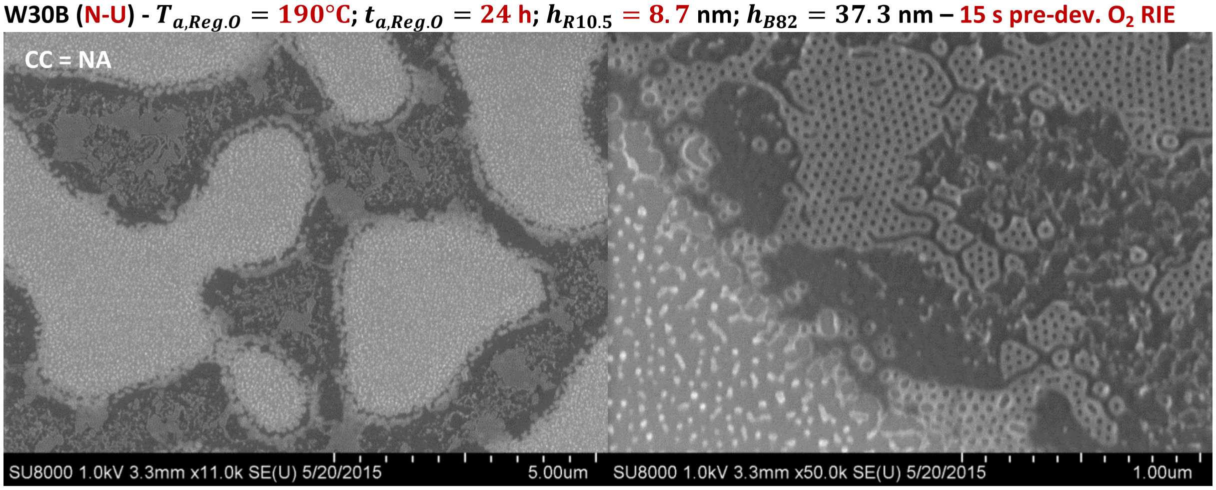
W30A (U) - $T_{a,RTP} = 250°C$; $t_{a,RTP} = 1$ h; $h_{R10.5} = 8.7$ nm; $h_{B82} = 36.0$ nm – 15 s pre-dev. O_2 RIE



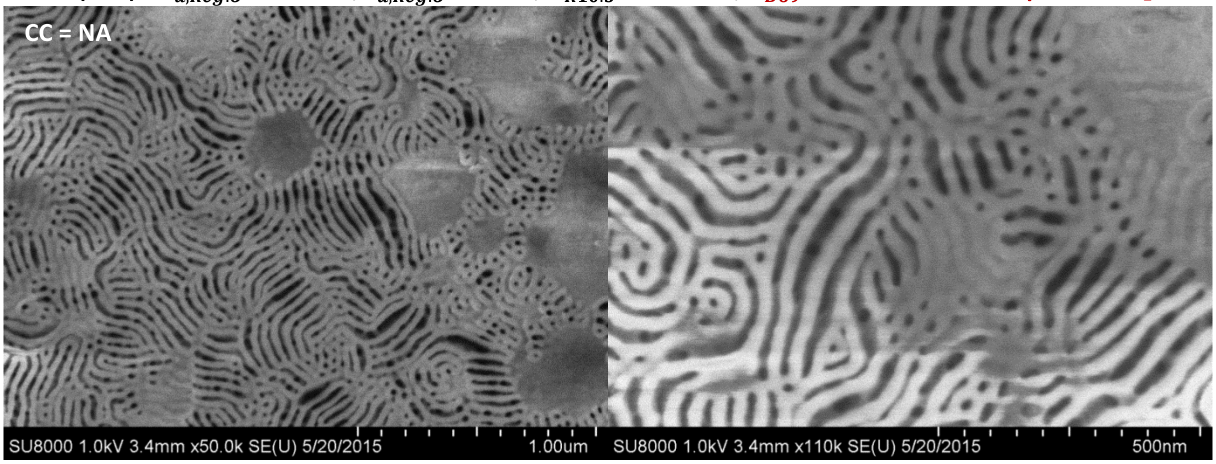
W30C (U) - $T_{a,RTP} = 250°C$; $t_{a,RTP} = 1$ h; $h_{R10.5} = 8.7$ nm; $h_{B69} = 146.1$ nm – 15 s pre-dev. O_2 RIE



W30B (N-U) - $T_{a,Reg.O} = 190°C$; $t_{a,Reg.O} = 24$ h; $h_{R10.5} = 8.7$ nm; $h_{B82} = 37.3$ nm – 15 s pre-dev. O_2 RIE

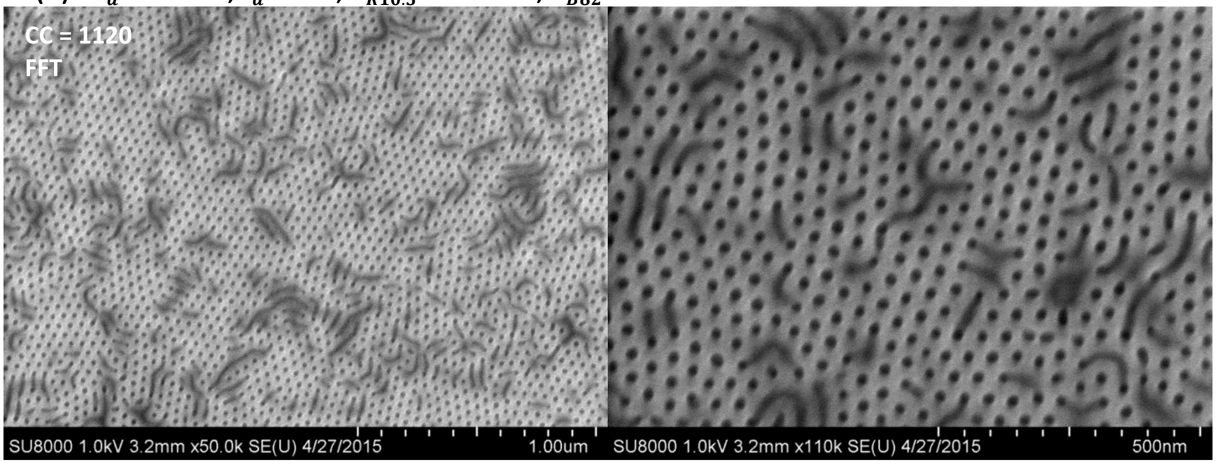


W30D (N-U) - $T_{a,Reg.O} = 190°C$; $t_{a,Reg.O} = 24$ h; $h_{R10.5} = 8.7$ nm; $h_{B69} = 145.7$ nm – 15 s pre-dev. O_2 RIE

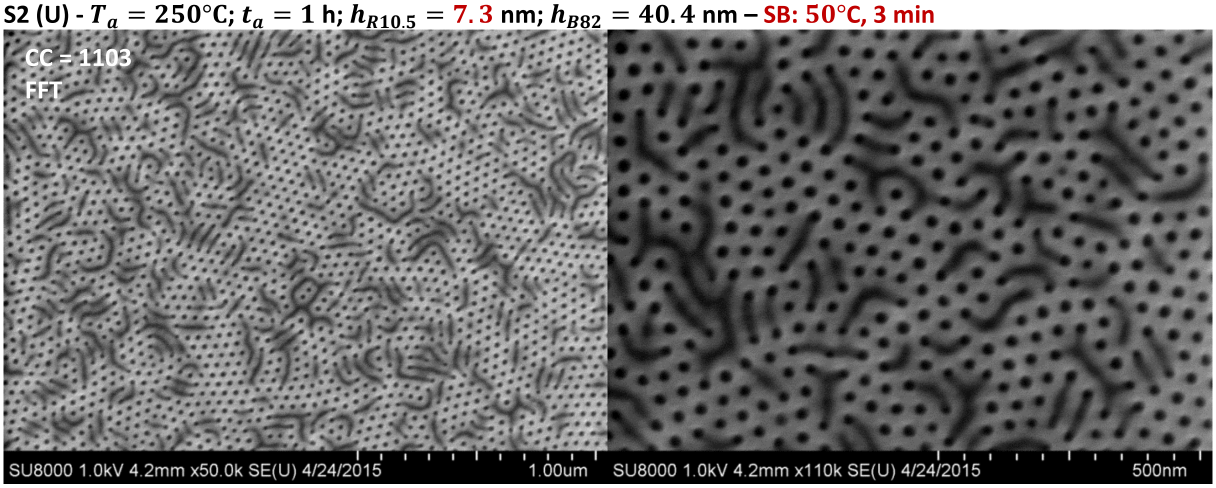


A2.17 Detrimental effects of post-SC soft-bake (on hotplate in ambient atmosphere)?

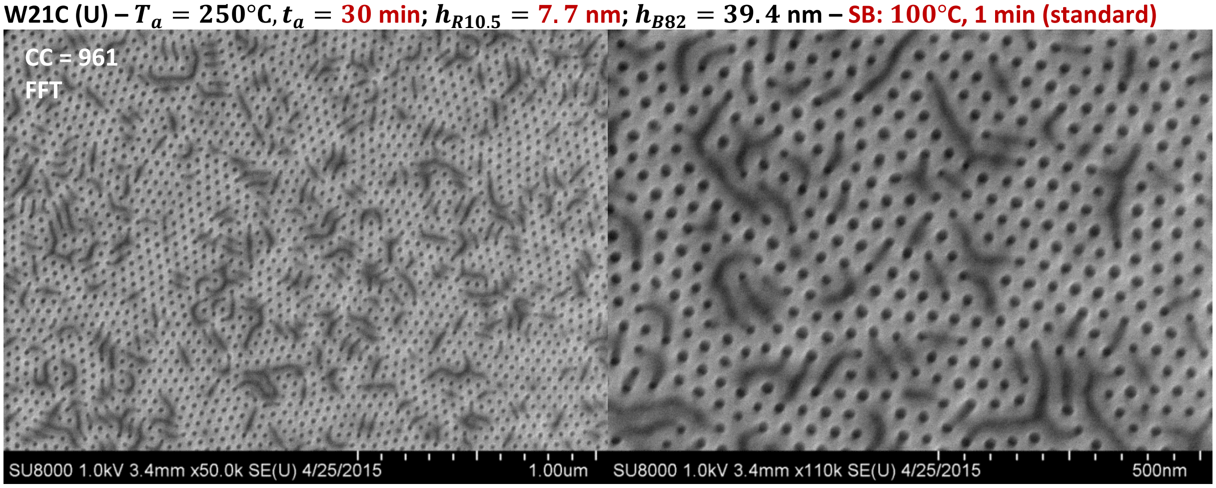
S3 (U) - $T_a = 250°\text{C}$; $t_a = 1$ h; $h_{R10.5} = 7.0$ nm; $h_{B82} = 39.9$ nm – SB: None



S2 (U) - $T_a = 250°\text{C}$; $t_a = 1$ h; $h_{R10.5} = 7.3$ nm; $h_{B82} = 40.4$ nm – SB: 50°C, 3 min

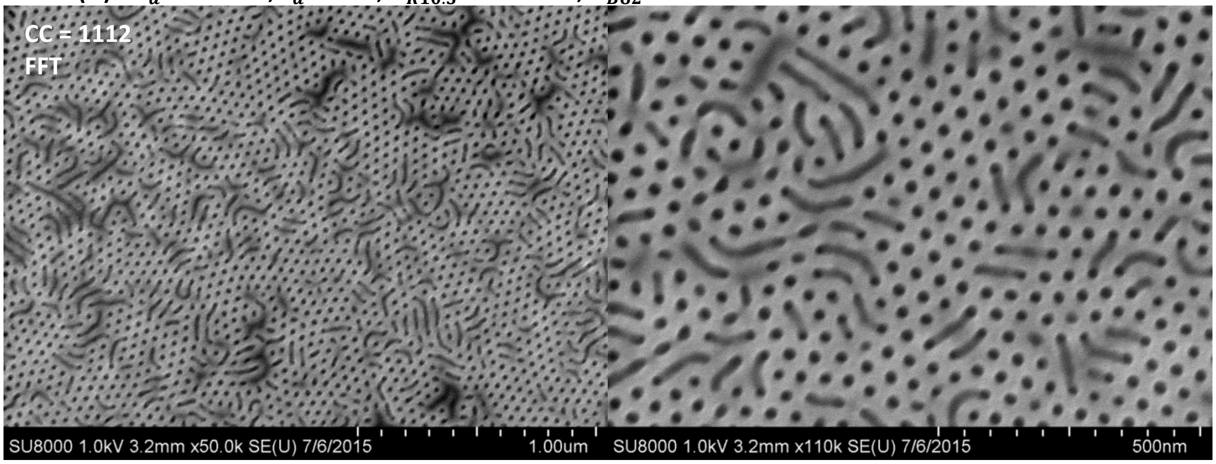


W21C (U) – $T_a = 250°\text{C}$, $t_a = 30$ min; $h_{R10.5} = 7.7$ nm; $h_{B82} = 39.4$ nm – SB: 100°C, 1 min (standard)

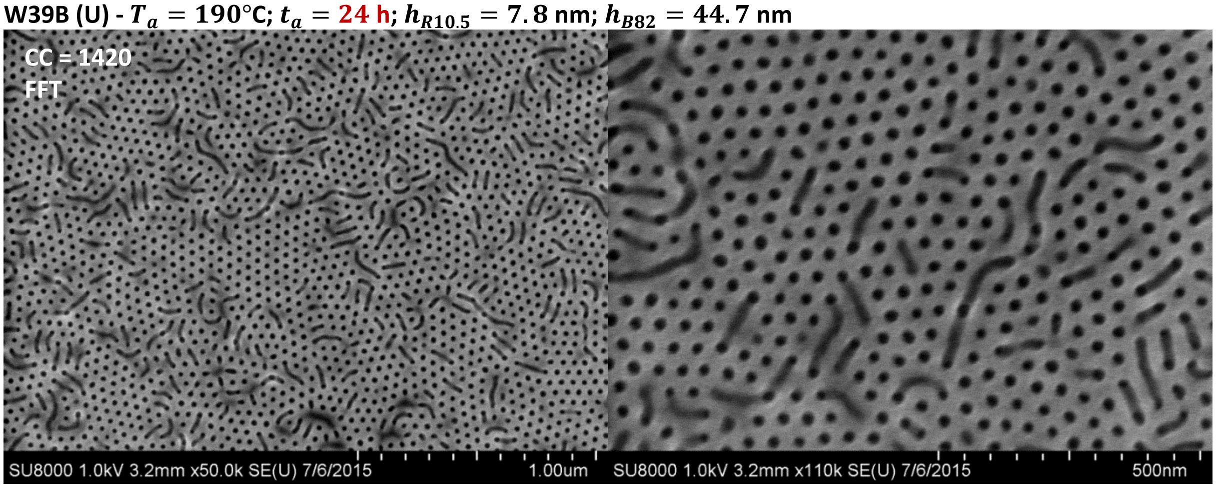


A2.18 Extended vacuum oven anneals of B82 samples

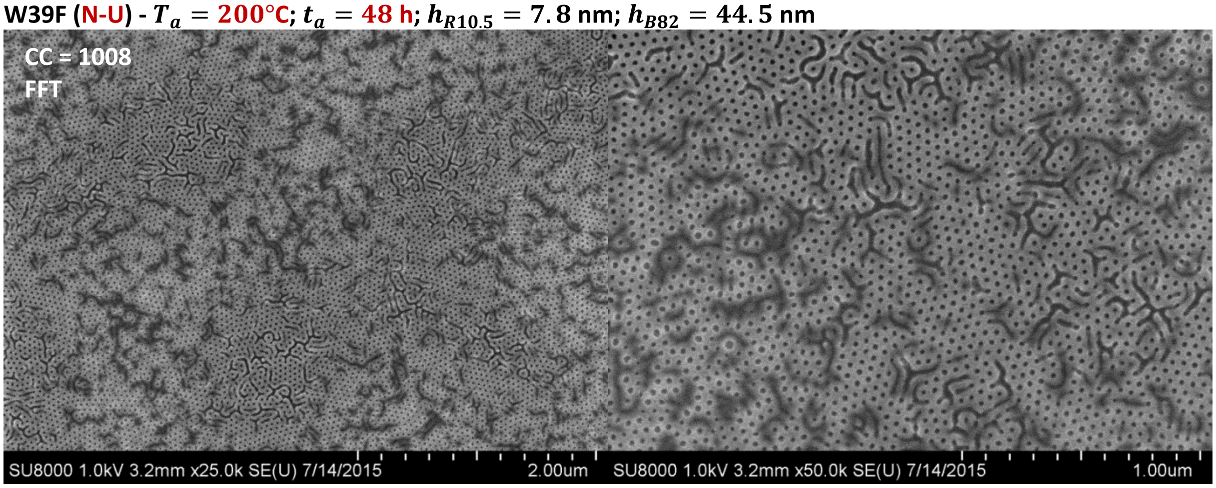
W39D (U) - $T_a = 190°C$; $t_a =$ 6 h; $h_{R10.5} = 7.8$ nm; $h_{B82} = 44.6$ nm



W39B (U) - $T_a = 190°C$; $t_a =$ 24 h; $h_{R10.5} = 7.8$ nm; $h_{B82} = 44.7$ nm



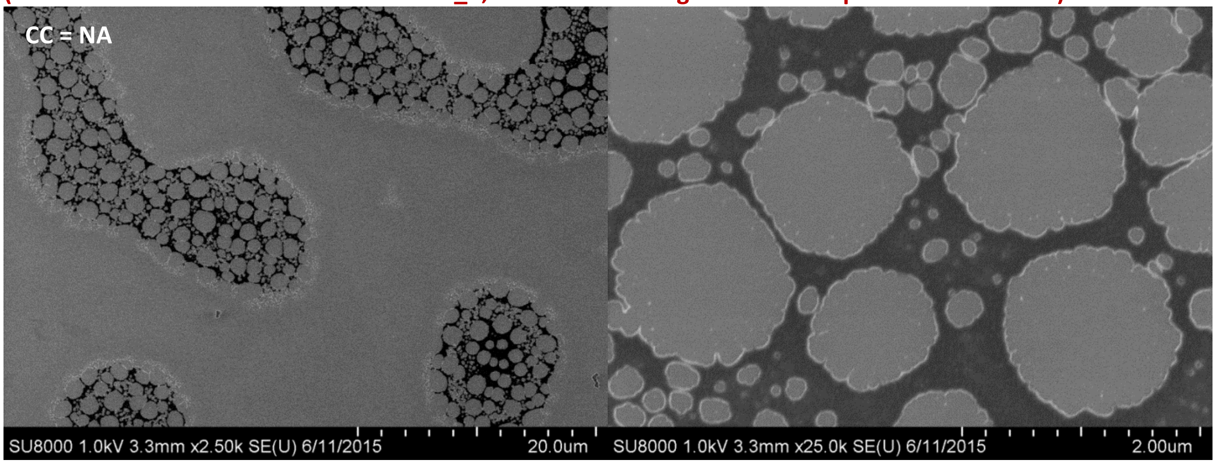
W39F (N-U) - $T_a = 200°C$; $t_a =$ 48 h; $h_{R10.5} = 7.8$ nm; $h_{B82} = 44.5$ nm



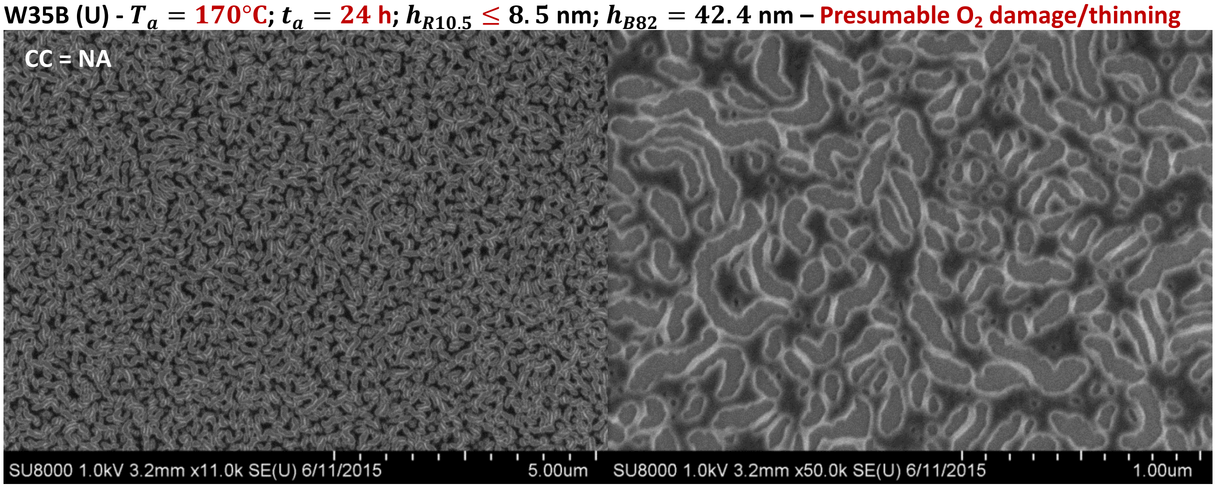
A2.19 Extended vacuum anneal, in custom-built ovenproof chamber (v. 1.0), of B82 samples

W34A (N-U) - $T_a = 190°C$; $t_a = 24$ h; $h_{R10.5} \leq 8.5$ nm; $h_{B82} = 41.6$ nm

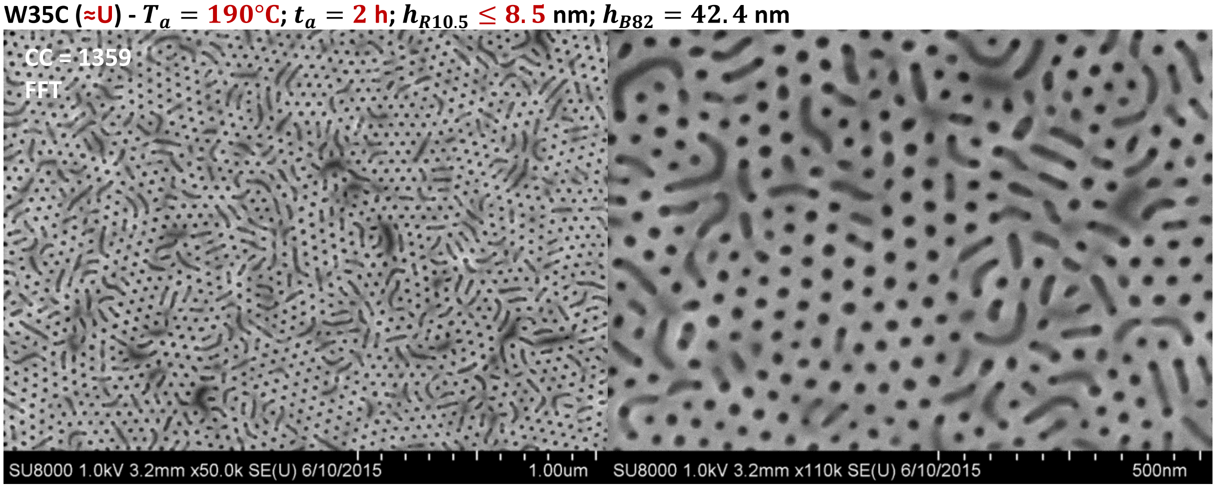
(White discoloration of B82 film after VA_C; Potential welding residue re-deposited on B82 film)



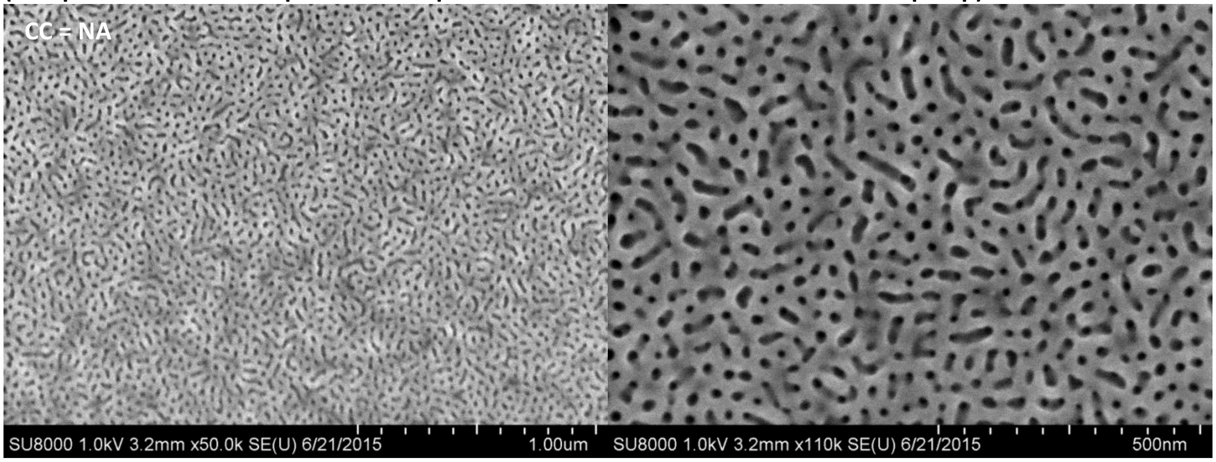
W35B (U) - $T_a = 170°C$; $t_a = 24$ h; $h_{R10.5} \leq 8.5$ nm; $h_{B82} = 42.4$ nm – Presumable O_2 damage/thinning



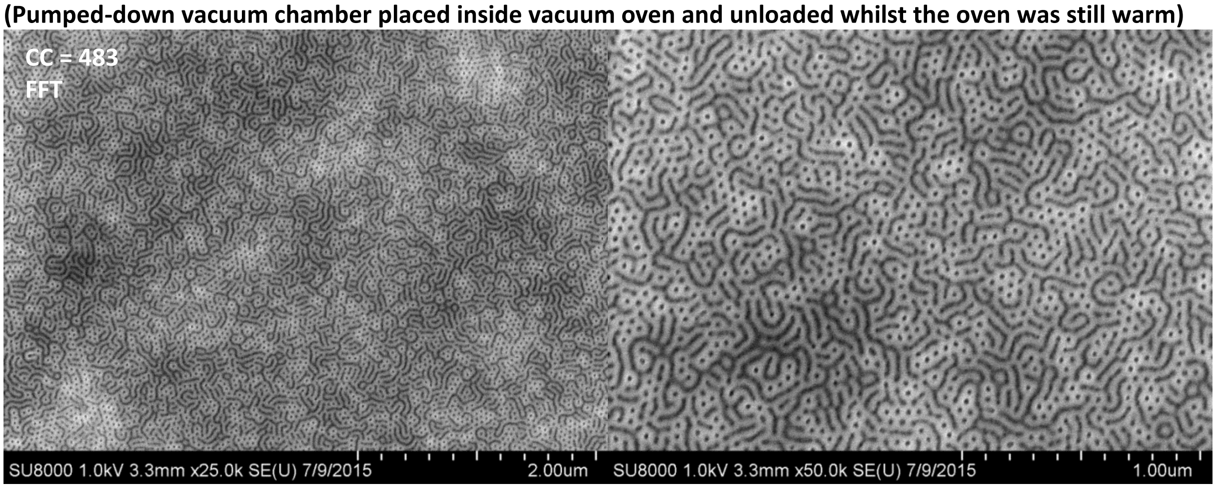
W35C (≈U) - $T_a = 190°C$; $t_a = 2$ h; $h_{R10.5} \leq 8.5$ nm; $h_{B82} = 42.4$ nm



W35F (U) - $T_a \approx 170°\mathrm{C}$ (Hotplate setpoint $= 200°\mathrm{C}$); $t_a = 6$ h; $h_{R10.5} \leq 8.5$ nm; $h_{B82} = 42.1$ nm
(Pumped-down chamber placed on hotplate whilst still attached to turbo vacuum pump)

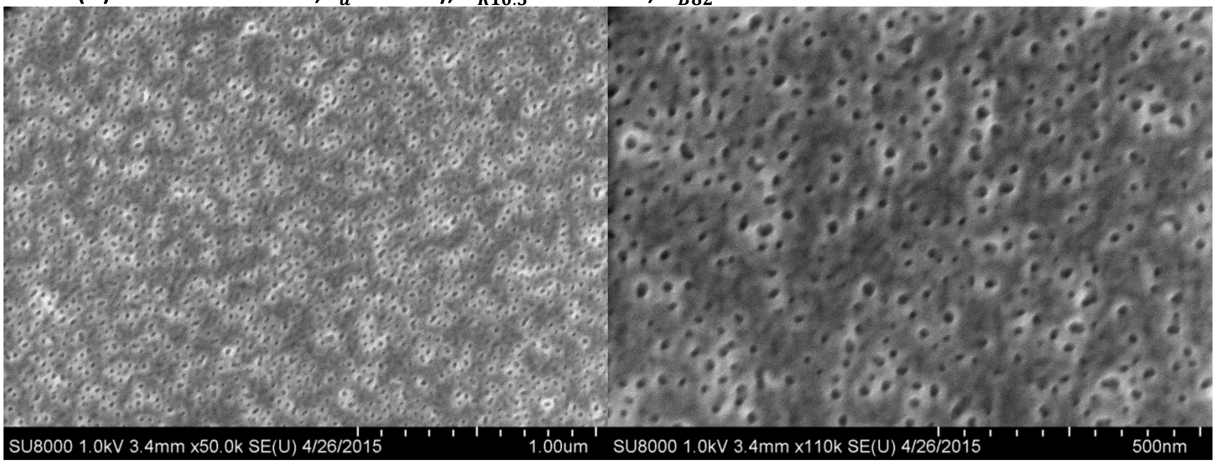


W39E (N-U) - $T_a = 190°\mathrm{C}$; $t_a = 24$ h; $h_{R10.5} = 7.8$ nm; $h_{B82} = 44.6$ nm
(Pumped-down vacuum chamber placed inside vacuum oven and unloaded whilst the oven was still warm)

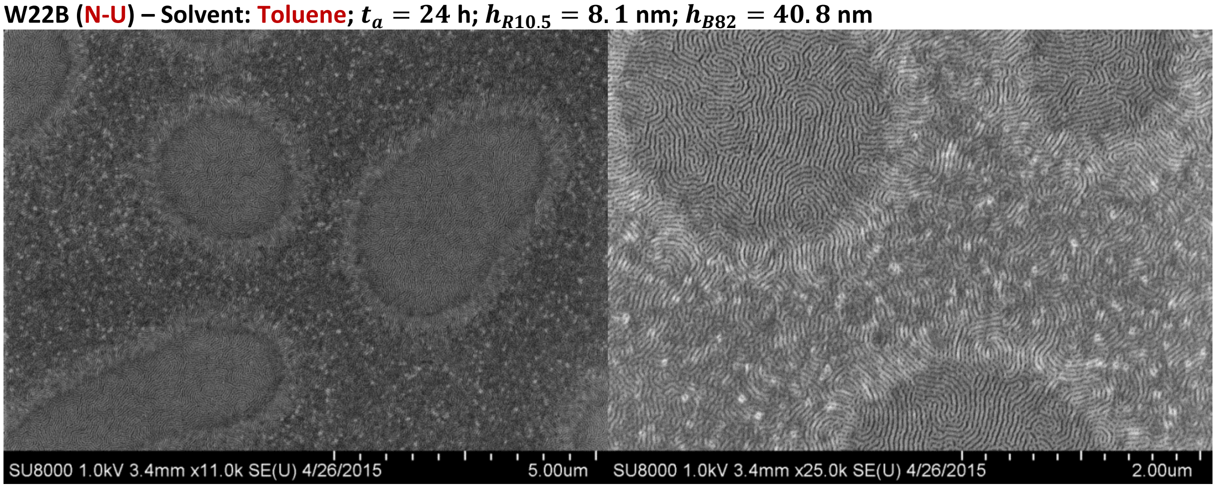


A2.20 24h SVA at $T_a = RT\ (21 - 23°\text{C})$ of B82 samples

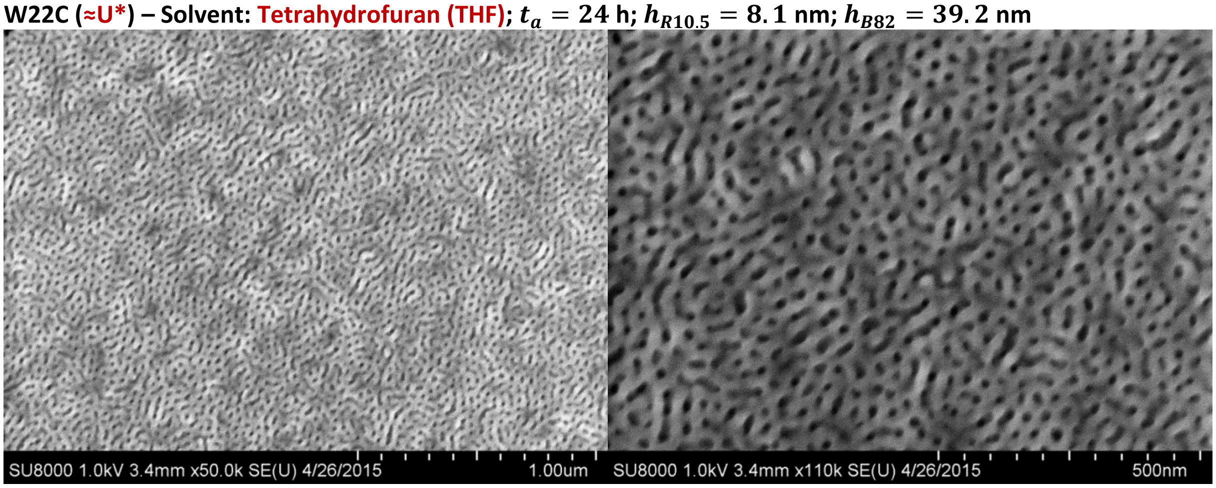
W22A (U) – Solvent: Anisole; $t_a = 24$ h); $h_{R10.5} = 8.1$ nm; $h_{B82} = 39.2$ nm



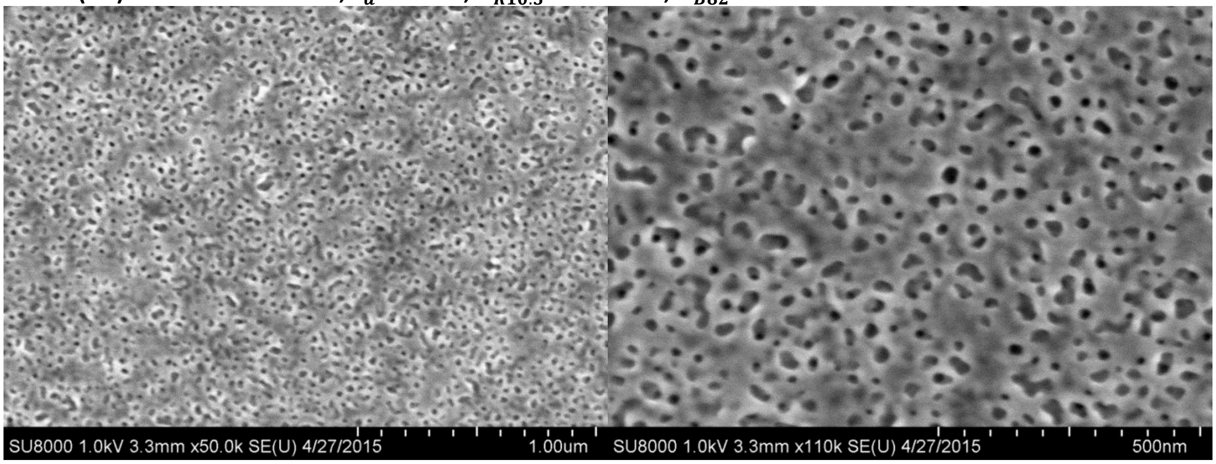
W22B (N-U) – Solvent: Toluene; $t_a = 24$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 40.8$ nm



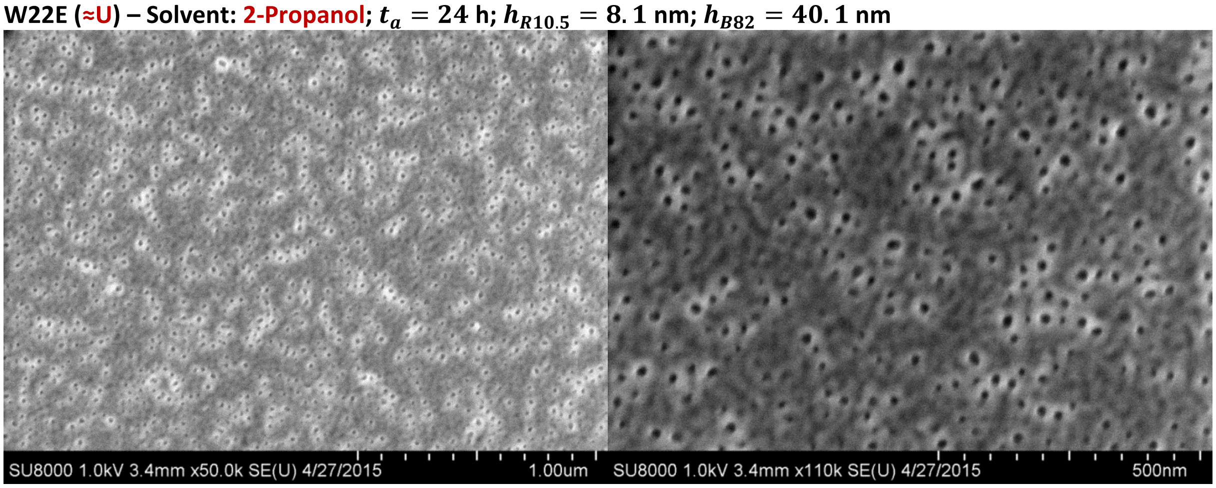
W22C (≈U*) – Solvent: Tetrahydrofuran (THF); $t_a = 24$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 39.2$ nm



W22D (≈U) – Solvent: Acetone; $t_a = 24$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 39.6$ nm

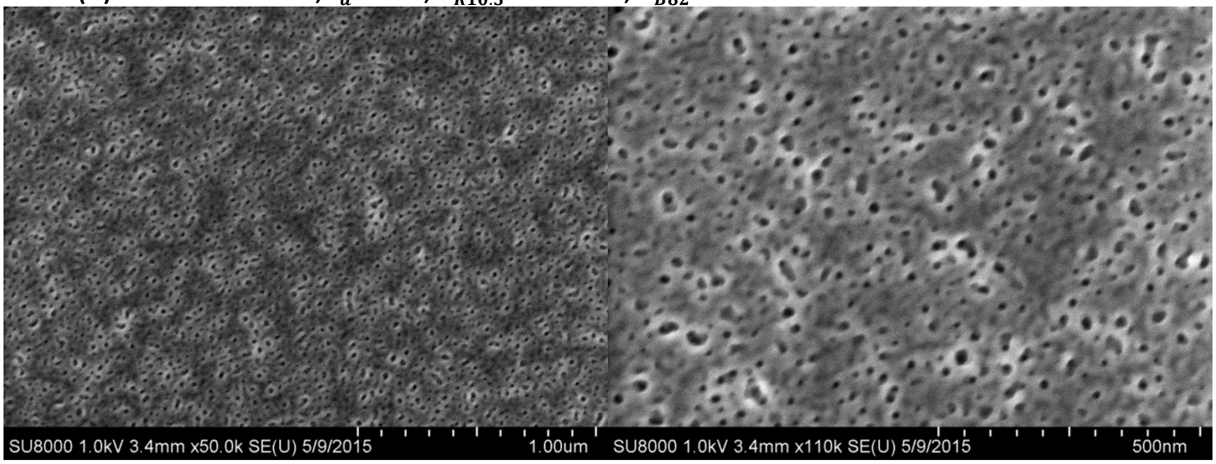


W22E (≈U) – Solvent: 2-Propanol; $t_a = 24$ h; $h_{R10.5} = 8.1$ nm; $h_{B82} = 40.1$ nm

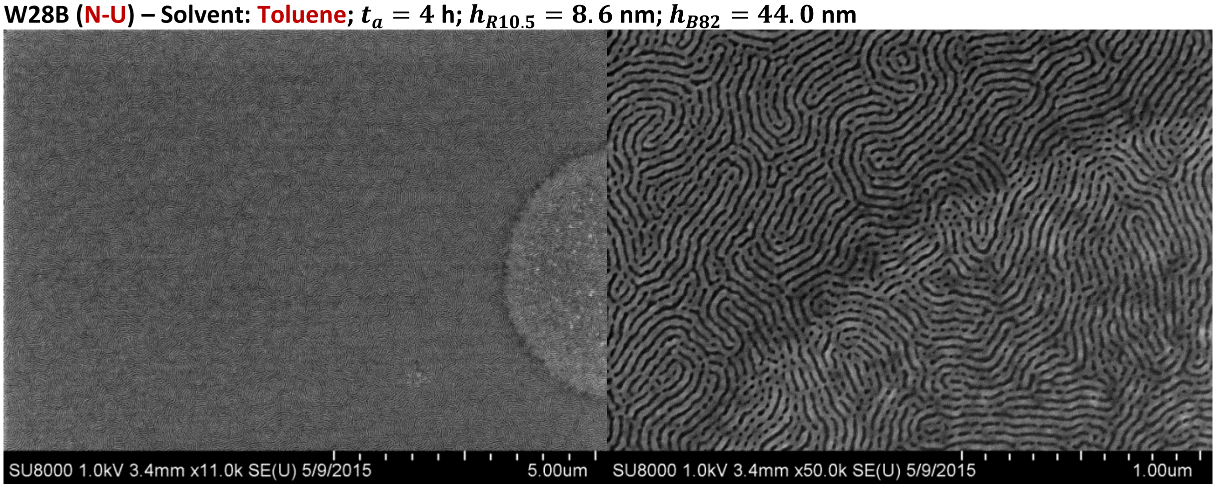


A2.21 4h SVA at $T_a = RT\ (21 - 23°\mathrm{C})$ of B82 samples

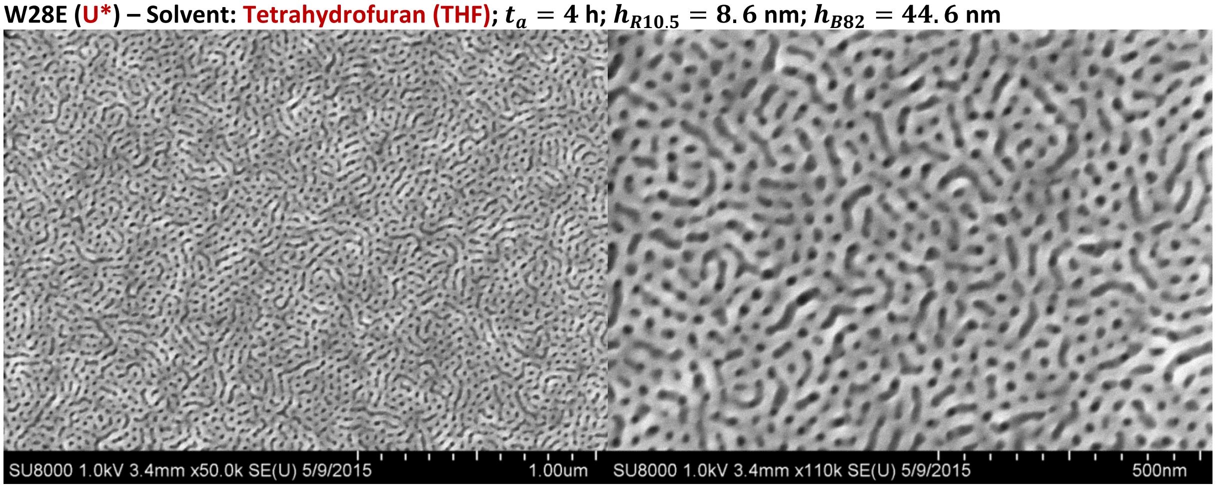
W28D (U) – Solvent: Anisole; $t_a = 4$ h; $h_{R10.5} = 8.6$ nm; $h_{B82} = 44.6$ nm



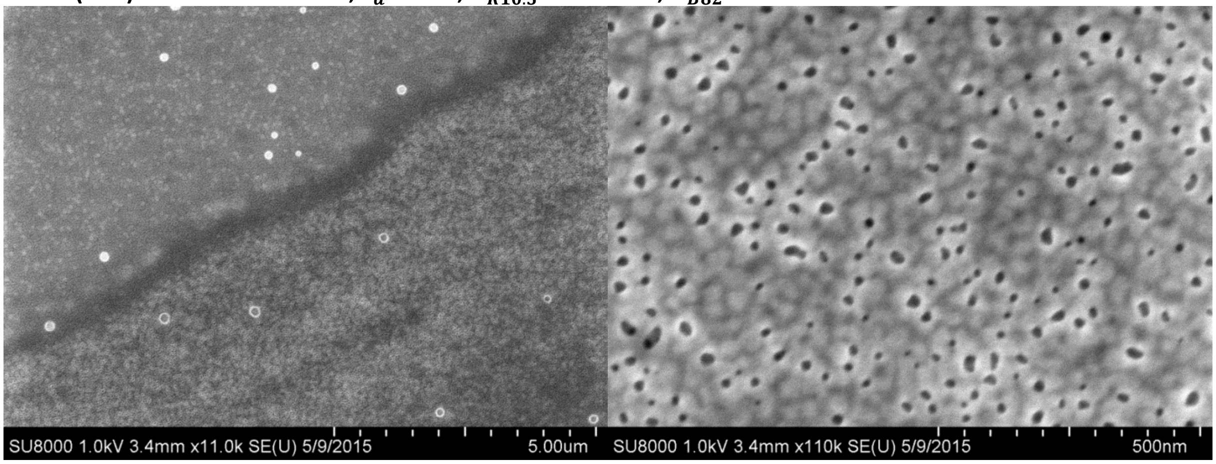
W28B (N-U) – Solvent: Toluene; $t_a = 4$ h; $h_{R10.5} = 8.6$ nm; $h_{B82} = 44.0$ nm



W28E (U*) – Solvent: Tetrahydrofuran (THF); $t_a = 4$ h; $h_{R10.5} = 8.6$ nm; $h_{B82} = 44.6$ nm

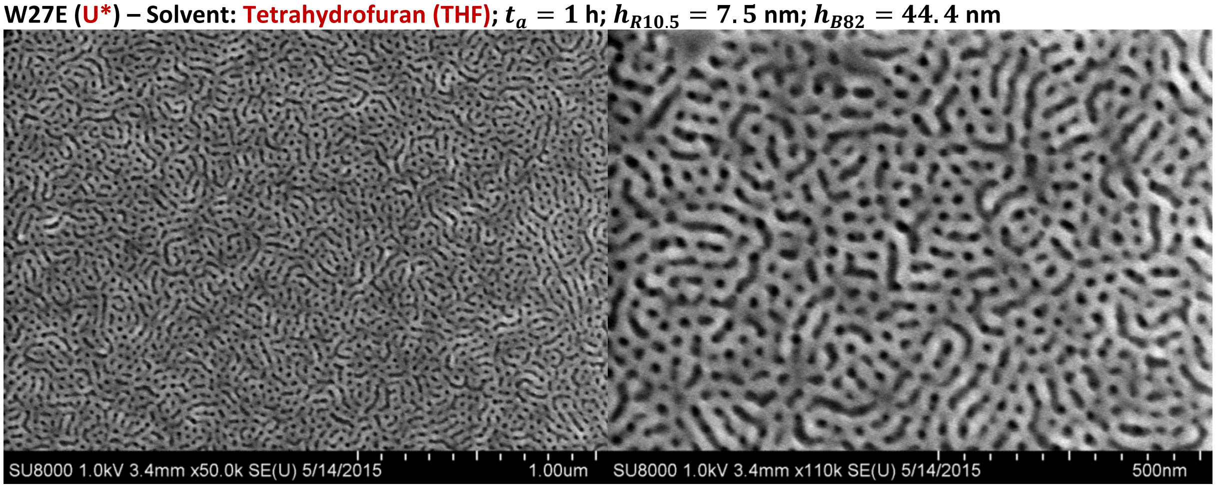


W28C (N-U) – Solvent: Acetone; $t_a = 4$ h; $h_{R10.5} = 8.6$ nm; $h_{B82} = 44.8$ nm



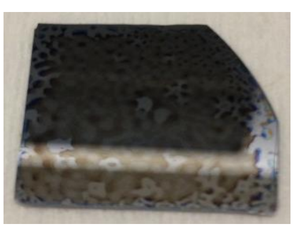
A2.22 1h SVA $T_a = RT\ (21 - 23°\mathrm{C})$ of B82 samples

W27E (U*) – Solvent: Tetrahydrofuran (THF); $t_a = 1$ h; $h_{R10.5} = 7.5$ nm; $h_{B82} = 44.4$ nm



A2.23 SVA – Post-development overview photos

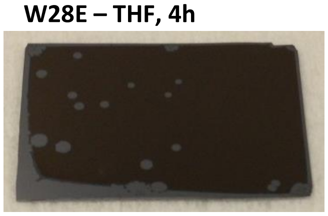
W22D – Acetone, 24h



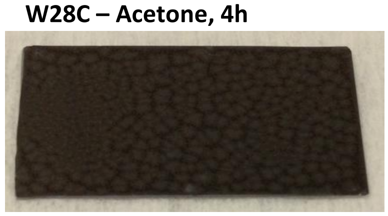
W28D – Anisole, 4h

W28B – Toluene, 4h

W28E – THF, 4h



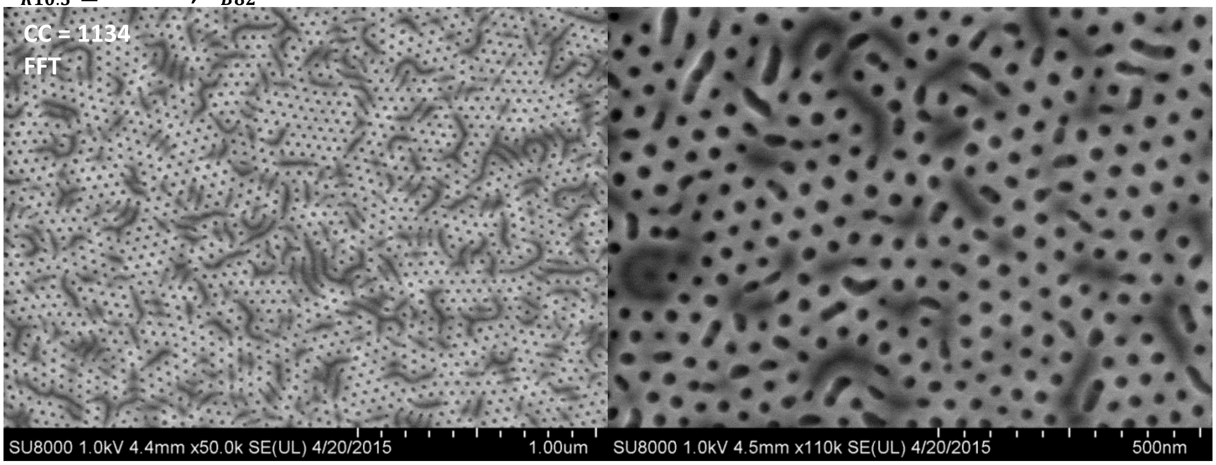
W28C – Acetone, 4h



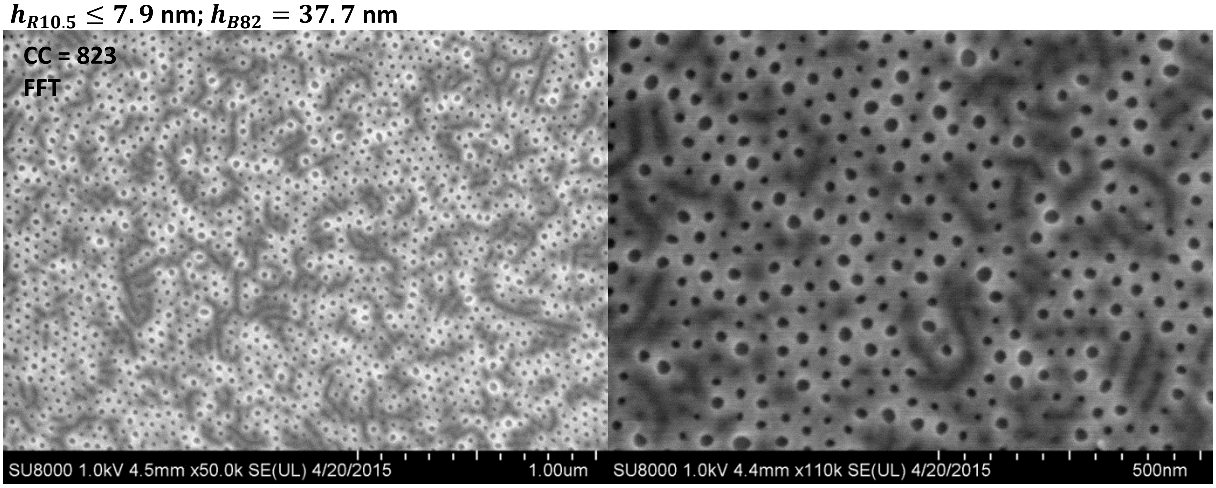
W27E – THF, 1h

A2.24 Sequential anneal in RTP and regular lab oven or VO of B82 samples

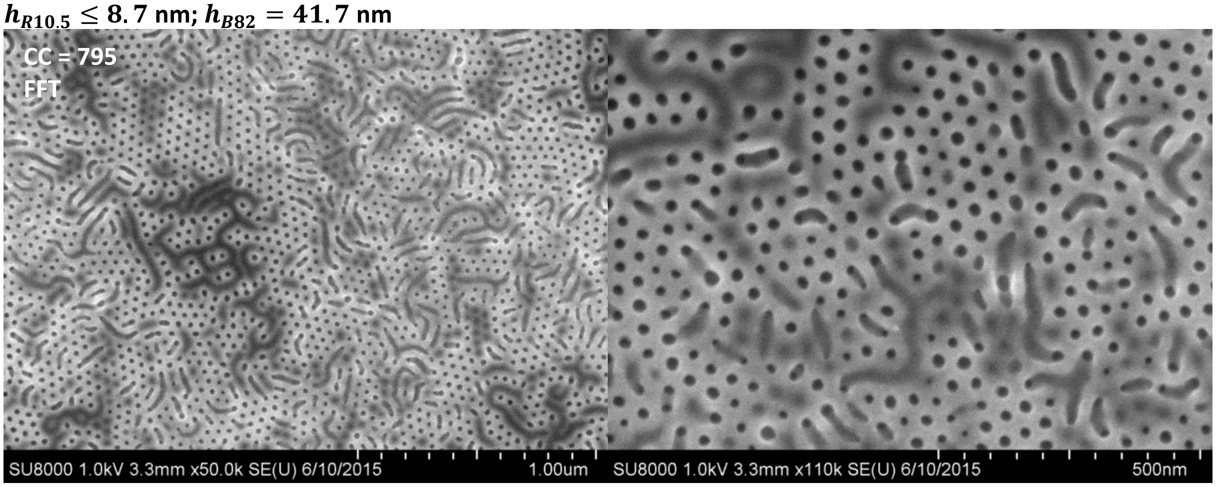
W17D (≈U) - $T_{a,RTP} = 250°\text{C}$; $t_{a,RTP} = 1\text{ h} \rightarrow T_{a,Reg.O} = 100°\text{C}$; $t_{a,Reg.O} = 18\text{ h}$;
$h_{R10.5} \leq 7.9$ nm; $h_{B82} = 38.2$ nm



W17E (≈U) - $T_{a,RTP} = 250°\text{C}$; $t_{a,RTP} = 1\text{ h} \rightarrow T_{a,Reg.O} = 150°\text{C}$; $t_{a,Reg.O} = 18\text{ h}$;
$h_{R10.5} \leq 7.9$ nm; $h_{B82} = 37.7$ nm

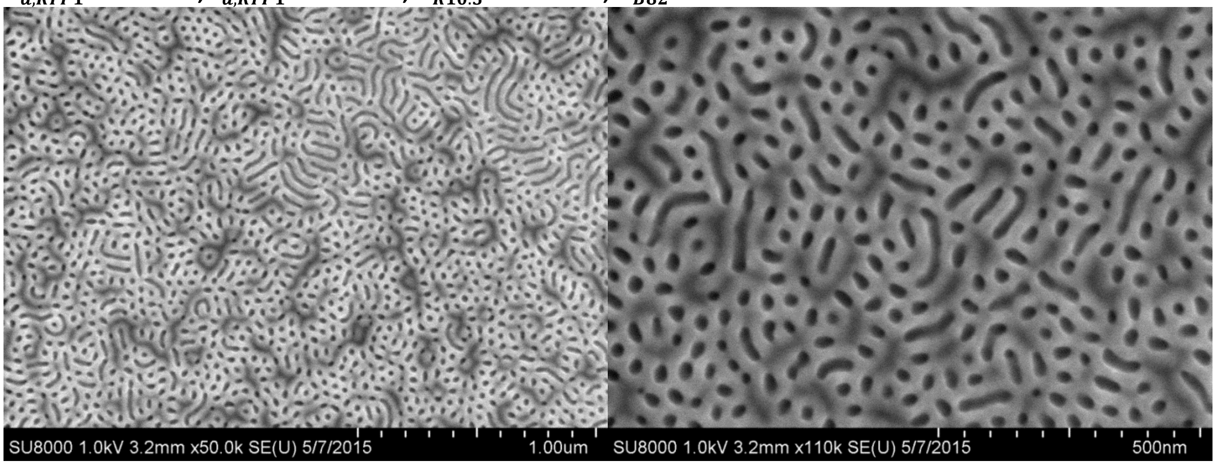


W33F (N-U) - $T_{a,RTP} = 250°\text{C}$; $t_{a,RTP} = 30\text{ min} \rightarrow T_{a,VA\_C} = 190°\text{C}$; $t_{a,VA\_C} = 2\text{ h}$;
$h_{R10.5} \leq 8.7$ nm; $h_{B82} = 41.7$ nm



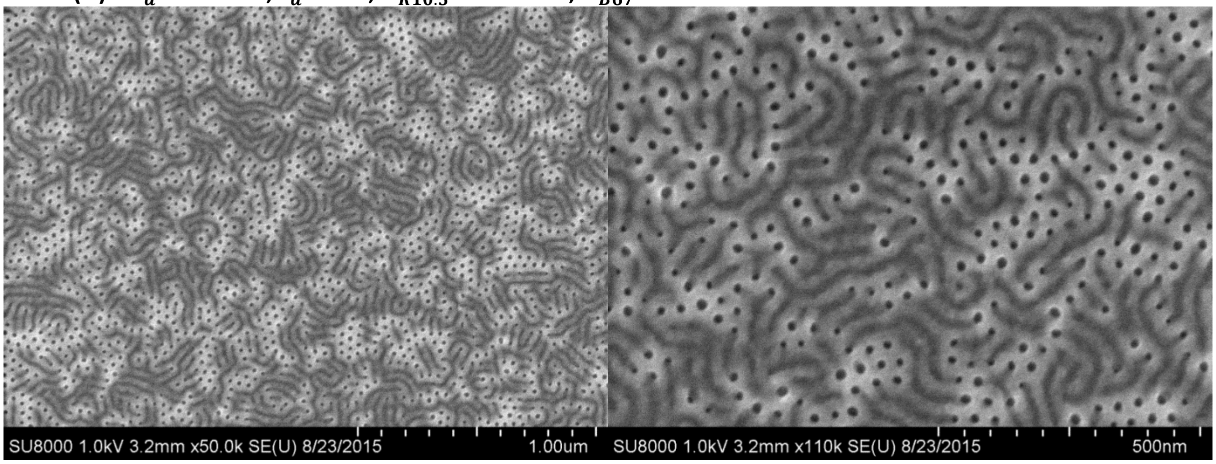
A2.25 Sequential RTP-SVA-RTP anneal of B82 sample

W27D (≈U) – $T_{a,RTP1} = 250°$ C, $t_{a,RTP1} = 15$ min→SVA: Anisole, $T_{a,SVA} = 60°$C, $t_{a,SVA} = 20$ min→ $T_{a,RTP1} = 250°$ C, $t_{a,RTP1} = 15$ min; $h_{R10.5} = 7.5$ nm; $h_{B82} = 44.0$ nm

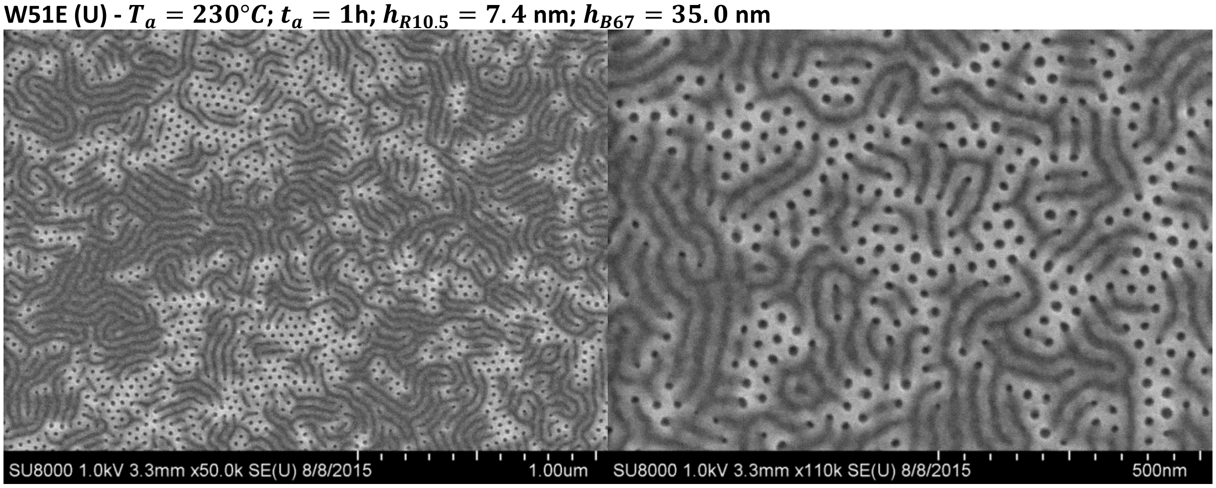


A2.26 RTP temperature (T_a) sweep of B67 ($h_{B67} \approx L_{0,B67}$) samples

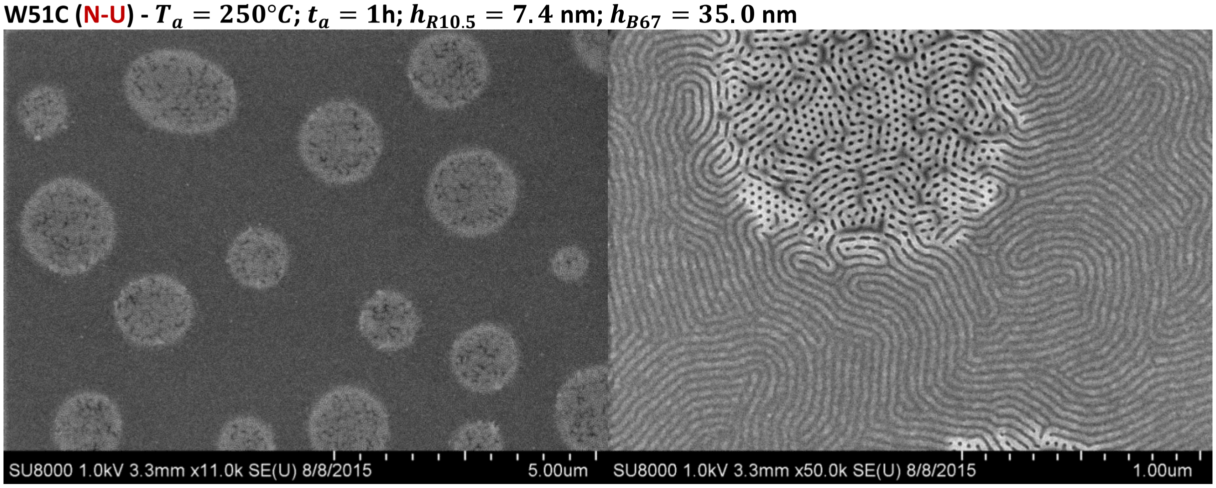
W51F (U) - $T_a = 210°C$; $t_a = 1h$; $h_{R10.5} = 7.4$ nm; $h_{B67} = 35.0$ nm



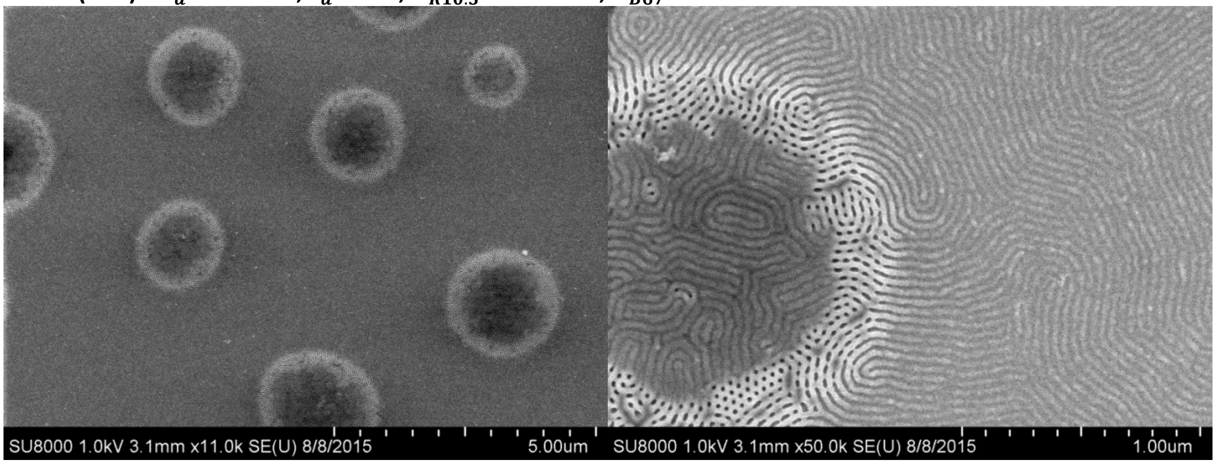
W51E (U) - $T_a = 230°C$; $t_a = 1h$; $h_{R10.5} = 7.4$ nm; $h_{B67} = 35.0$ nm



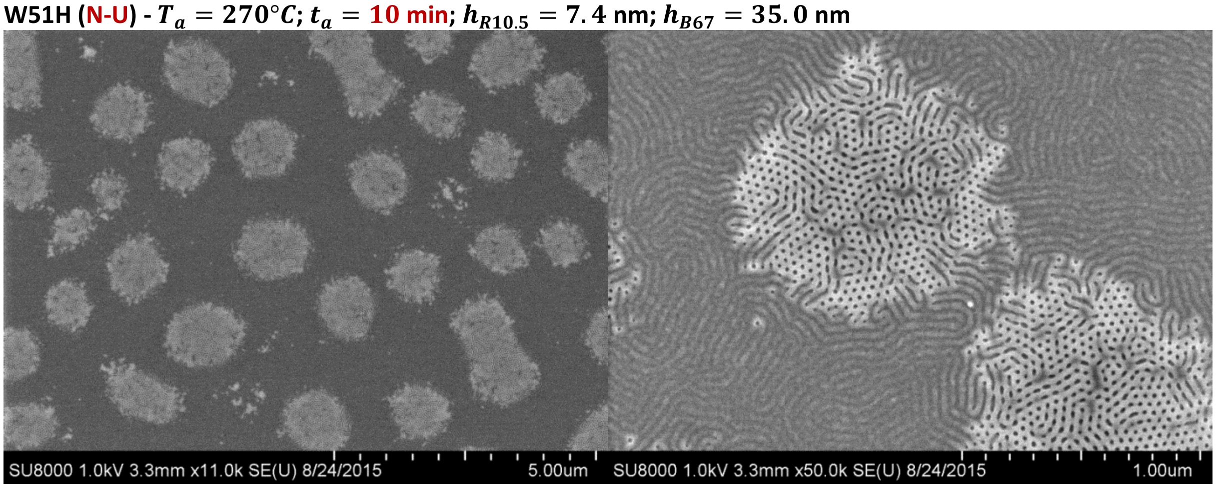
W51C (N-U) - $T_a = 250°C$; $t_a = 1h$; $h_{R10.5} = 7.4$ nm; $h_{B67} = 35.0$ nm



W51D (N-U) - $T_a = 270°C$; $t_a = 1$h; $h_{R10.5} = 7.4$ nm; $h_{B67} = 35.0$ nm

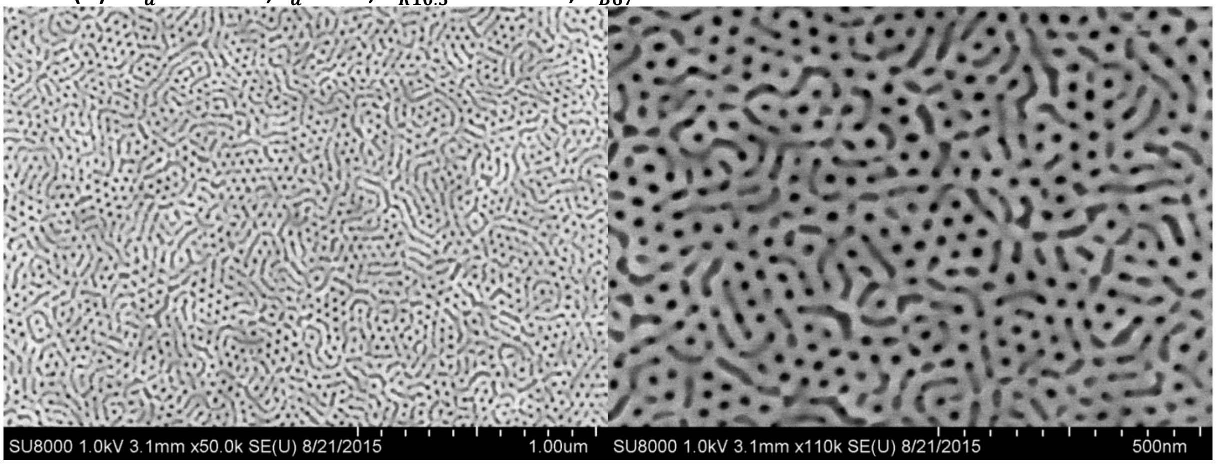


W51H (N-U) - $T_a = 270°C$; $t_a =$ 10 min; $h_{R10.5} = 7.4$ nm; $h_{B67} = 35.0$ nm

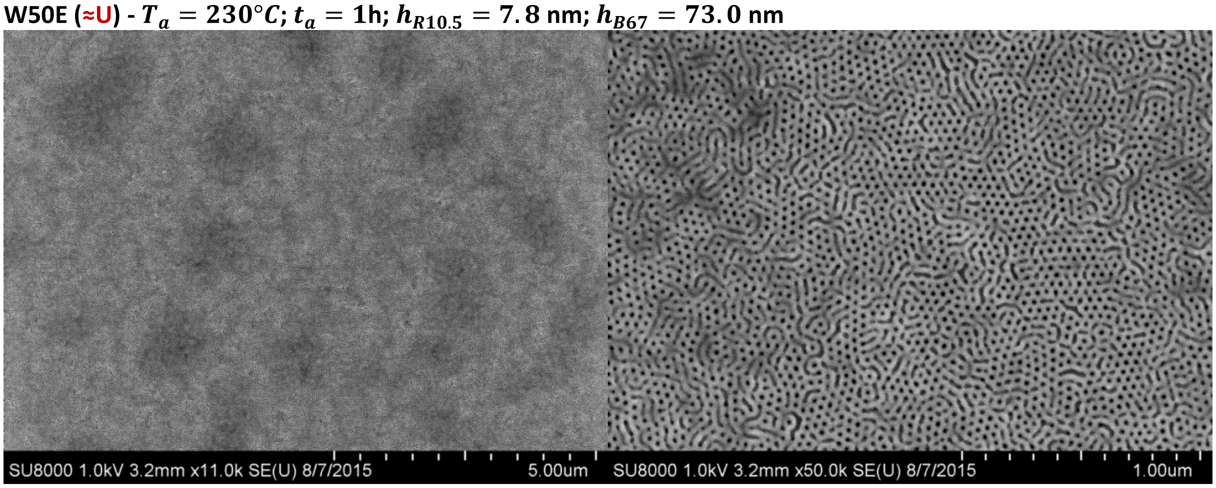


A2.27 RTP temperature (T_a) sweep of B67 ($h_{B67} \approx 2L_{0,B67}$) samples

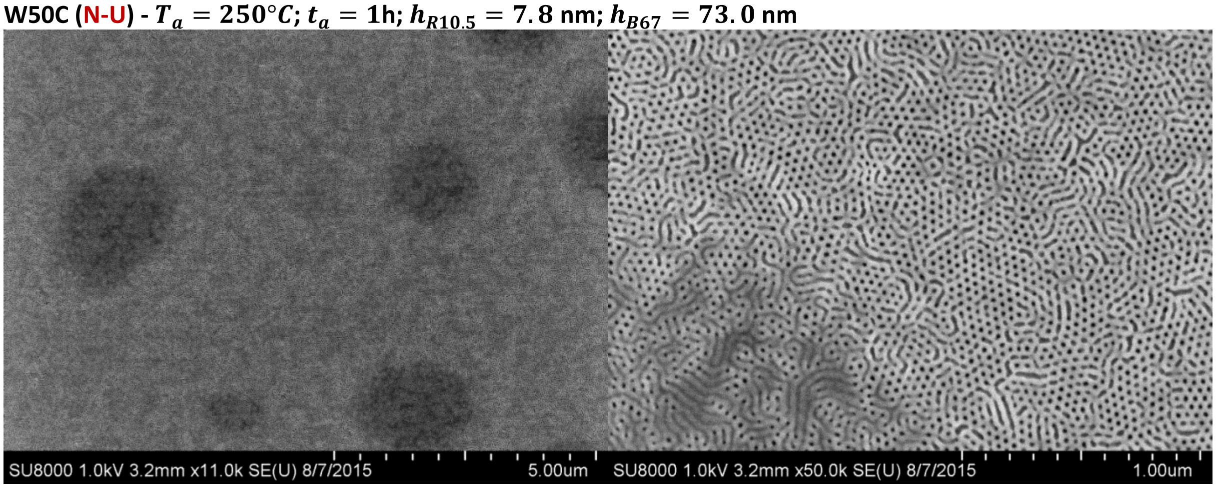
W50F (U) - $T_a = 210°C$; $t_a = 1$h; $h_{R10.5} = 7.8$ nm; $h_{B67} = 73.0$ nm



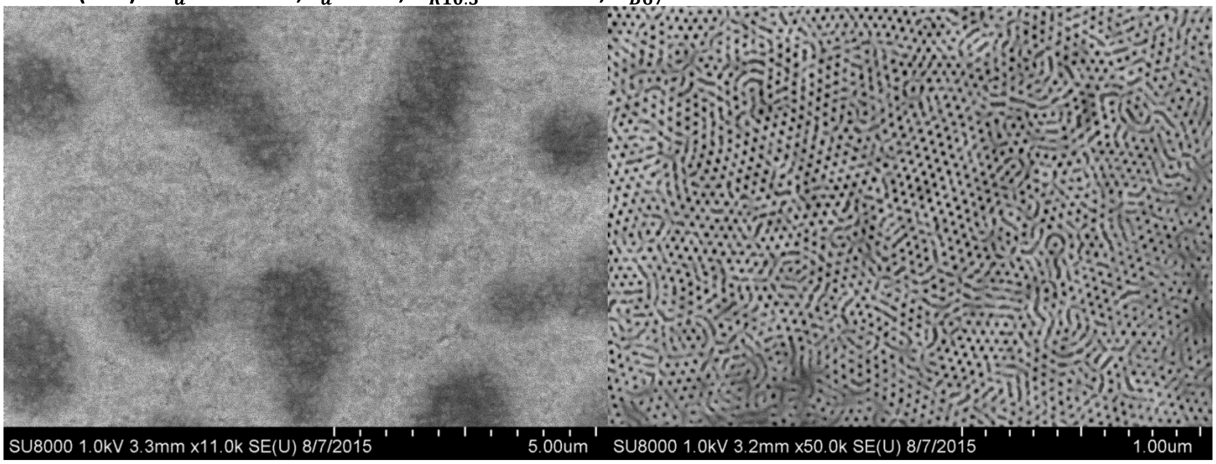
W50E (≈U) - $T_a = 230°C$; $t_a = 1$h; $h_{R10.5} = 7.8$ nm; $h_{B67} = 73.0$ nm



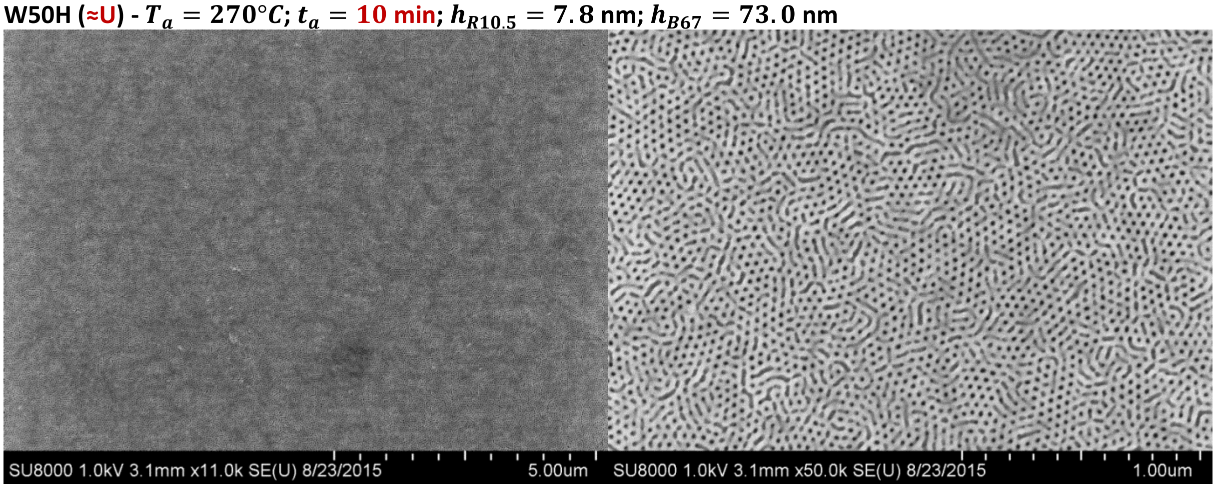
W50C (N-U) - $T_a = 250°C$; $t_a = 1$h; $h_{R10.5} = 7.8$ nm; $h_{B67} = 73.0$ nm



W50D (N-U) - $T_a = 270°C$; $t_a = 1$h; $h_{R10.5} = 7.8$ nm; $h_{B67} = 73.0$ nm

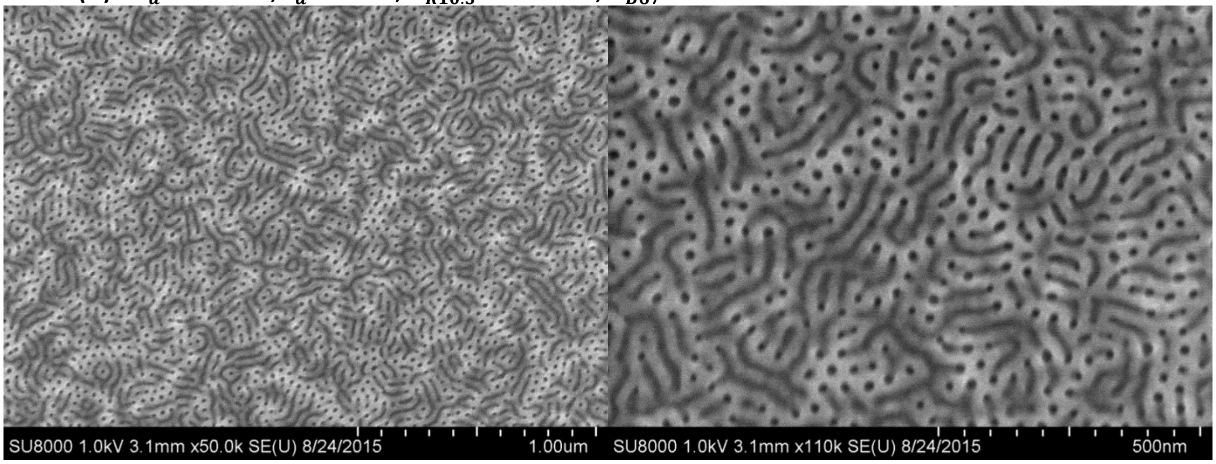


W50H (≈U) - $T_a = 270°C$; $t_a =$ 10 min; $h_{R10.5} = 7.8$ nm; $h_{B67} = 73.0$ nm

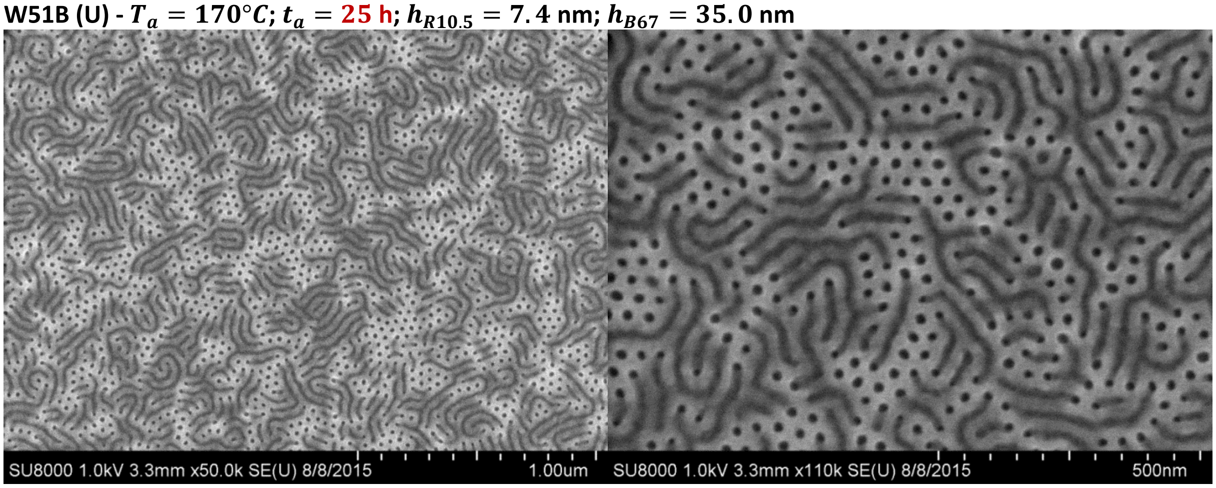


A2.28 Vacuum oven T_a-sweep at $t_a = 24$ h of B67 ($h_{B67} \approx L_{0,B67}$) samples

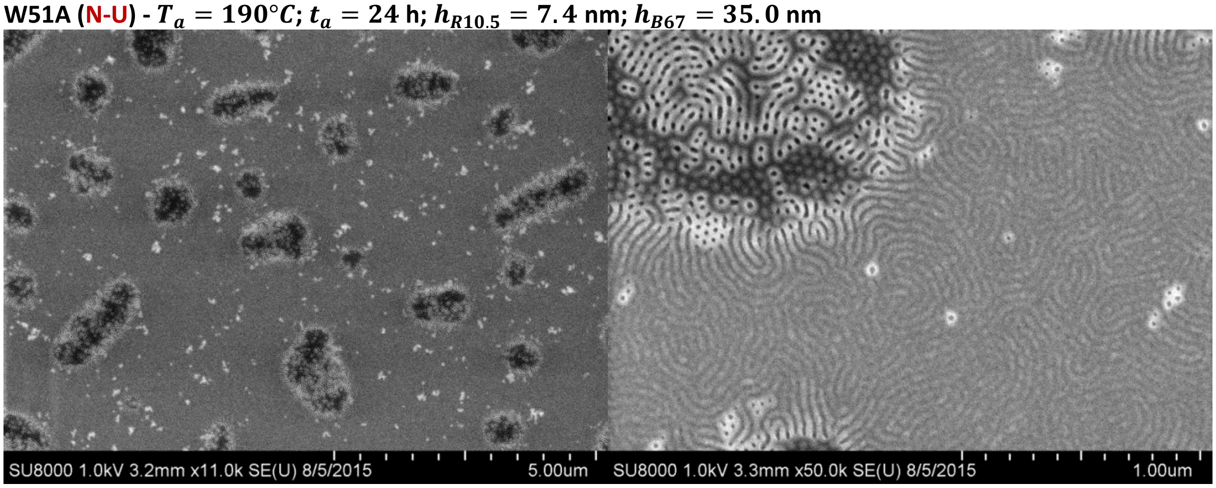
W51G (U) - $T_a = 150°C$; $t_a = 24$ h; $h_{R10.5} = 7.4$ nm; $h_{B67} = 35.0$ nm



W51B (U) - $T_a = 170°C$; $t_a = 25$ h; $h_{R10.5} = 7.4$ nm; $h_{B67} = 35.0$ nm

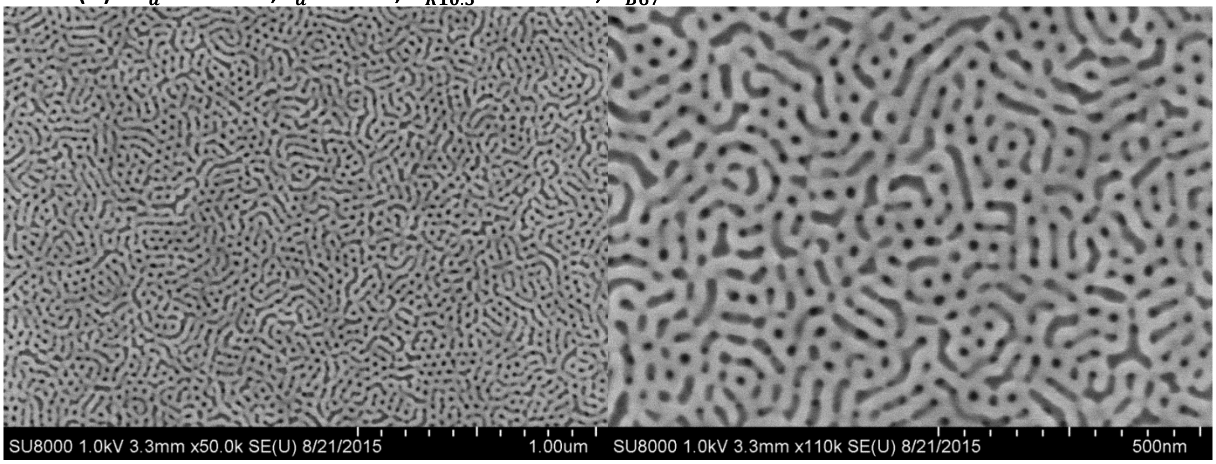


W51A (N-U) - $T_a = 190°C$; $t_a = 24$ h; $h_{R10.5} = 7.4$ nm; $h_{B67} = 35.0$ nm

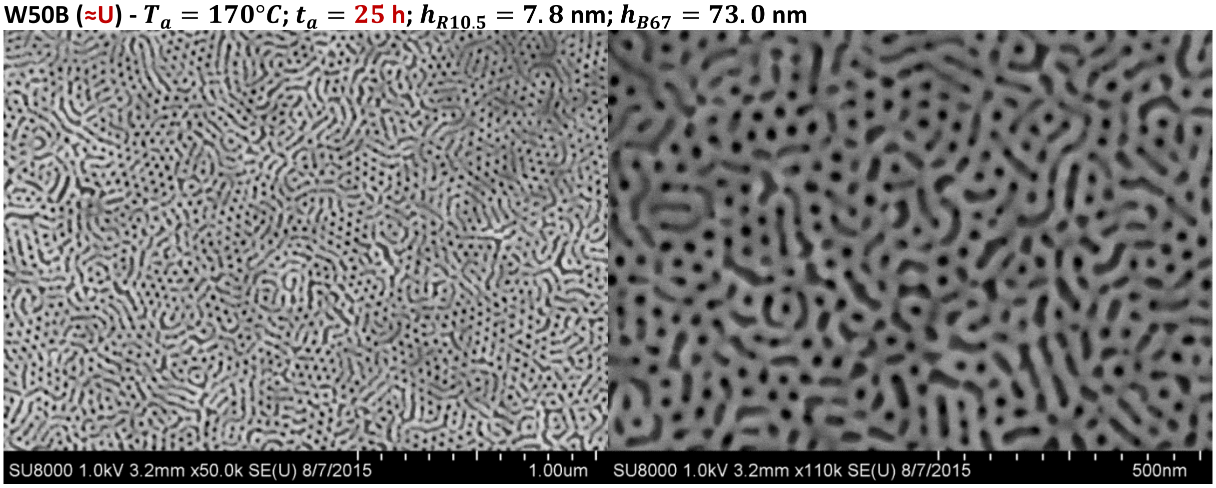


A2.29 Vacuum oven T_a-sweep at $t_a = 24$ h of B67 ($h_{B67} \approx 2L_{0,B67}$) samples

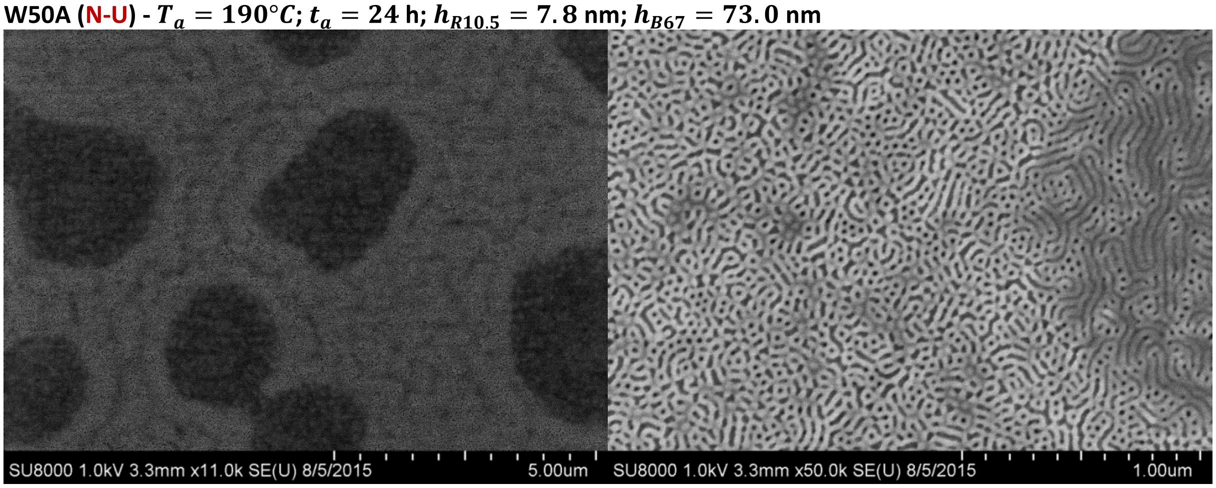
W50G (U) - $T_a = 150°C$; $t_a = 24$ h; $h_{R10.5} = 7.8$ nm; $h_{B67} = 73.0$ nm



W50B (≈U) - $T_a = 170°C$; $t_a = 25$ h; $h_{R10.5} = 7.8$ nm; $h_{B67} = 73.0$ nm

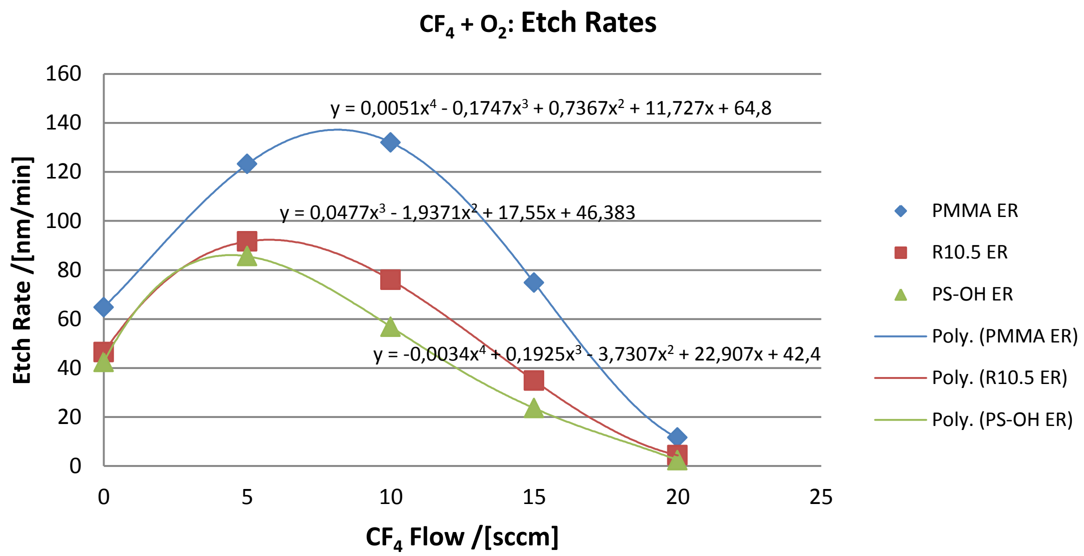


W50A (N-U) - $T_a = 190°C$; $t_a = 24$ h; $h_{R10.5} = 7.8$ nm; $h_{B67} = 73.0$ nm

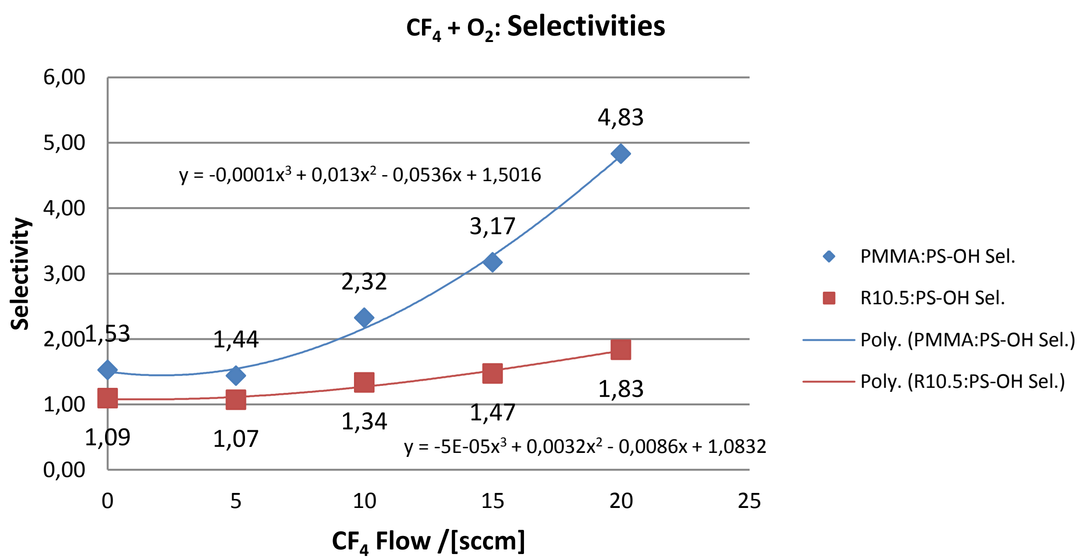


APPENDIX A3
Selective Block and Brush Removal Using RIE

A3.1 CF_4/O_2 RIE Screening – ER Plot



A3.2 CF_4/O_2 RIE Screening – Selectivity Plot



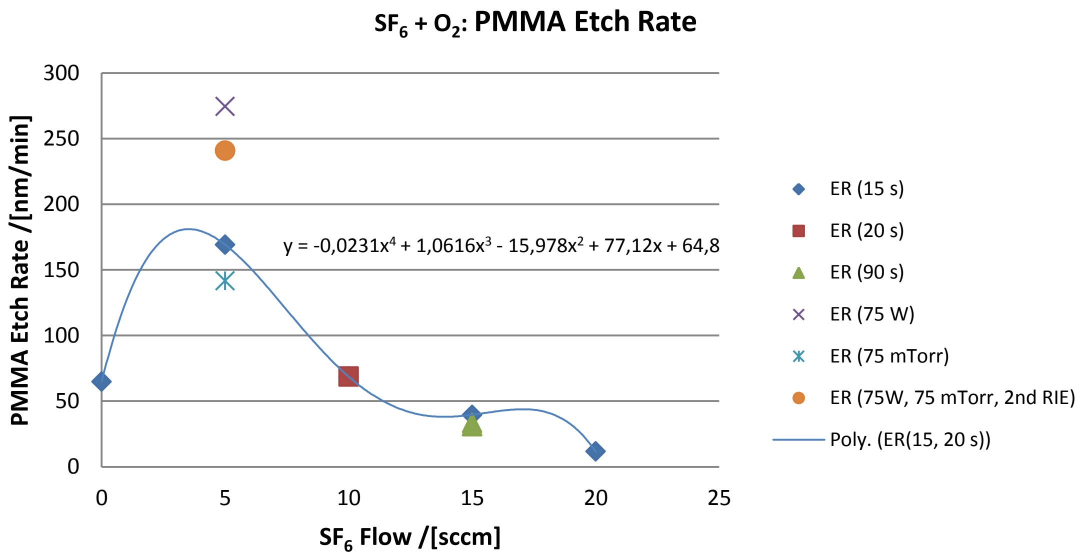
A3.3 CF_4/O_2 RIE Screening – Selectivities

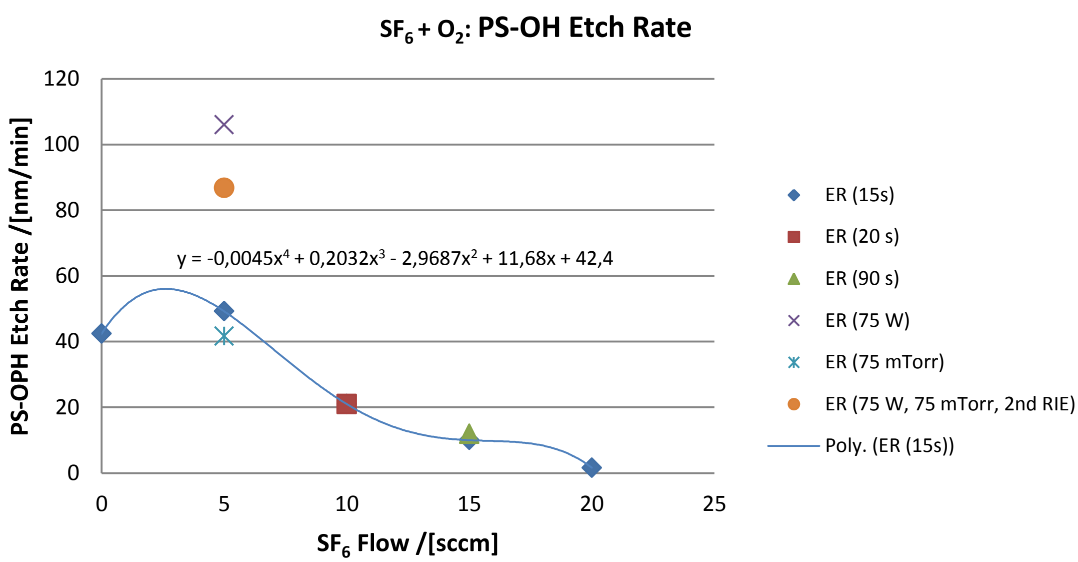
Exp. #	Samples in run	Time /[s]	Power /[W] (Nom./Frwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	CF_4 /[sccm]	Selectivity PMMA:PS-OH	Selectivity R10.5:PS-OH
1	W1A;W3A;W4A	15	30/18-19/0	100	20	0	1.53	1.09
2	W1B;W3B;W4B	15	30/18-19/3	100	15	5	1.44	1.07
3	W1C;W3C;W4C	15	30/19/3-5	100	10	10	2.32	1.34
4	W2A;W3E;W4E	15	30/18-19/2-7	100	5	15	3.17	1.47
5	W2B;W3F;W4F	15	30/18-19/0	100	0	20	4.83	1.83

A3.4 CF_4/O_2 RIE Screening – Etch Rates

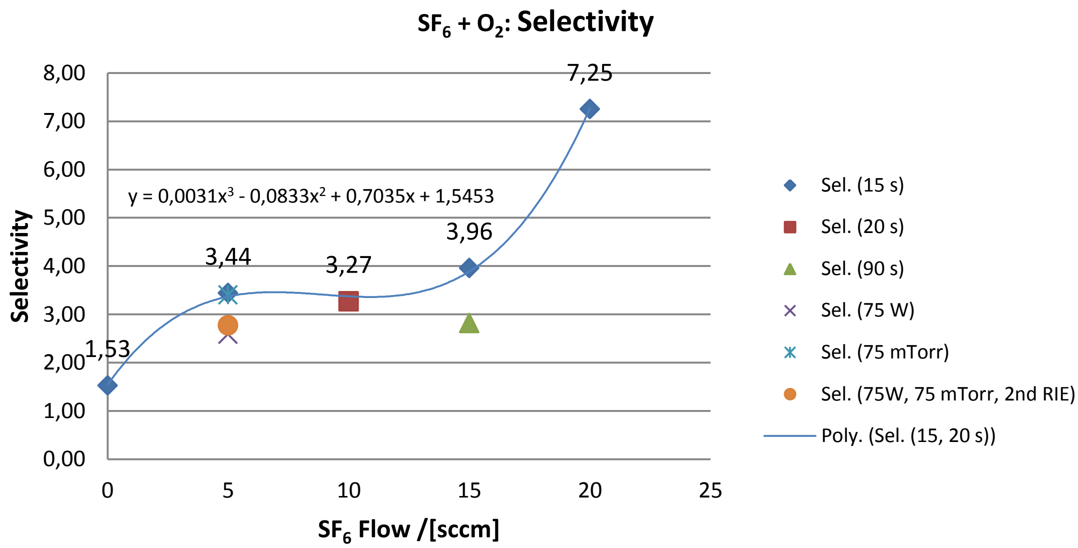
Exp. #	Sample #	Material	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	CF_4 /[sccm]	Before h_1 /[nm]	After h_2 /[nm]	Δh /[nm]	Etch rate /[nm min^{-1}]
1	W1A	PMMA	15	30/18-19/0	100	20	0	224.6	208.4	16.2	64.8
2	W1B	PMMA	15	30/18-19/3	100	15	5	224.9	194.1	30.8	123.2
3	W1C	PMMA	15	30/19/3-5	100	10	10	224.6	191.6	33	132
4	W2A	PMMA	15	30/18-19/2-7	100	5	15	224	205.3	18.7	74.8
5	W2B	PMMA	15	30/18-19/0	100	0	20	224.4	221.5	2.9	11.6
1	W3A	R10.5	15	30/18-19/0	100	20	0	38.5	26.9	11.6	46.4
2	W3B	R10.5	15	30/18-19/3	100	15	5	38.7	15.8	22.9	91.6
3	W3C	R10.5	15	30/19/3-5	100	10	10	37.7	18.7	19	76
4	W3E	R10.5	15	30/18-19/2-7	100	5	15	38	29.3	8.7	34.8
5	W3F	R10.5	15	30/18-19/0	100	0	20	37.6	36.5	1.1	4.4
1	W4A	PS-OH	15	30/18-19/0	100	20	0	37.2	26.6	10.6	42.4
2	W4B	PS-OH	15	30/18-19/3	100	15	5	36.6	15.2	21.4	85.6
3	W4C	PS-OH	15	30/19/3-5	100	10	10	36.9	22.7	14.2	56.8
4	W4E	PS-OH	15	30/18-19/2-7	100	5	15	36.7	30.8	5.9	23.6
5	W4F	PS-OH	15	30/18-19/0	100	0	20	37.1	36.5	0.6	2.4

A3.5 SF_6/O_2 RIE Screening – ER Plots





A3.6 SF_6/O_2 RIE Screening – Selectivity Plot



A3.7 SF_6/O_2 RIE Screening – Selectivities

Exp. #	Samples in run	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Selectivity PMMA:PS-OH
1	W1A;W3A;W4A	15	30/18-19/0	100	20	0	1.53
2	W2C;W7A	15	30/19/1	100	15	5	3,44
3	W2D;W7B	15	30/18-19/1	100	5	15	3,96
4	W5A;W7C	15	30/19/1	100	0	20	7,25
5	W6C;W8E	90	30/19/1	100	5	15	2,82
6	W5C **2nd RIE;W7E 2nd RIE**	90	30/19/1	100	5	15	2,71
7	W6D;W8F	20	30/18-19/1	100	10	10	3,27
8	W10C;W9E	15	**75/64-65/1-4**	100	15	5	2,59
9	W10D;W9F	15	30/19/1	**75**	15	5	3,40
10	W6D **2nd RIE**; W8F **2nd RIE**	15	**75/64/5-8**	**75**	15	5	2,77

A3.8 SF_6/O_2 RIE Screening – PMMA (50 kg/mol) Etch Rates

Exp. #	Sample #	Material	Time /[s]	Power /[W] (Nom./Frwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Before h_1 /[nm]	After h_2 /[nm]	Δh /[nm]	Etch rate /[nm min^{-1}]
2	W2C	PMMA	15	30/19/1	100	15	5	224,4	182,1	42,3	169,2
3	W2D	PMMA	15	30/18-19/1	100	5	15	225,5	215,6	9,9	39,6
4	W5A	PMMA	15	30/19/1	100	0	20	223	220,1	2,9	11,6
5	W6C	PMMA	90	30/19/1	100	5	15	221,7	171,5	50,2	33,5
6	W5C **2nd RIE**	PMMA	90	30/19/1	100	5	15	197,4	150,8	46,6	31,1
7	W6D	PMMA	20	30/18-19/1	100	10	10	220,6	197,7	22,9	68,7
8	W10C	PMMA	15	**75/64-65/1-4**	100	15	5	216,1	147,5	68,6	274,4
9	W10D	PMMA	15	30/19/1	**75**	15	5	216,1	180,7	35,4	141,6
10	W6D **2nd RIE**	PMMA	15	**75/64/5-8**	**75**	15	5	197,7	137,5	60,2	240,8

A3.9 SF_6/O_2 RIE Screening – PS-OH (1.2 kg/mol) Etch Rates

Exp. #	Sample #	Material	Time /[s]	Power /[W] (Nom./Frwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Before h_1 /[nm]	After h_2 /[nm]	Δh /[nm]	Etch rate /[nm min^{-1}]
2	W7A	PS-OH	15	30/19/1	100	15	5	36,4	24,1	12,3	49,2
3	W7B	PS-OH	15	30/18-19/1	100	5	15	36,5	34	2,5	10
4	W7C	PS-OH	15	30/19/1	100	0	20	36,4	36	0,4	1,6
5	W8E	PS-OH	90	30/19/1	100	5	15	37,2	19,4	17,8	11,9
6	W7E **2nd RIE**	PS-OH	90	30/19/1	100	5	15	27,4	10,2	17,2	11,5
7	W8F	PS-OH	20	30/18-19/1	100	10	10	36,8	29,8	7	21
8	W9E	PS-OH	15	**75/64-65/1-4**	100	15	5	36,3	9,8	26,5	106
9	W9F	PS-OH	15	30/19/1	**75**	15	5	36,3	25,9	10,4	41,6
10	W8F **2nd RIE**	PS-OH	15	**75/64/5-8**	**75**	15	5	29,8	8,1	21,7	86,8

A3.10 SF_6/O_2 RIE DOE – Selectivities

Exp #	Run Order	Samples in run	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Selectivity PMMA:PS-OH	Selectivity R10.5:PS-OH	
1	1	W12A;W18A;W14A	15	30/19/0	75	18	2	1.602	1.122	
11	2	W12B;W18B;W14B	20	30/19/1	100	15	5	3.547	1.460	
7	3	W12C;W18C;W14C	25	30/18-19/1	75	12	8	3.204	1.408	
2	4	W12D;W18D;W14D	15	30/19/0	125	18	2	1.639	1.120	
10	5	W12E;W18E;W14E	20	30/19/1	100	15	5	3.611	1.465	
2 (2^{nd})	6	W12F;W18F;W14F	15	30/19/1	125	18	2	2.146	1.269	
8	7	W13A;W31A;W32A	25	30/18-19/2	125	12	8	3.289	1.430	
3	8	W13B;W31B;W32B	15	30/19/1	75	12	8	3.172	1.422	
9	9	W13C;W31C;W32C	20	30/19/1	100	15	5	3.486	1.450	
6	10	W13D;W31D;W32D	25	30/18-19/1	125	18	2	2.253	1.288	Excl. from DOE
5	11	W13E;W31E;W32E	25	30/18-19/0-1	75	18	2	2.449	1.346	Unreliable but Incl.
4	12	W13F;W31F;W32F	15	30/19/1	125	12	8	3.413	1.453	
C17	13	W38A;W37A;W36A	20	30/19/1	100	15	5	3.541	1.486	
C16	14	W38B;W37B;W36B	25	30/18-19/1	100	15	5	3.649	1.526	
C15	15	W38C;W37C;W36C	15	30/18-19/1	100	15	5	3.418	1.445	
C13	16	W38D;W37D;W36D	20	30/18-19/0	100	18	2	2.297	1.336	
C14	17	W38E;W37E;W36E	20	30/19/1	100	12	8	3.292	1.438	
N18	18	W38F;W37F;W36F	12	30/19/1	75	13	7	3.269	1.358	
N19	19	W44A;W43A;W42A	9	30/19/1	75	13	7	3.551	1.449	
DUV1	20	W44B;W43B;W42B	15	30/19/1	100	15	5	3.213	1.451	
DUV2	21	W44C;W43C;W42C	20	30/19/1	100	15	5	3.237	1.450	
DUV3	22	W44D;W43D;W42D	20	30/19/1	100	12	8	3.034	1.432	
DUV4	23	W44E;W43E;W42E	9	30/18-19/1	75	13	7	3.096	1.519	
DUV5	24	W44F;W43F;W42F	6	30/19/1	75	14	6	3,367	1,462	

A3.11 SF_6/O_2 RIE DOE – Non-DUV Exposed PMMA (50 kg/mol) Etch Data

Exp #	Run Order	Sample #	Material	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Before h_1 /[nm]	After h_2 /[nm]	Δh /[nm]	Etch rate /[nm·min^{-1}]
1	1	W12A	PMMA	15	30/19/0	75	18	2	222.2	202.5	19.7	78.8
11	2	W12B	PMMA	20	30/19/1	100	15	5	223.5	170.3	53.2	159.6
7	3	W12C	PMMA	25	30/18-19/1	75	12	8	223.1	190.1	33.0	79.2
2	4	W12D	PMMA	15	30/19/0	125	18	2	223.0	209.4	13.6	54.4
10	5	W12E	PMMA	20	30/19/1	100	15	5	222.7	170.7	52.0	156.0
2 (2nd)	6	W12F	PMMA	15	30/19/1	125	18	2	222.9	186.2	36.7	146.8
8	7	W13A	PMMA	25	30/18-19/2	125	12	8	220.6	183.1	37.5	90.0
3	8	W13B	PMMA	15	30/19/1	75	12	8	220.0	199.7	20.3	81.2
9	9	W13C	PMMA	20	30/19/1	100	15	5	219.9	171.1	48.8	146.4
6	10	W13D	PMMA	25	30/18-19/1	125	18	2	220.0	150.6	69.4	166.6
5	11	W13E	PMMA	25	30/18-19/0-1	75	18	2	220.4	148.9	71.5	171.6
4	12	W13F	PMMA	15	30/19/1	125	12	8	220.1	194.5	25.6	102.4
C17	13	W38A	PMMA	20	30/19/1	100	15	5	229.2	176.8	52.4	157.2
C16	14	W38B	PMMA	25	30/18-19/1	100	15	5	230.1	173.9	56.2	134.9
C15	15	W38C	PMMA	15	30/18-19/1	100	15	5	229.5	191.9	37.6	150.4
C13	16	W38D	PMMA	20	30/18-19/0	100	18	2	230.9	177.6	53.3	159.9
C14	17	W38E	PMMA	20	30/19/1	100	12	8	230.1	200.8	29.3	87.9
N18	18	W38F	PMMA	12	30/19/1	75	13	7	230	208.1	21.9	109.5
N19	19	W44A	PMMA	9	30/19/1	75	13	7	222.8	205.4	17.4	116.0

A3.12 SF_6/O_2 RIE – DUV Exposed PMMA (50 kg/mol) Etch Data

Exp #	Run Order	Sample #	Material	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Before DUV h_1 /[nm]	After DUV h_2 /[nm]	Δh_{DUV} /[nm]	Δh_{DUV} /[%]	After RIE h_3 /[nm]	Δh_{RIE} /[nm]	Etch rate /[nm min^{-1}]
DUV1	20	W44B	PMMA	15	30/19/1	100	15	5	222.6	206.7	**NA**	**NA**	167.5*	39.2	156.8
DUV2	21	W44C	PMMA	20	30/19/1	100	15	5	222.0	206.1	**NA**	**NA**	163.7*	42.4	127.2
DUV3	22	W44D	PMMA	20	30/19/1	100	12	8	222.5	206.6	**NA**	**NA**	179.9*	26.7	80.1
DUV4	23	W44E	PMMA	9	30/18-19/1	75	13	7	222.3	206.4	**NA**	**NA**	190.3*	16.1	107.3
DUV5	24	W44F	PMMA	6	30/19/1	75	14	6	222.6	206.7	15.9	7.14	190.1	16.6	166.2

A3.13 SF_6/O_2 RIE DOE – Non-DUV Exposed R10.5 Etch Data

Exp #	Run Order	Sample #	Material	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Before h_1 /[nm]	After h_2 /[nm]	Δh /[nm]	Etch rate /[nm·min^{-1}]	
1	1	W18A	P(S-r-MMA)	15	30/19/0	75	18	2	32.5	18.7	13.8	55.2	
11	2	W18B	P(S-r-MMA)	20	30/19/1	100	15	5	32.3	10.4	21.9	65.7	
7	3	W18C	P(S-r-MMA)	25	30/18-19/1	75	12	8	31.8	17.3	14.5	34.8	
2	4	W18D	P(S-r-MMA)	15	30/19/0	125	18	2	32.9	23.6	9.3	37.2	
10	5	W18E	P(S-r-MMA)	20	30/19/1	100	15	5	32.3	11.2	21.1	63.3	
2 (2^{nd})	6	W18F	P(S-r-MMA)	15	30/19/1	125	18	2	32.7	11.0	21.7	86.8	
8	7	W31A	P(S-r-MMA)	25	30/18-19/2	125	12	8	39.7	23.4	16.3	39.1	
3	8	W31B	P(S-r-MMA)	15	30/19/1	75	12	8	39.6	30.5	9.1	36.4	
9	9	W31C	P(S-r-MMA)	20	30/19/1	100	15	5	40.3	20.0	20.3	60.9	
6	10	W31D	P(S-r-MMA)	25	30/18-19/1	125	18	2	39.8	0.1	39.7	95.2	Excl. from DOE
E5	11	W31E	P(S-r-MMA)	25	30/18-19/0-1	75	18	2	40.7	1.4	39.3	94.3	Incl. in DOE
4	12	W31F	P(S-r-MMA)	15	30/19/1	125	12	8	40.0	29.1	10.9	43.6	
C17	13	W37A	P(S-r-MMA)	20	30/19/1	100	15	5	42.9	20.9	22.0	66.0	
C16	14	W37B	P(S-r-MMA)	25	30/18-19/1	100	15	5	42.3	18.8	23.5	56.4	
C15	15	W37C	P(S-r-MMA)	15	30/18-19/1	100	15	5	42.7	26.8	15.9	63.6	
C13	16	W37D	P(S-r-MMA)	20	30/18-19/0	100	18	2	42.8	11.8	31.0	93.0	
C14	17	W37E	P(S-r-MMA)	20	30/19/1	100	12	8	42.3	29.5	12.8	38.4	
N18	18	W37F	P(S-r-MMA)	12	30/19/1	75	13	7	42.7	33.6	9.1	45.5	
N19	19	W43A	P(S-r-MMA)	9	30/19/1	75	13	7	39.3	32.2	7.1	47.3	

A3.14 SF_6/O_2 RIE – DUV Exposed R10.5 Etch Data

Exp #	Run Order	Sample #	Material	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Before DUV h_1 /[nm]	After DUV h_2 /[nm]	Δh_{DUV} /[nm]	Δh_{DUV} /[%]	After RIE h_3 /[nm]	Δh_{RIE} /[nm]	Etch rate /[nm min^{-1}]
DUV1	20	W43B	R10.5	15	30/19/1	100	15	5	39.6	37.4	**NA**	**NA**	19.7	17.7	70.8
DUV2	21	W43C	R10.5	20	30/19/1	100	15	5	38.9	36.7	**NA**	**NA**	17.7	19.0	57.0
DUV3	22	W43D	R10.5	20	30/19/1	100	12	8	39.1	36.9	**NA**	**NA**	24.3	12.6	37.8
DUV4	23	W43E	R10.5	9	30/18-19/1	75	13	7	39.5	37.3	**NA**	**NA**	29.4	7.9	52.7
DUV5	24	W43F	R10.5	6	30/19/1	75	14	6	39.5	37.5	2	5.06	30.3	7.2	72.2

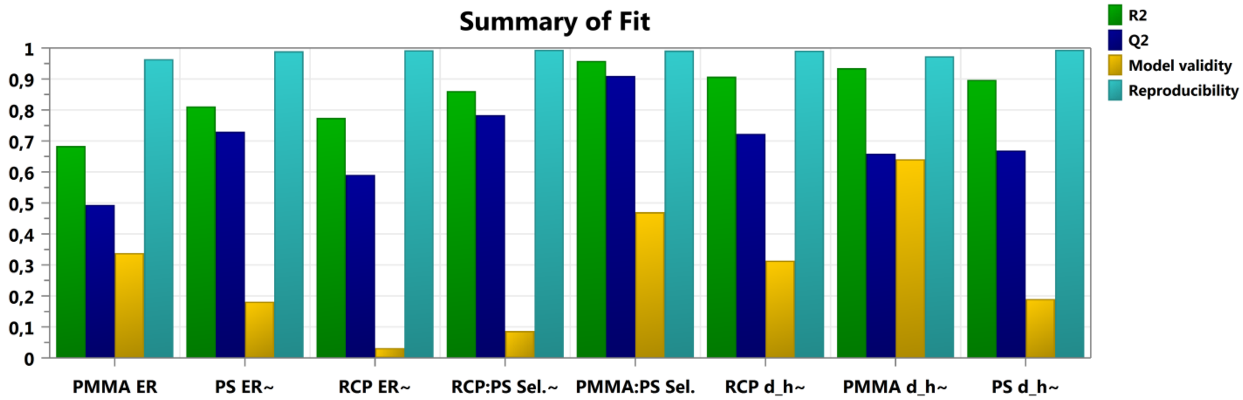
A3.15 SF_6/O_2 RIE DOE – Non-DUV Exposed PS-OH (1.2 kg/mol) Etch Data

Exp #	Run Order	Sample #	Material	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O^2 /[sccm]	SF^6 /[sccm]	Before h^1 /[nm]	After h^2 /[nm]	Δh /[nm]	Etch rate /[nm·min^{-1}]
1	1	W14A	PS-OH	15	30/19/0	75	18	2	61.7	49.4	12.3	49.2
11	2	W14B	PS-OH	20	30/19/1	100	15	5	61.4	46.4	15.0	45.0
7	3	W14C	PS-OH	25	30/18-19/1	75	12	8	61.4	51.1	10.3	24.7
2	4	W14D	PS-OH	15	30/19/0	125	18	2	61.6	53.3	8.3	33.2
10	5	W14E	PS-OH	20	30/19/1	100	15	5	61.2	46.8	14.4	43.2
2 (2^{nd})	6	W14F	PS-OH	15	30/19/1	125	18	2	61.4	44.3	17.1	68.4
8	7	W32A	PS-OH	25	30/18-19/2	125	12	8	63.6	52.2	11.4	27.4
3	8	W32B	PS-OH	15	30/19/1	75	12	8	63.7	57.3	6.4	25.6
9	9	W32C	PS-OH	20	30/19/1	100	15	5	63.5	49.5	14.0	42.0
6	10	W32D	PS-OH	25	30/18-19/1	125	18	2	63.5	32.7	30.8	73.9
5	11	W32E	PS-OH	25	30/18-19/0-1	75	18	2	63.5	34.3	29.2	70.1
4	12	W32F	PS-OH	15	30/19/1	125	12	8	63.4	55.9	7.5	30.0
C17	13	W36A	PS-OH	20	30/19/1	100	15	5	65.5	50.7	14.8	44.4
C16	14	W36B	PS-OH	25	30/18-19/1	100	15	5	65.5	50.1	15.4	37.0
C15	15	W36C	PS-OH	15	30/18-19/1	100	15	5	68.0	57.0	11.0	44.0
C13	16	W36D	PS-OH	20	30/18-19/0	100	18	2	66.1	42.9	23.2	69.6
C14	17	W36E	PS-OH	20	30/19/1	100	12	8	65.9	57.0	8.9	26.7
N18	18	W36F	PS-OH	12	30/19/1	75	13	7	67.6	60.9	6.7	33.5
N19	19	W42A	PS-OH	9	30/19/1	75	13	7	68.9	64.0	4.9	32.7

A3.16 SF_6/O_2 RIE – DUV Exposed PS-OH (1.2 kg/mol) Etch Data

Exp #	Run Order	Sample #	Material	Time /[s]	Power /[W] (Nom./Fwd./Ref.)	Pressure /[mTorr]	O_2 /[sccm]	SF_6 /[sccm]	Before DUV h_1 /[nm]	After DUV h_2 /[nm]	Δh_{DUV} /[nm]	Δh_{DUV} /[%]	After RIE h_3 /[nm]	Δh_{RIE} /[nm]	Etch rate /[nm min^{-1}]
DUV1	20	W42B	PS-OH	15	30/19/1	100	15	5	68.9	68.5	**NA**	**NA**	56.3	12.2	48.8
DUV2	21	W42C	PS-OH	20	30/19/1	100	15	5	69.4	69	**NA**	**NA**	55.9	13.1	39.3
DUV3	22	W42D	PS-OH	20	30/19/1	100	12	8	69.2	68.8	**NA**	**NA**	60.0	8.8	26.4
DUV4	23	W42E	PS-OH	9	30/18-19/1	75	13	7	68.9	68.5	**NA**	**NA**	63.3	5.2	34.7
DUV5	**24**	**W42F**	**PS-OH**	**6**	**30/19/1**	**75**	**14**	**6**	**69.4**	**69**	**0.4**	**0.58**	**64.1**	**4.9**	**49.4**

A3.17 SF_6 /O_2 RIE DOE – Summary of Fit



A3.18 SF_6 /O_2 RIE DOE – Coefficients (Centered and Scaled)

PMMA Etch Rate	Coeff. SC	Std. Err.	P	Conf. int(±)
Constant	143,864	9,11097	7,32E-10	19,6831
SF6 Flow	-18,3121	5,84758	0,00794878	12,6329
Time	11,9798	5,90553	0,063499	12,7581
SF6*SF6	-24,3826	7,7104	0,00749208	16,6573
SF6*t	-15,7852	6,15017	0,023443	13,2867
N = 18	Q2 =	0,494	Cond. no. =	3,163
DF = 13	R2 =	0,684	RSD =	23,18
Comp. = 2	R2 adj. =	0,587		
			Conf. lev. =	0,95

PS Etch Rate	Coeff. SC	Std. Err.	P	Conf. int(±)
Constant	1,59481	0,0167322	4,28E-21	0,0358874
SF6 Flow	-0,127739	0,0172191	3,26E-06	0,0369317
Time	0,0227649	0,0180227	0,227176	0,0386551
SF6*t	-0,042549	0,0184324	0,0367594	0,0395339
N = 18	Q2 =	0,73	Cond. no. =	1,358
DF = 14	R2 =	0,812	RSD =	0,07099
Comp. = 2	R2 adj. =	0,771		
			Conf. lev. =	0,95

RCP Etch Rate	Coeff. SC	Std. Err.	P	Conf. int(±)
Constant	-1,62479	0,0708003	6,65E-12	0,152955
SF6 Flow	-0,218497	0,0454408	0,00034167	0,098169
Time	0,122809	0,0458912	0,0190422	0,0991419
SF6*SF6	0,0765118	0,0599166	0,223949	0,129442
SF6*t	-0,174281	0,0477923	0,00295623	0,103249
N = 18	Q2 =	0,591	Cond. no. =	3,163
DF = 13	R2 =	0,774	RSD =	0,1801
Comp. = 2	R2 adj. =	0,705		
			Conf. lev. =	0,95

RCP:PS Selectivity	Coeff. SC	Std. Err.	P	Conf. int(±)
Constant	4,31913	0,0730575	3,43E-17	0,157831
SF6 Flow	0,218386	0,0468895	0,00044842	0,101299
Time	0,132197	0,0473542	0,0152717	0,102303
SF6*SF6	-0,319256	0,0618268	0,00018225	0,133569
SF6*t	-0,075879	0,0493159	0,147871	0,106541
N = 18	Q2 =	0,783	Cond. no. =	3,163
DF = 13	R2 =	0,861	RSD =	0,1858
Comp. = 2	R2 adj. =	0,818		
			Conf. lev. =	0,95

PMMA:PS Selectivity	Coeff. SC	Std. Err.	P	Conf. int(±)
Constant	3,53445	0,0634503	7,41E-17	0,137076
SF6 Flow	0,398883	0,0407234	2,29E-07	0,0879777
Time	0,110355	0,0411271	0,0187831	0,0888497
SF6*SF6	-0,544357	0,0536964	1,53E-07	0,116004
SF6*t	-0,095188	0,0428308	0,044619	0,0925304

N = 18	Q2 =	0,91	Cond. no. =	3,163
DF = 13	R2 =	0,959	RSD =	0,1614
Comp. = 2	R2 adj. =	0,946		
			Conf. lev. =	0,95

RCP Δh	Coeff. SC	Std. Err.	P	Conf. int(±)
Constant	-1,91284	0,0037318	2,55E-31	0,0080039
SF6 Flow	-0,028243	0,0038404	3,60E-06	0,0082368
Time	0,0342567	0,0040196	6,51E-07	0,0086212
SF6*t	-0,023428	0,004111	5,50E-05	0,0088172

N = 18	Q2 =	0,723	Cond. no. =	1,358
DF = 14	R2 =	0,908	RSD =	0,01583
Comp. = 2	R2 adj. =	0,888		
			Conf. lev. =	0,95

PMMA Δh	Coeff. SC	Std. Err.	P	Conf. int(±)
Constant	-1,73273	0,0141125	2,61E-21	0,0304883
SF6 Flow	-0,056811	0,0090577	2,87E-05	0,0195679
Time	0,0992172	0,0091474	6,95E-08	0,0197618
SF6*SF6	-0,049732	0,0119431	0,00111164	0,0258015
SF6*t	-0,057509	0,0095264	4,19E-05	0,0205805

N = 18	Q2 =	0,659	Cond. no. =	3,163
DF = 13	R2 =	0,935	RSD =	0,0359
Comp. = 2	R2 adj. =	0,915		
			Conf. lev. =	0,95

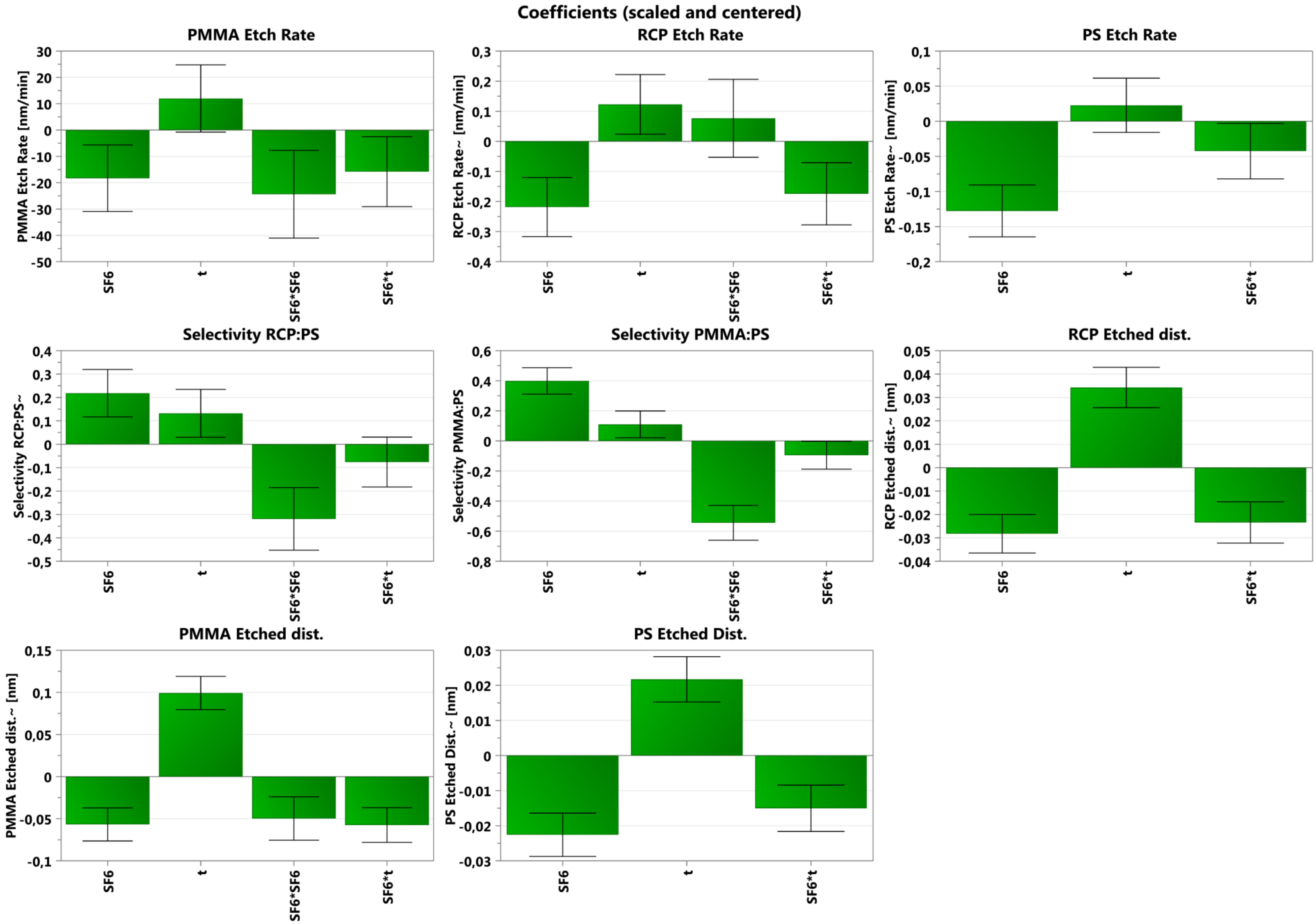
PS Δh	Coeff. SC	Std. Err.	P	Conf. int(±)
Constant	-1,9389	0,0027904	3,61E-33	0,0059849
SF6 Flow	-0,022582	0,0028716	1,67E-06	0,0061591
Time	0,0217116	0,0030056	4,40E-06	0,0064465
SF6*t	-0,015026	0,003074	0,00023951	0,006593

N = 18	Q2 =	0,669	Cond. no. =	1,358
DF = 14	R2 =	0,897	RSD =	0,01184
Comp. = 2	R2 adj. =	0,875		
			Conf. lev. =	0,95

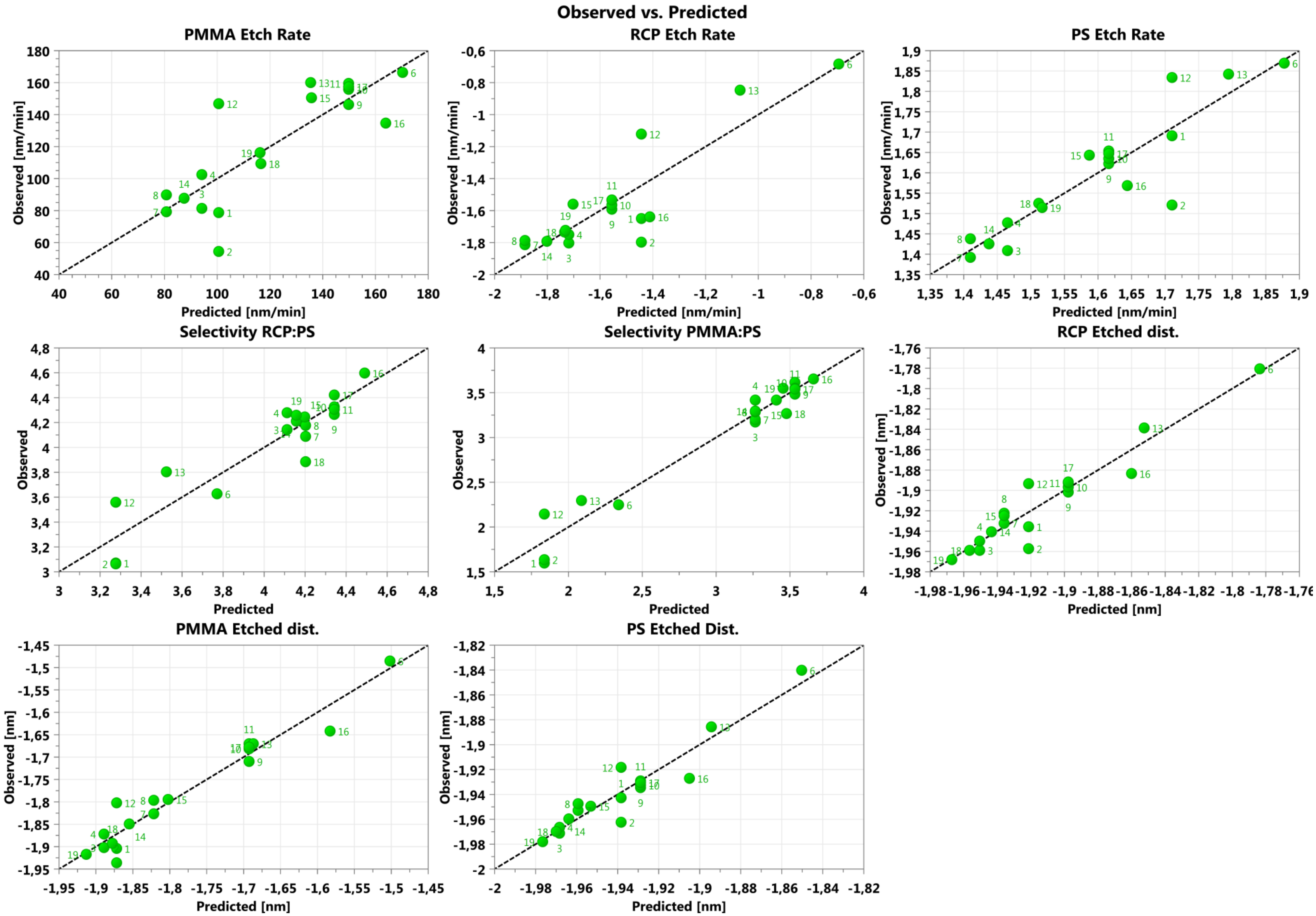
A3.19 SF_6 /O_2 RIE MODDE DOE – Coefficients (Unscaled)

	PMMA Etch Rate	PS Etch Rate	RCP Etch Rate	RCP:PS Selectivity	PMMA:PS Selectivity	PMMA Δh	PS Δh	R10.5 Δh
Constant	-111,335	1,42859	-2,71987	1,17121	-1,1608	-2,71128	-2,09943	-2,17991
SF6 Flow	62,3314	0,015055	0,049264	0,797251	1,31542	0,159743	0,014742	0,0259
Time	9,72359	0,024217	0,105377	0,0623528	0,0666105	0,047053	0,011413	0,017879
SF6*SF6	-4,26835	-	0,013394	-0,0558881	-0,0952935	-0,00871	-	-
SF6*t	-1,38195	-0,00373	-0,01526	-0,006643	-0,0083335	-0,00503	-0,00132	-0,00205

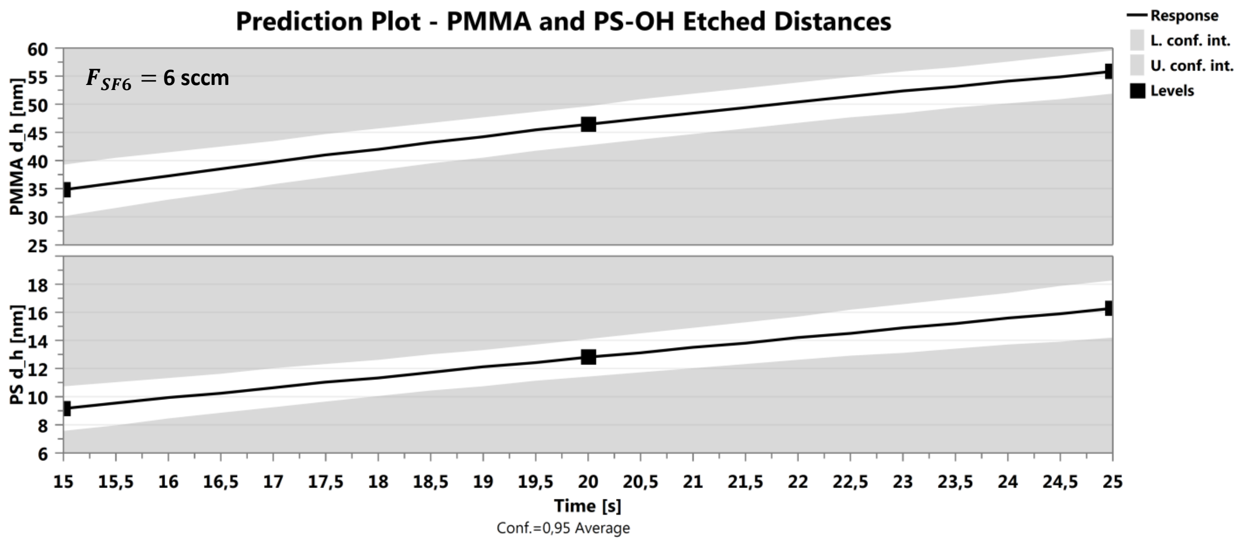
A3.20 SF_6 /O_2 RIE MODDE DOE – Plotted Scaled and Centered Coefficients

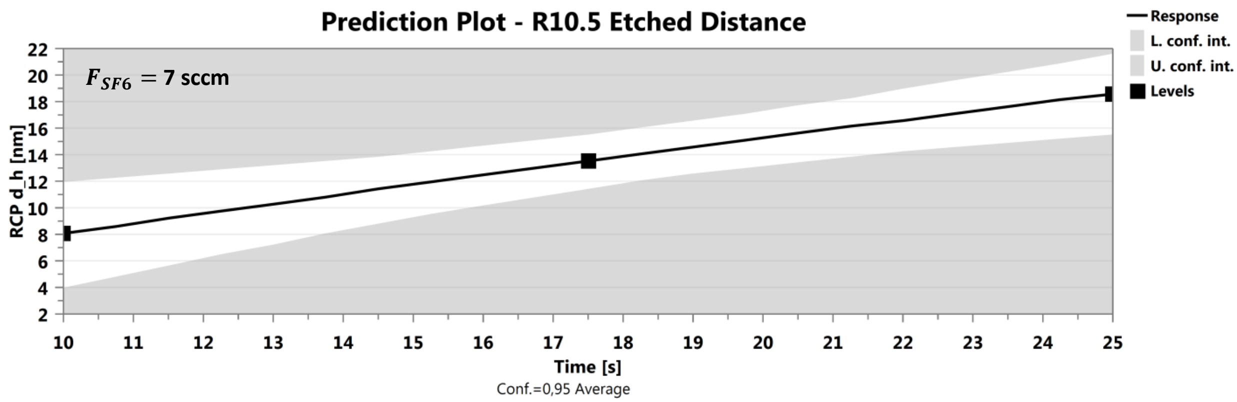


A3.21 SF_6 /O_2 RIE MODDE DOE – Observed vs. Predicted



A3.22 SF_6 /O_2 RIE MODDE DOE –Predictions of etched distances





A3.23 Effects of DUV and AA on grafted R10.5 blanket samples from Exp. I

	Treatment		R10.5 Ellipsometer Measurement				
	Step 1	Step 2	Before		After		Diff.
Sample #	D_{DUV} /[J/cm^2]	AA Bath /[min]	MSE_1	$h_{R10.5;1}$ /[nm]	MSE_2	$h_{R10.5;2}$ /[nm]	$\Delta h_{R10.5}$ /[nm]
C9	**2,28**	8	3,37	7,2	3,742	3,178	4,022
C10	**2,28**	8	3,428	7	3,739	3,283	3,717
C11	**2,28**	8	3,365	6,1	3,476	3,013	3,087
C12	**2,28**	8	4,113	6,3	3,632	2,923	3,377
C1	**0**	8	3,986	5,2	2,777	3,291	1,909
C3	**0**	8	3,761	5,5	3,057	3,259	2,241
C4	**0**	8	3,805	5,7	3,321	3,58	2,120

APPENDIX A4
Deposition of SiN_x/SiO_2 and Pattern Transfer

A4.1 SiN_x PECVD on samples WN1-5

"Deposition parameters:
200°C, gas flow 50 sccm Ar, 6 sccm SiH_4, 8 sccm NH_3 (samples 1, 4, 5) or 9 sccm NH_3 (samples 2, 3), process pressure 0.015mbar, RF bias voltage is set to 300V (RF load power 70-85W), ICP load power is set to 1000W, process time 20 sec.
Process is based on quick start of the generators and getting flow of SiH_4 after plasma ignition." /**Mariusz Graczyk**

A4.2 Ellipsometer measurements of PECVD SiN_x on WN1-5

Model: SiN_x/Si(100) (Si3N4.mat/Si.jell)

Sample #	MSE	h_{SiNx} /[nm]	$n_{633\,nm}$	Fitted
WN1	17.39	11.672	NA	h
WN1	7.117	12.939	2.5076	h. n
WN2	5.023	11.257	NA	h
WN2	3.649	11.376	1.8502	h. n
WN3	5.324	11.401	NA	h
WN3	3.693	11.525	1.8458	h. n
WN4	4.282	10.544	NA	h
WN4	3.458	10.642	2.0664	h. n
WN5	4.281	10.514	NA	h
WN5	3.369	10.609	1.8664	h. n

A4.3 Ellipsometer measurements of PECVD SiN_x before and after surface treatments

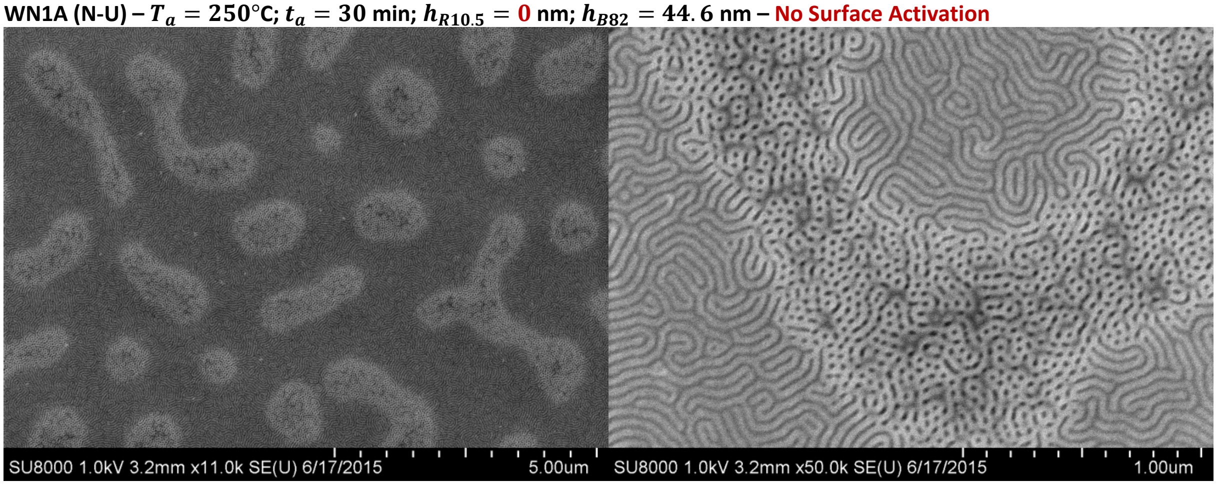
λ /[nm]: [370.44, 1239]

Model: SiN_x/Native oxide (15 Å)/Si(100) (Si3N4.mat/ntve.jaw/Si.jaw)

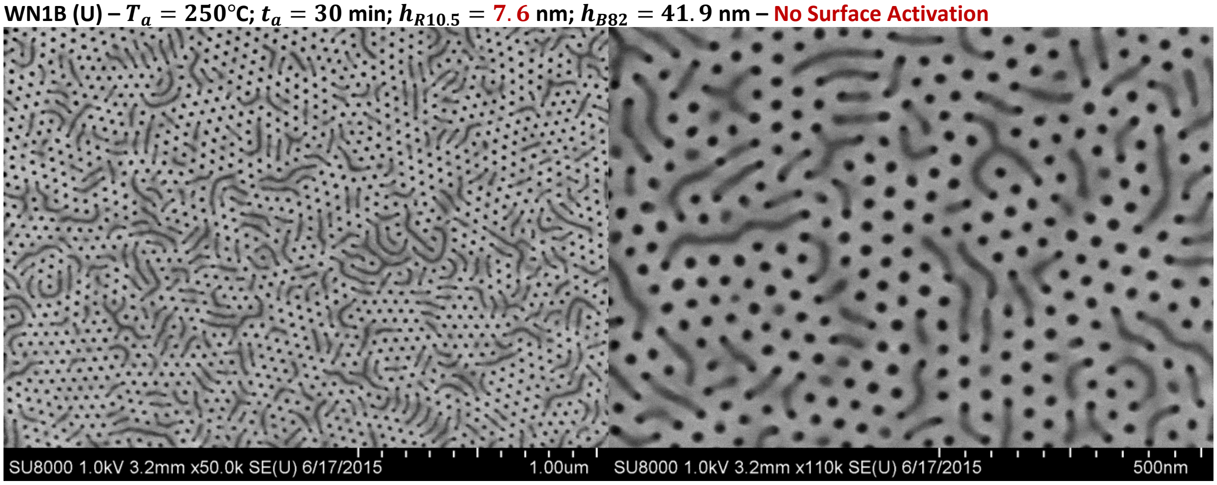
		Before Surface Activation Ellipsometer measurement 1				After Surface Activation Ellipsometer measurement 2				
Sample #	α_i /[°]	MSE	h_{SiNx} /[Å]	$n_{633\,nm}$	Fitted	MSE	h_{SiNx} /[Å]	$n_{633\,nm}$	Fitted	Surface Activation
WN1D	65-75	24.49	103.86	2.0211	h	15.5	109.13	2.0211	h	O_2 RIE (60s, 150 mTorr, 20 sccm O_2, 30W)
WN1D	65-75	9.159	116.10	2.5399	h, n	6.917	115.30	2.388	h, n	
WN2	50-75	4.804	100.58	2.0211	h	5.655	101.27	2.0211	h	O_2 RIE (80s, 150 mTorr, 20 sccm O_2, 30W)
WN2	50-75	3.637	101.72	1.8448	h, n	3.615	103.22	1.7953	h, n	
WN3	50-75	4.021	102.09	2.0211	h	4.877	100.77	2.0211	h	Ozone (150°C, 10 min)
WN3	50-75	2.963	103.27	2.0211	h, n	3.306	102.09	1.8467	h, n	
WN4A	50-75	3.78	94.06	2.0211	h	5.891	97.42	2.0211	h	O_2 RIE (120s, 150 mTorr, 40 sccm O_2, 50W)
WN4A	50-75	3.036	95.26	2.1378	h, n	3.487	99.41	1.7975	h, n	

A4.4 R10.5 grafting and wetting behavior on PECVD SiN_x

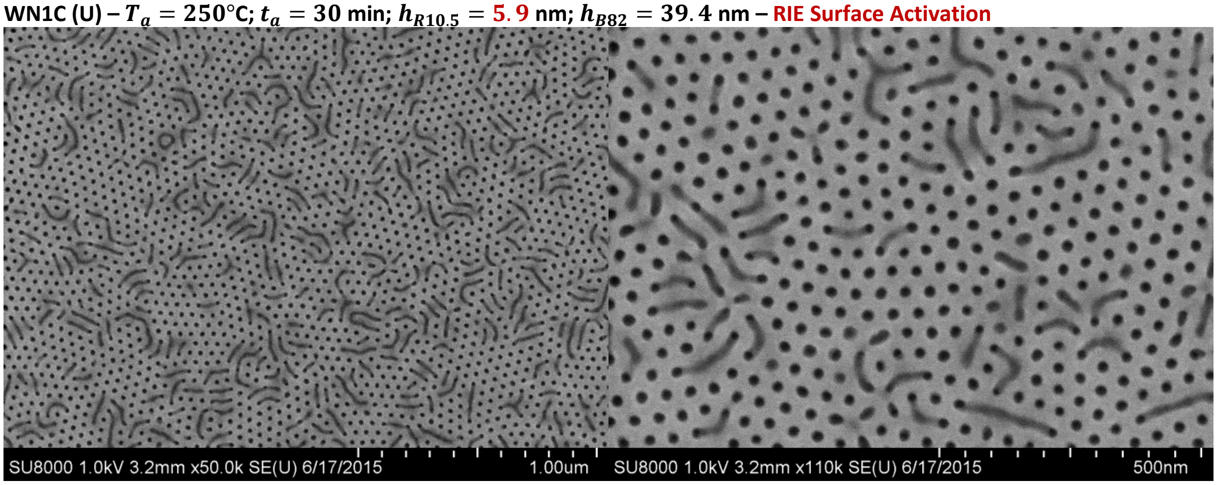
WN1A (N-U) – $T_a = 250$°C; $t_a = 30$ min; $h_{R10.5} = 0$ nm; $h_{B82} = 44.6$ nm – No Surface Activation



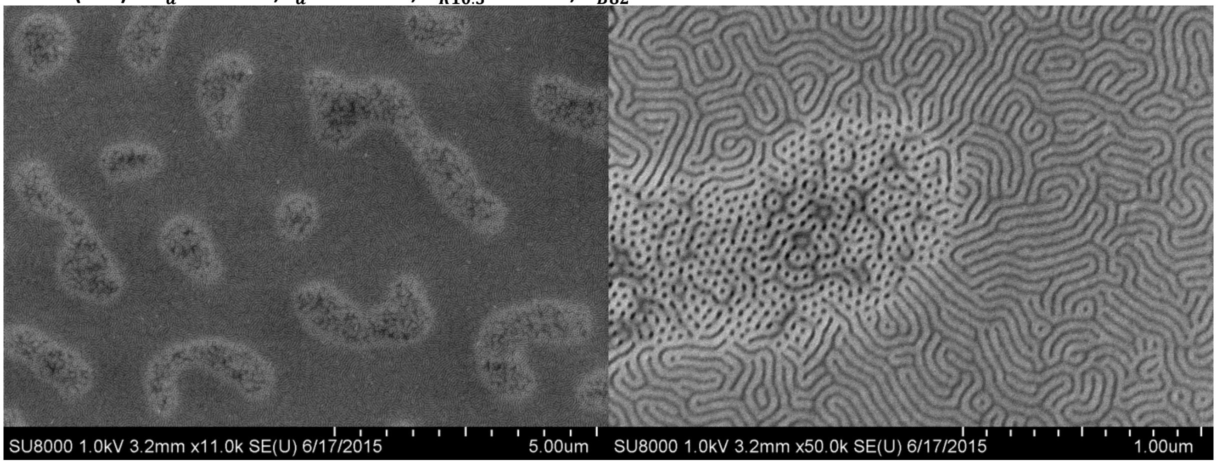
WN1B (U) – $T_a = 250$°C; $t_a = 30$ min; $h_{R10.5} = 7.6$ nm; $h_{B82} = 41.9$ nm – No Surface Activation



WN1C (U) – $T_a = 250$°C; $t_a = 30$ min; $h_{R10.5} = 5.9$ nm; $h_{B82} = 39.4$ nm – RIE Surface Activation

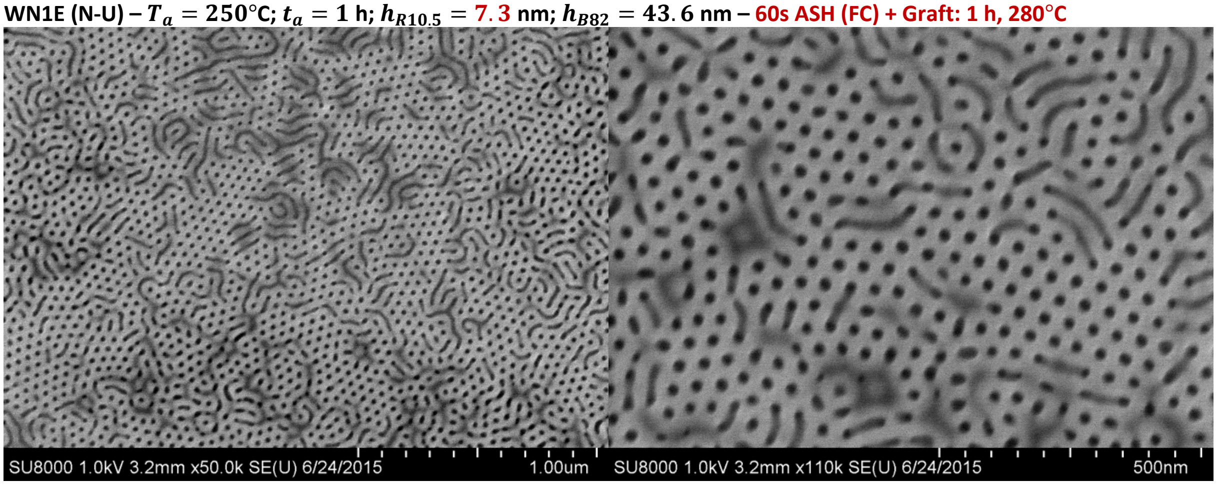


WN1D (N-U) – $T_a = 250°\text{C}$; $t_a = 30$ **min;** $h_{R10.5} = 0$ **nm;** $h_{B82} = 44.4$ **nm – No Surface Activation**

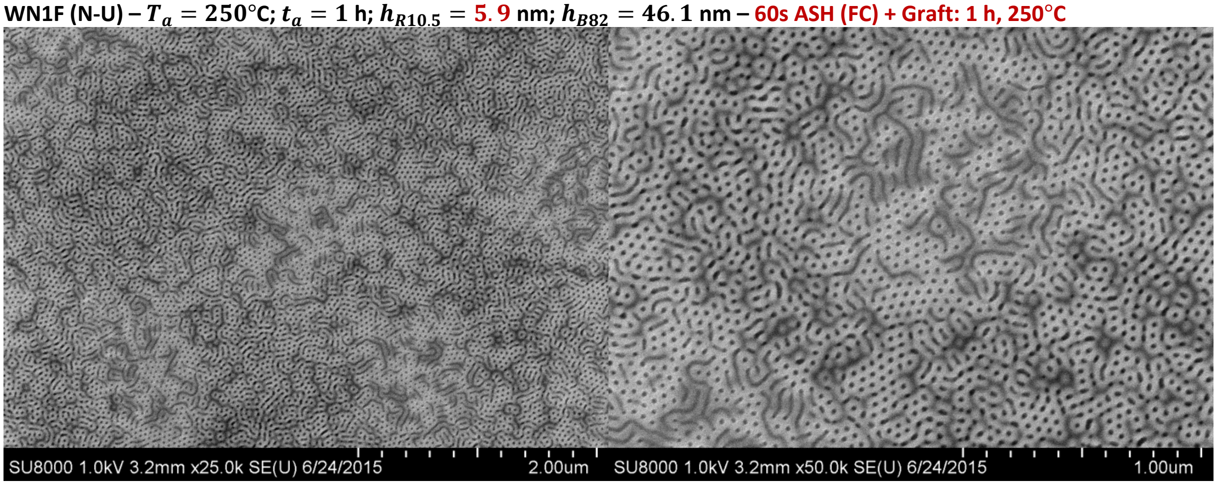


A4.5 Extended grafts on PECVD SiN_x

WN1E (N-U) – $T_a = 250°\text{C}$; $t_a = 1$ **h;** $h_{R10.5} = 7.3$ **nm;** $h_{B82} = 43.6$ **nm – 60s ASH (FC) + Graft: 1 h, 280°C**

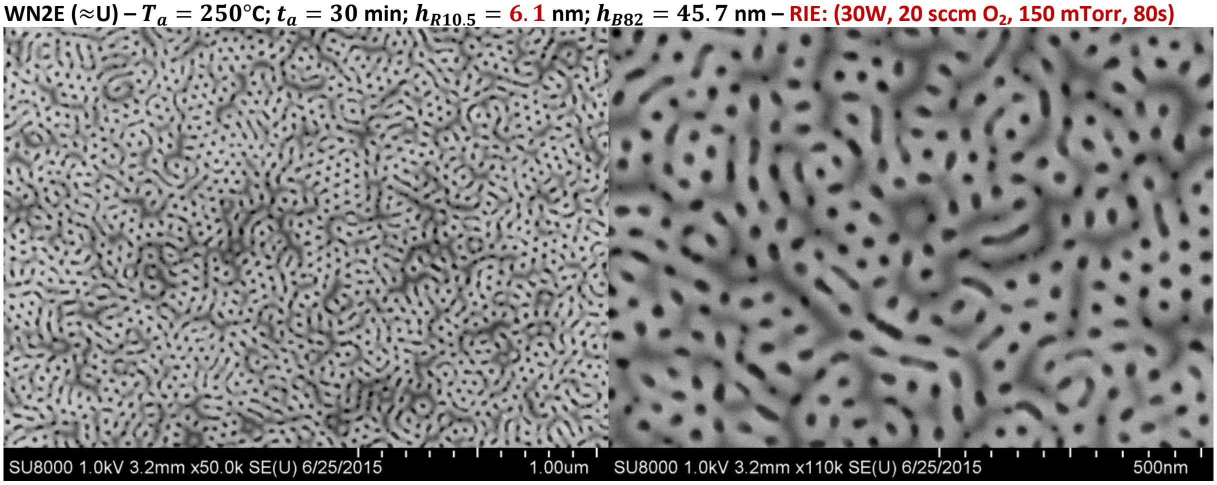


WN1F (N-U) – $T_a = 250°\text{C}$; $t_a = 1$ **h;** $h_{R10.5} = 5.9$ **nm;** $h_{B82} = 46.1$ **nm – 60s ASH (FC) + Graft: 1 h, 250°C**

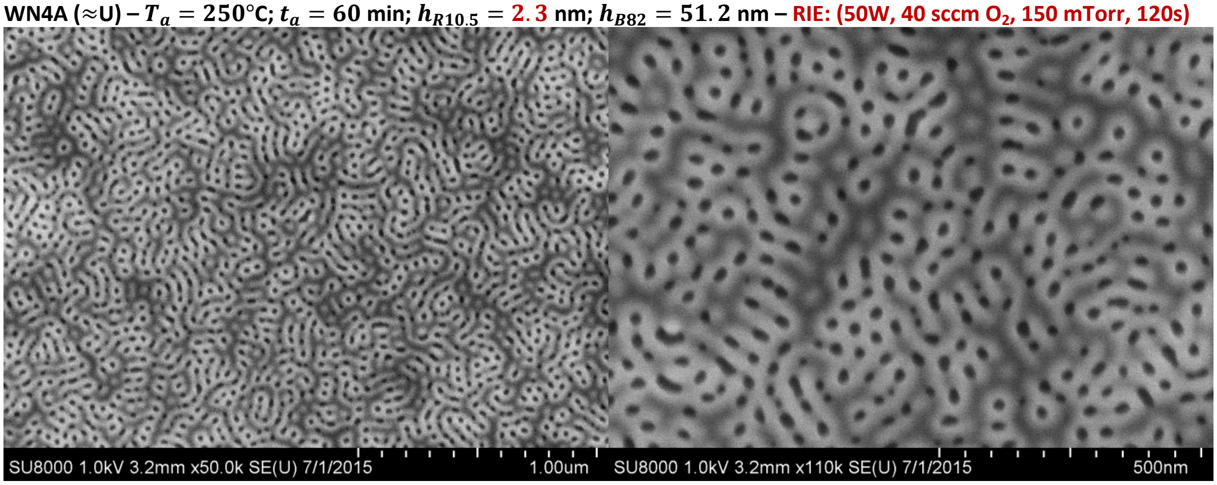


A4.6 Efficacy of various surface activation treatments on PECVD SiN_x

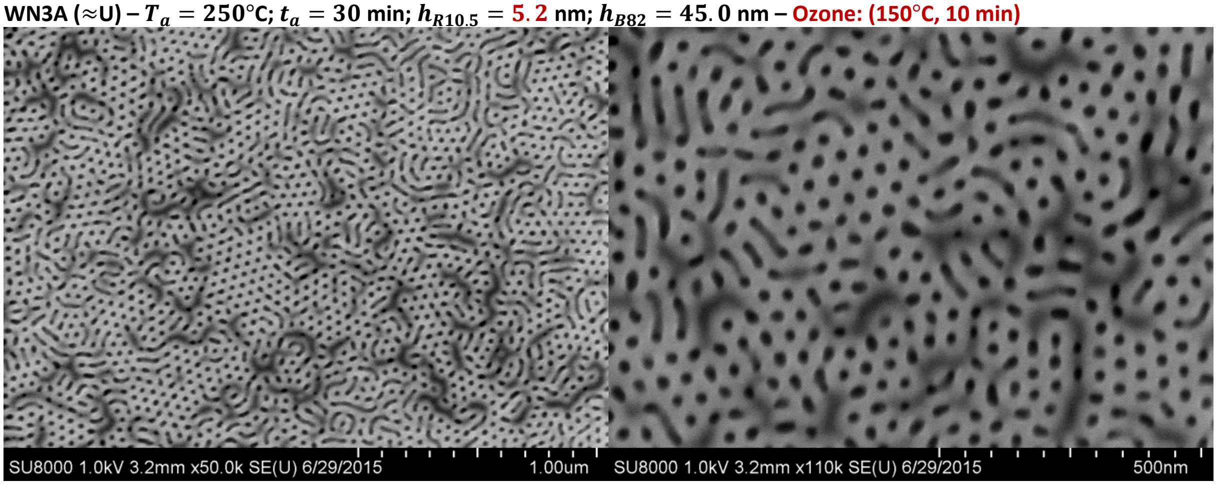
WN2E (≈U) – $T_a = 250$°C; $t_a = 30$ min; $h_{R10.5} = 6.1$ nm; $h_{B82} = 45.7$ nm – RIE: (30W, 20 sccm O_2, 150 mTorr, 80s)



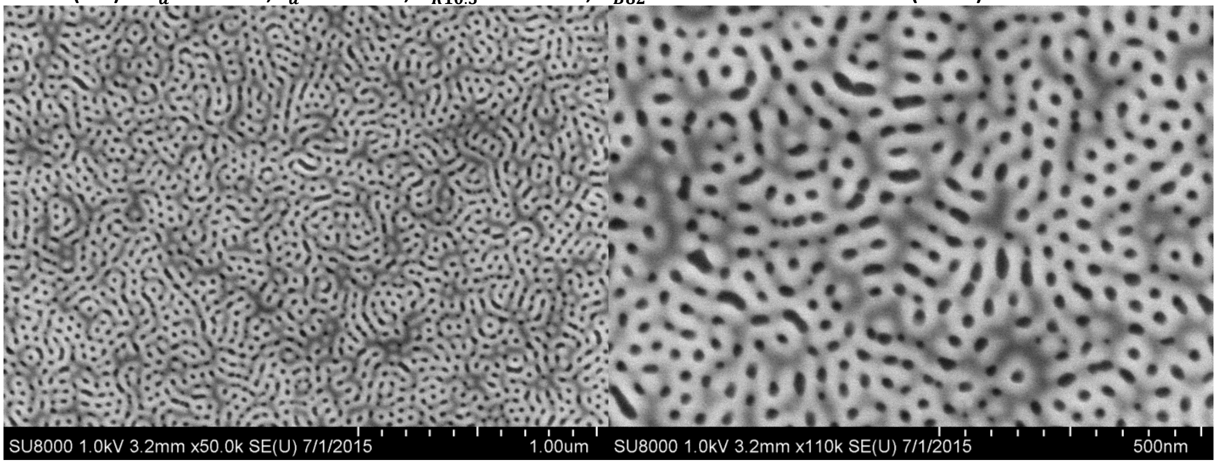
WN4A (≈U) – $T_a = 250$°C; $t_a = 60$ min; $h_{R10.5} = 2.3$ nm; $h_{B82} = 51.2$ nm – RIE: (50W, 40 sccm O_2, 150 mTorr, 120s)



WN3A (≈U) – $T_a = 250$°C; $t_a = 30$ min; $h_{R10.5} = 5.2$ nm; $h_{B82} = 45.0$ nm – Ozone: (150°C, 10 min)



WN4B (≈U) – $T_a = 250$°C; $t_a = 60$ min; $h_{R10.5} = 5.8$ nm; $h_{B82} = 54.1$ nm – PP Ash: 60s (No FC)



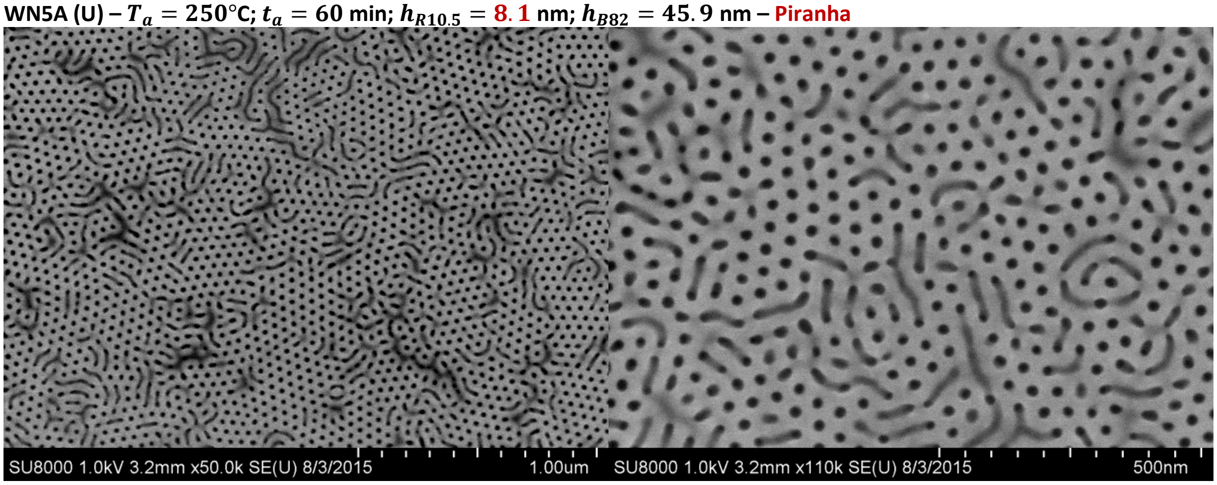
A4.7 SiO_2 and SiN_x ellipsometer data for WN5 and WHD1

λ /[nm]: [370.44, 1239]

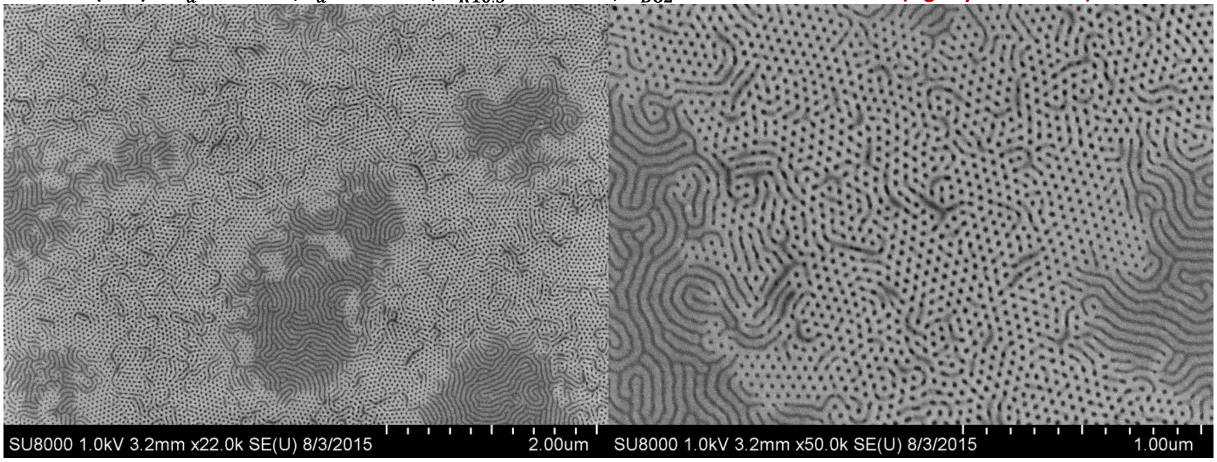
Sample #	MSE	h_{SiO2} /[Å]	h_{SiNx} /[Å]	$n_{SiNx;633}$	h_{SiOx} /[Å]	Fitted	α_i /[°]	Comments
WHD1	9.385	0	138.48	2.0211	0	h_{SiNx}	[65,75]	After PECVD
WHD1	5.145	0	145.67	1.6803	0	h_{SiNx}, n_{SiNx}	[65,75]	After PECVD
WHD1	5.933	14.31	145.67	1.6803	0	h_{SiO2}	[50,75]	After ALD
WN5	3.411	18.50	91.59	2.0683	15	h_{SiO2}	[50,75]	After ALD
WHD1	5.669	14.17	145.67	1.6803	0	h_{SiO2}	[50,75]	Before 2nd Piranha
WN5	3.204	18.45	91.59	2.0683	15	h_{SiO2}	[50,75]	Before 2nd Piranha

A4.8 B82 polymer pattern on R10.5 grafted to a SiO_2/SiN_x stack

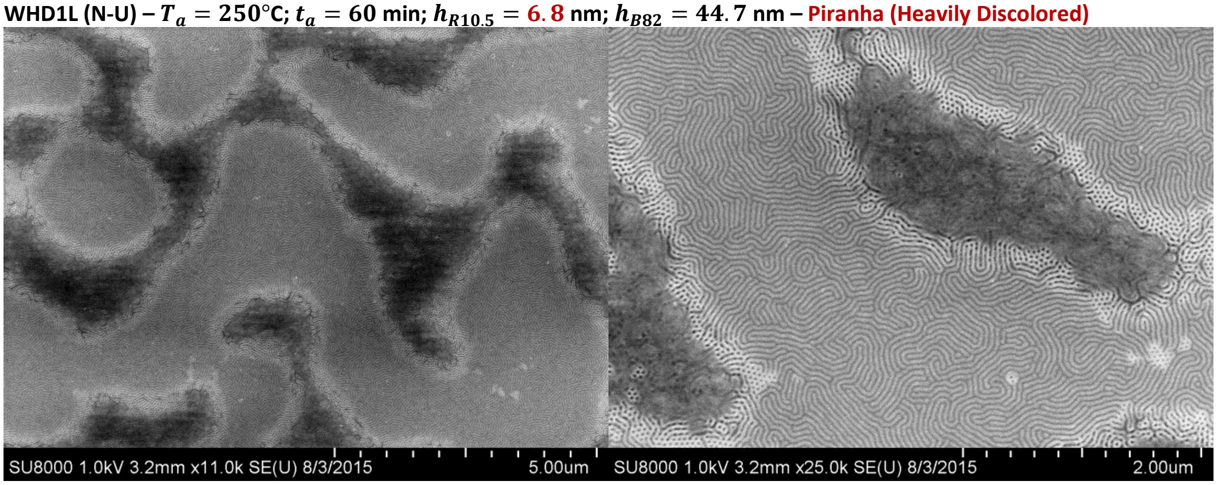
WN5A (U) – $T_a = 250$°C; $t_a = 60$ min; $h_{R10.5} = 8.1$ nm; $h_{B82} = 45.9$ nm – Piranha



WHD1M (N-U) – $T_a = 250°C$; $t_a = 60$ min; $h_{R10.5} = 6.8$ nm; $h_{B82} = 44.7$ nm – Piranha (Lightly Discolored)

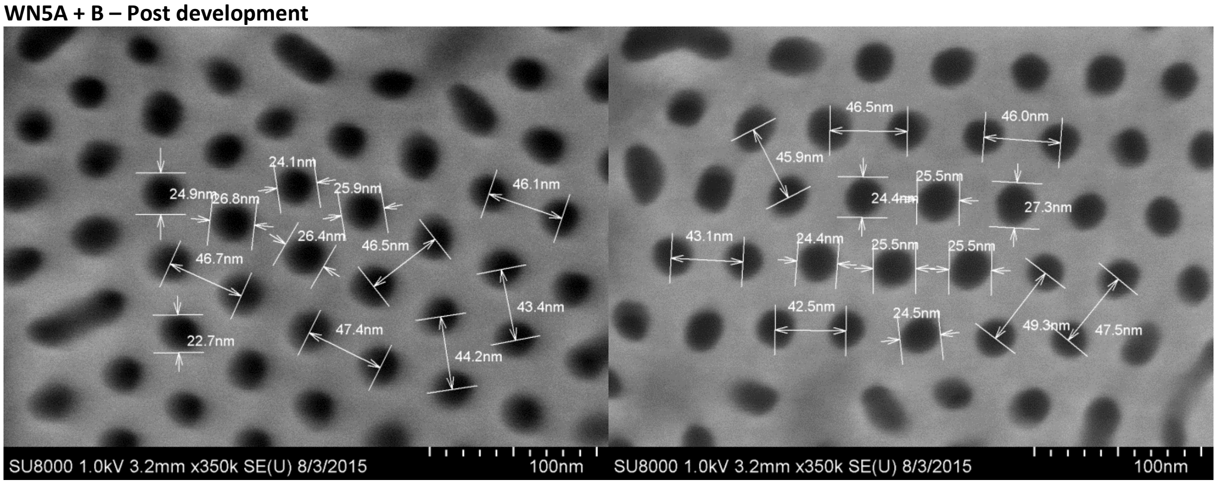


WHD1L (N-U) – $T_a = 250°C$; $t_a = 60$ min; $h_{R10.5} = 6.8$ nm; $h_{B82} = 44.7$ nm – Piranha (Heavily Discolored)



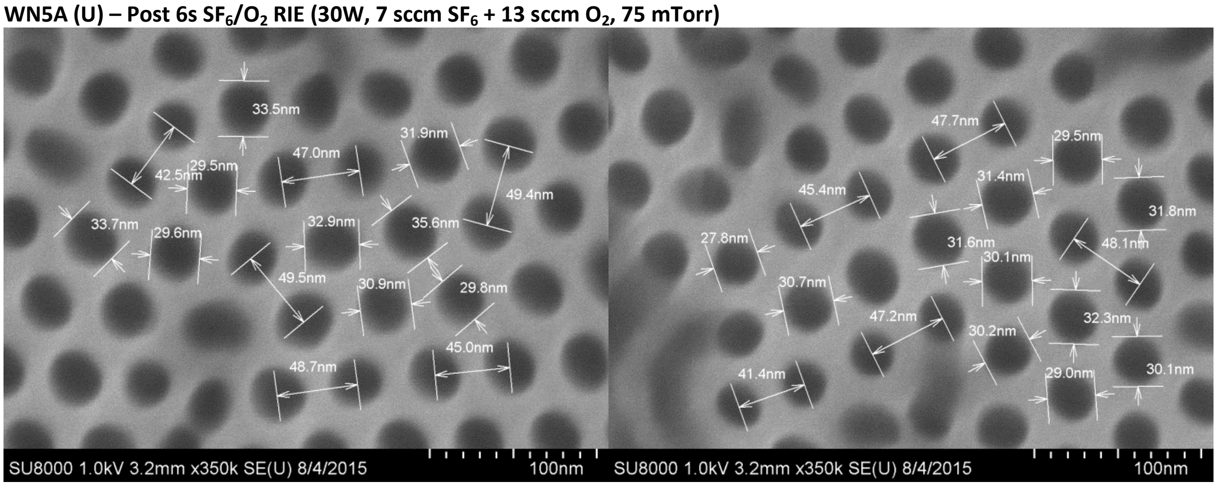
A4.9 Pattern Transfer Calibration – After Step 0: Post-Development

WN5A + B – Post development

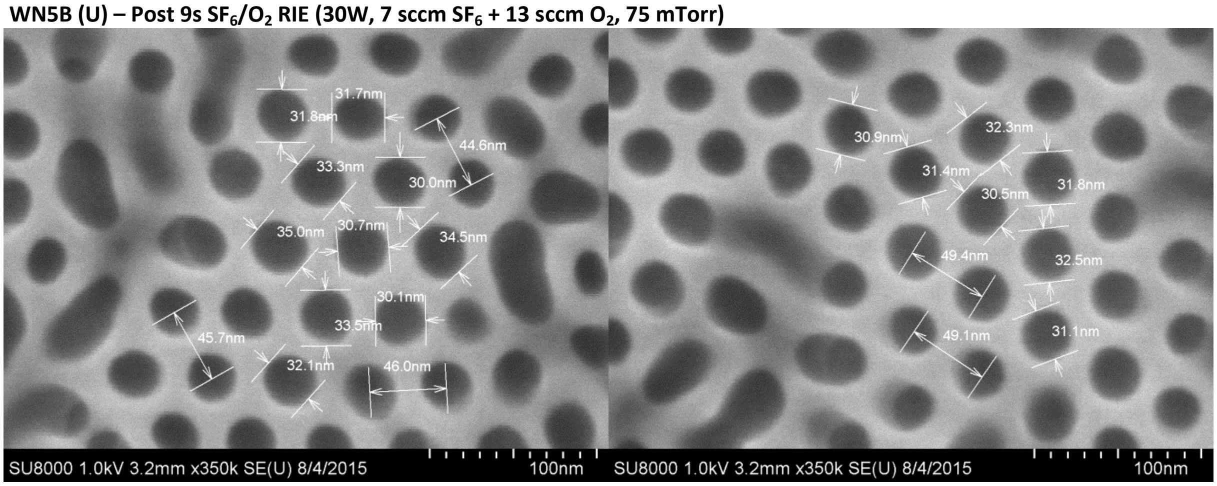


A4.10 Pattern Transfer Calibration – After Step 1: SF_6/O_2 RIE

WN5A (U) – Post 6s SF_6/O_2 RIE (30W, 7 sccm SF_6 + 13 sccm O_2, 75 mTorr)

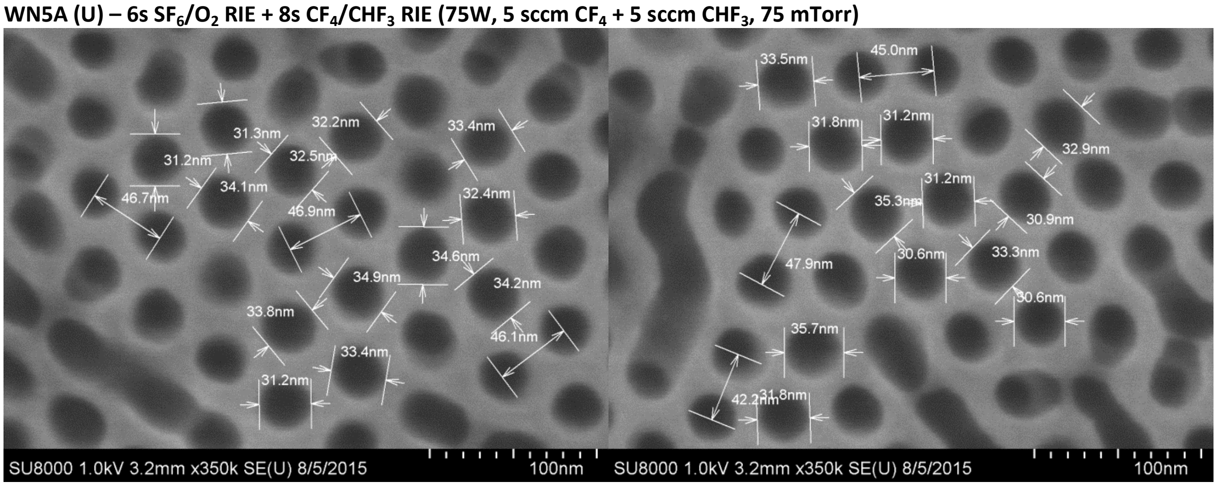


WN5B (U) – Post 9s SF_6/O_2 RIE (30W, 7 sccm SF_6 + 13 sccm O_2, 75 mTorr)

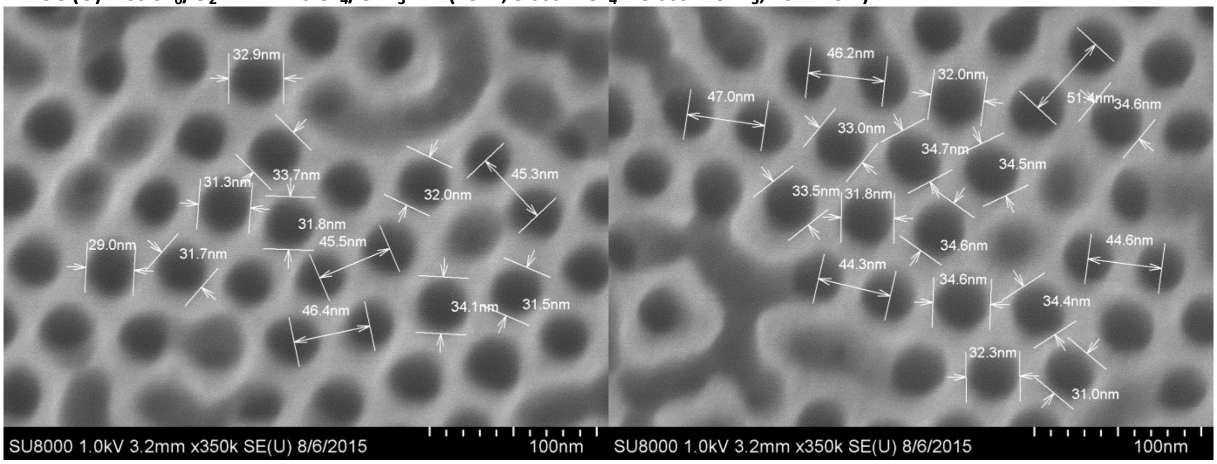


A4.11 Pattern Transfer Calibration – After Step 2: CF_4/CHF_3 RIE

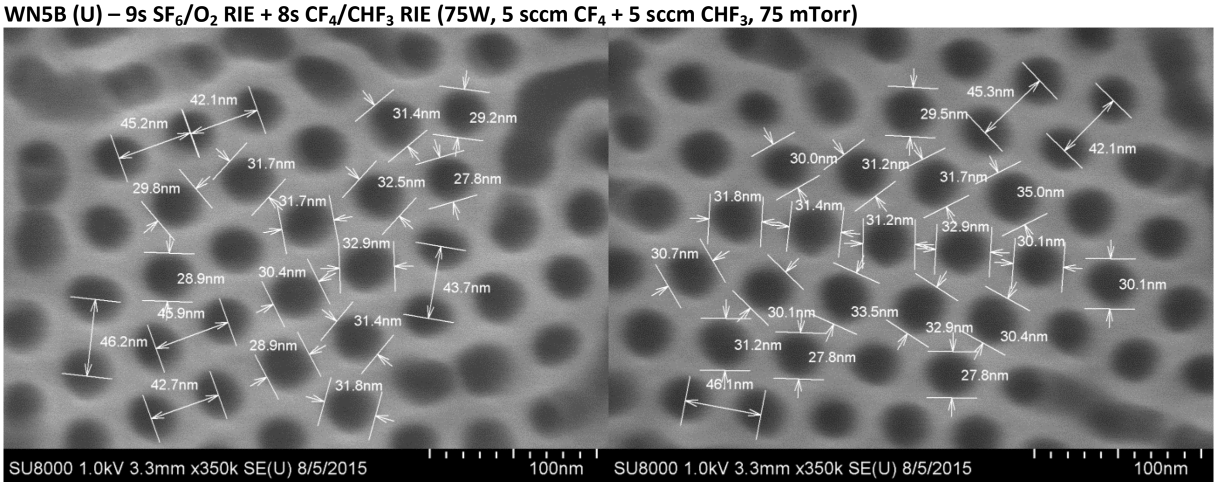
WN5A (U) – 6s SF_6/O_2 RIE + 8s CF_4/CHF_3 RIE (75W, 5 sccm CF_4 + 5 sccm CHF_3, 75 mTorr)



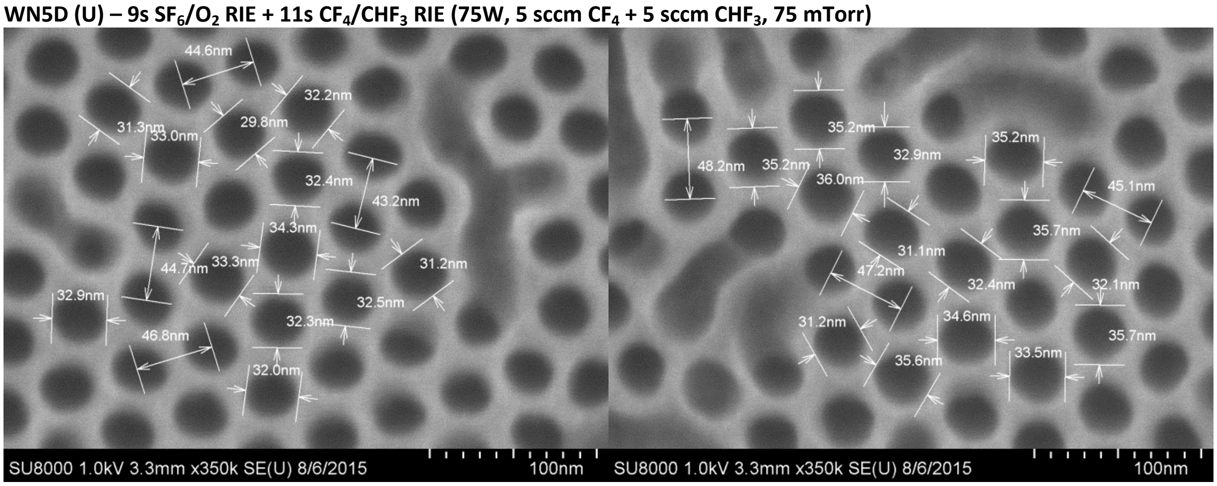
WN5C (U) – 6s SF_6/O_2 RIE + 11s CF_4/CHF_3 RIE (75W, 5 sccm CF_4 + 5 sccm CHF_3, 75 mTorr)



WN5B (U) – 9s SF_6/O_2 RIE + 8s CF_4/CHF_3 RIE (75W, 5 sccm CF_4 + 5 sccm CHF_3, 75 mTorr)

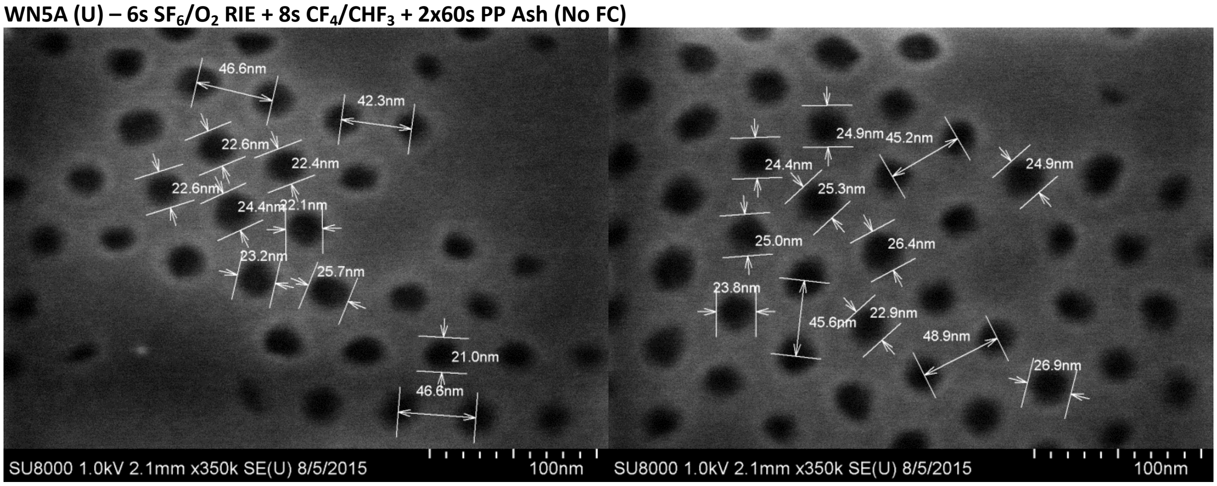


WN5D (U) – 9s SF_6/O_2 RIE + 11s CF_4/CHF_3 RIE (75W, 5 sccm CF_4 + 5 sccm CHF_3, 75 mTorr)

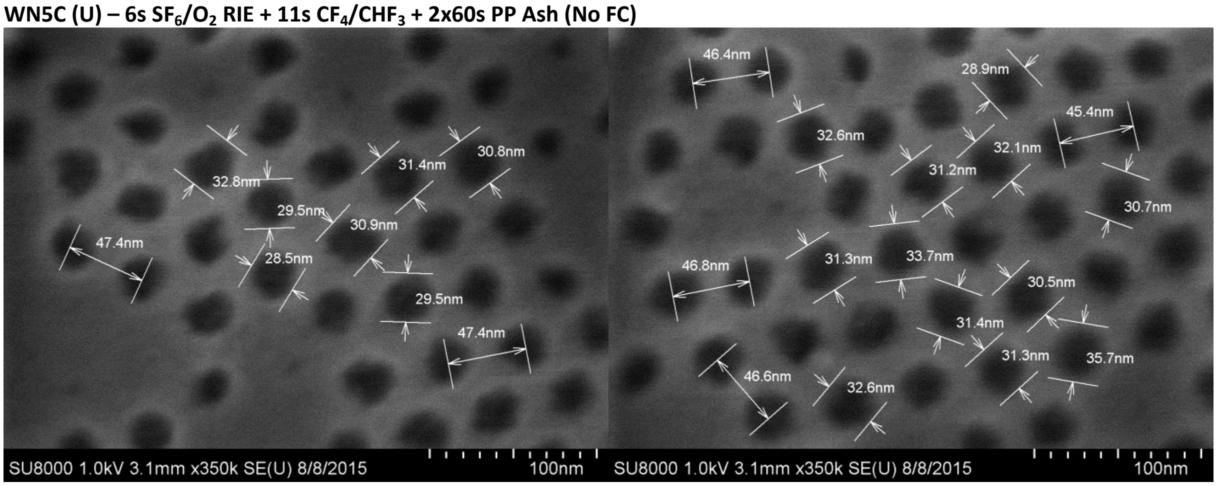


A4.12 Pattern Transfer Calibration – After Step 3: PS Removal

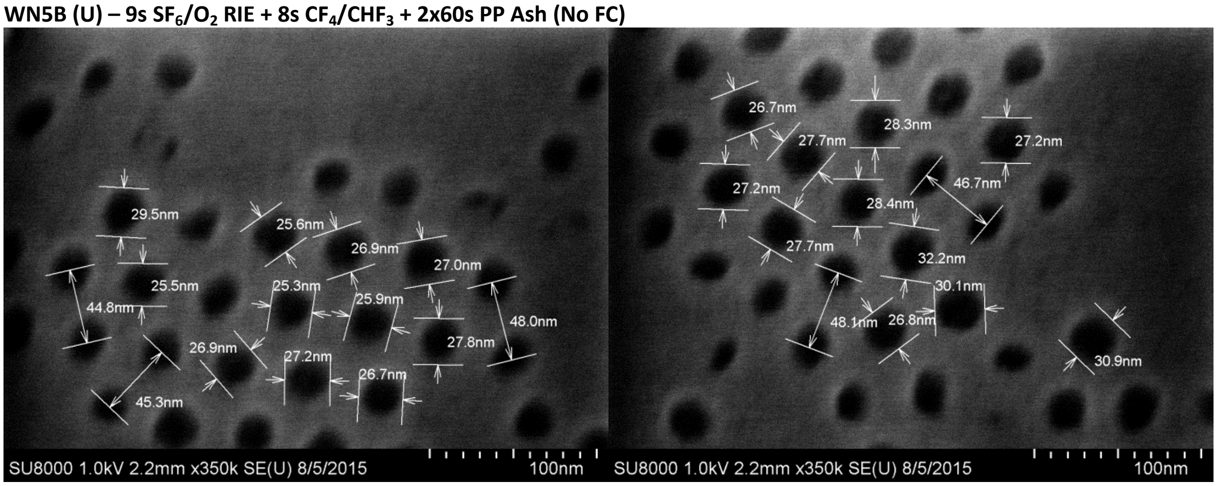
WN5A (U) – 6s SF_6/O_2 RIE + 8s CF_4/CHF_3 + 2x60s PP Ash (No FC)



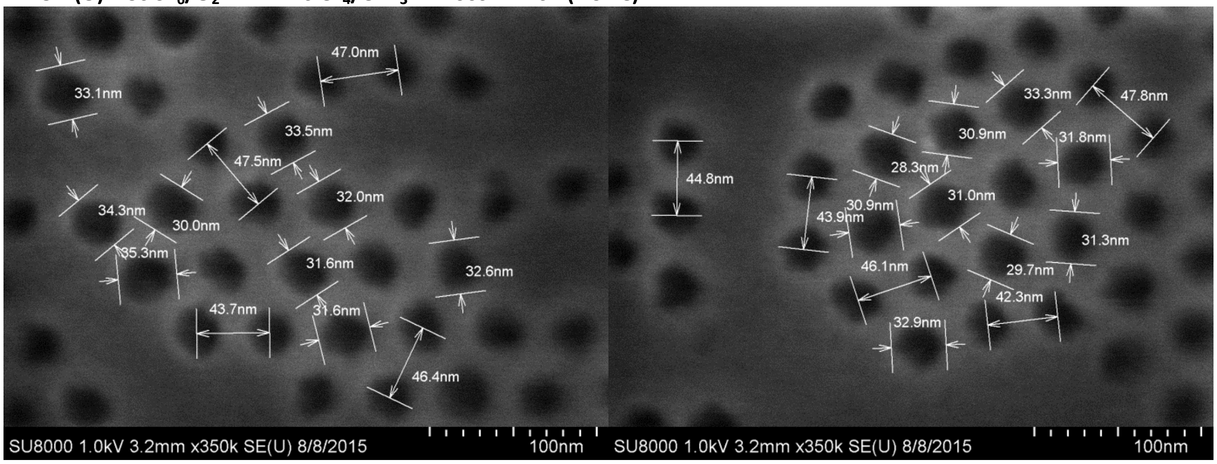
WN5C (U) – 6s SF_6/O_2 RIE + 11s CF_4/CHF_3 + 2x60s PP Ash (No FC)



WN5B (U) – 9s SF_6/O_2 RIE + 8s CF_4/CHF_3 + 2x60s PP Ash (No FC)

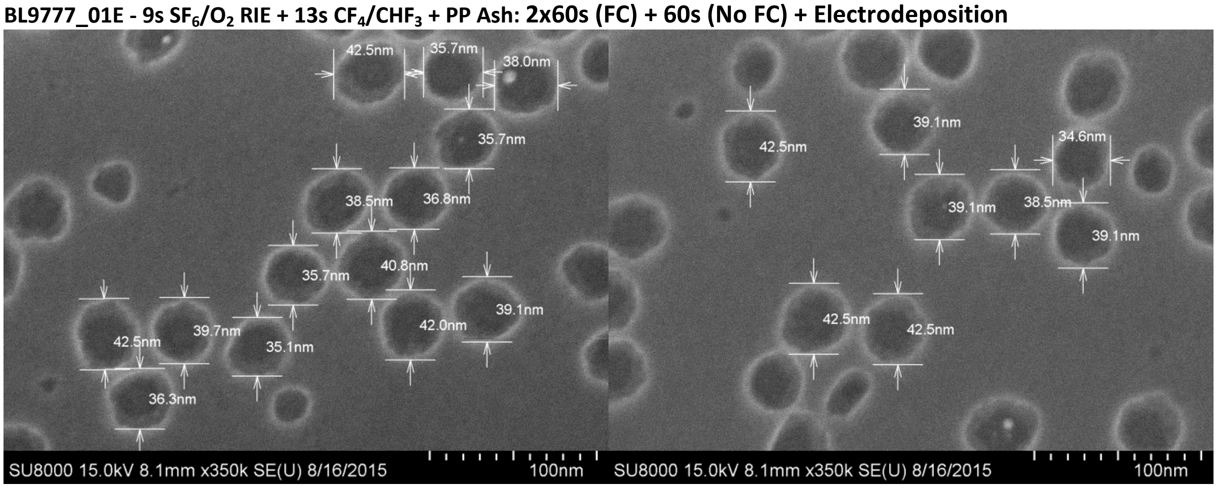


WN5D (U) – 9s SF_6/O_2 RIE + 11s CF_4/CHF_3 + 2x60s PP Ash (No FC)

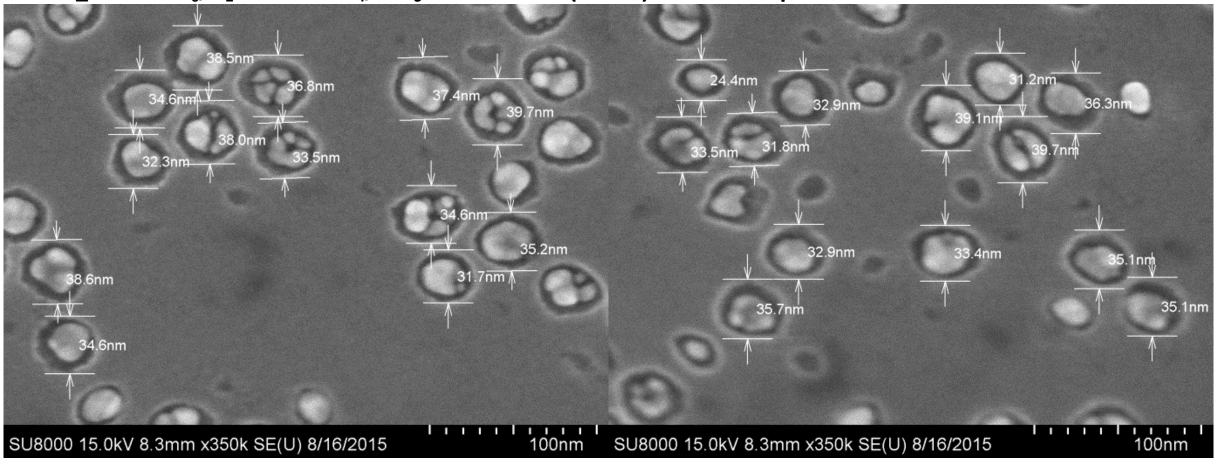


A4.13 Higher quality SEM images and measurements taken post-electrodeposition

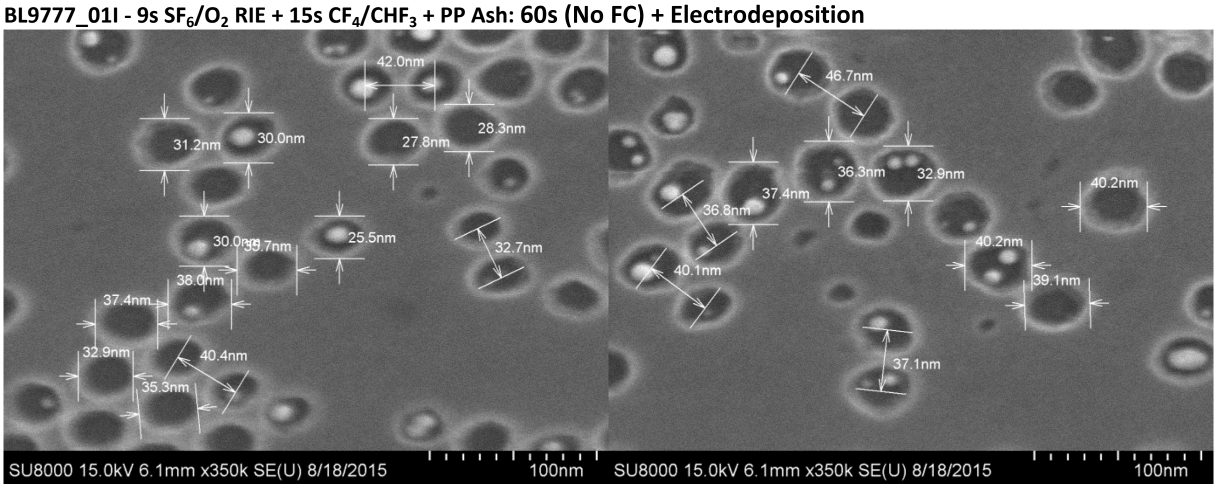
BL9777_01E - 9s SF_6/O_2 RIE + 13s CF_4/CHF_3 + PP Ash: 2x60s (FC) + 60s (No FC) + Electrodeposition



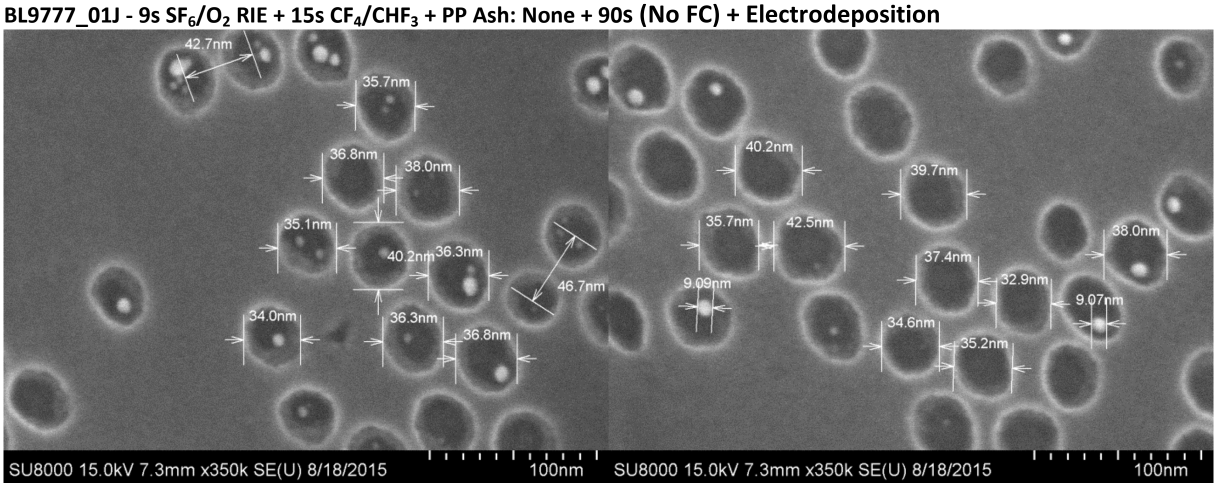
BL9777_01F - 9s SF_6/O_2 RIE + 15s CF_4/CHF_3 + PP Ash: 20s (No FC) + Electrodeposition



BL9777_01I - 9s SF_6/O_2 RIE + 15s CF_4/CHF_3 + PP Ash: 60s (No FC) + Electrodeposition



BL9777_01J - 9s SF_6/O_2 RIE + 15s CF_4/CHF_3 + PP Ash: None + 90s (No FC) + Electrodeposition



A4.14 SiO_2, SiN_x and InAs ellipsometer data of BL9777_01, _02, _04

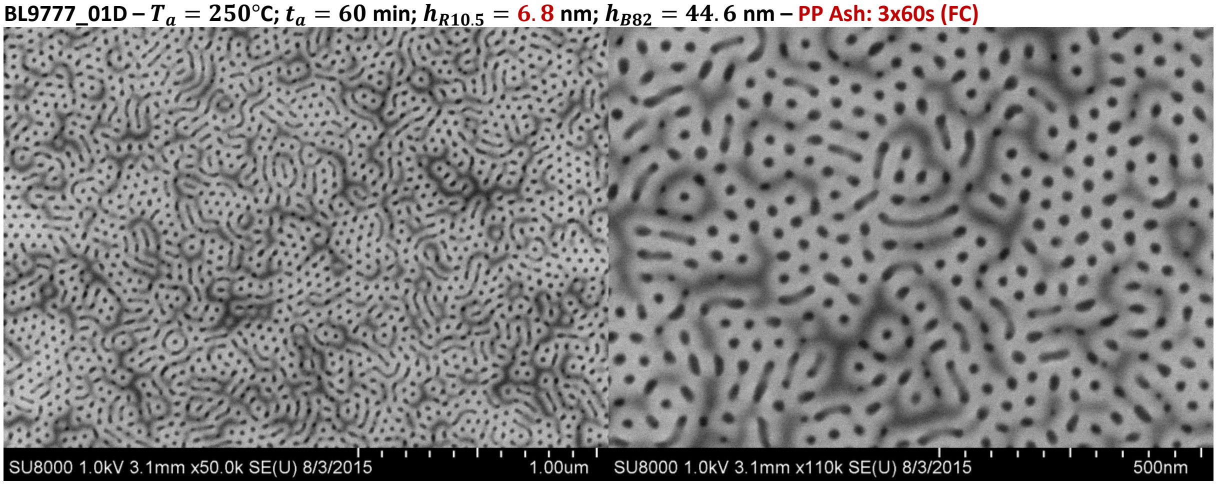
λ /[nm]: [370.44, 1694.6]

α_i /[°]: 50-75

Sample #	MSE	h_{SiO2} /[Å]	h_{SiNx} /[Å]	$n_{SiNx,633}$	$h_{InAs\text{-}OX}$ /[Å]	h_{InAs} /[nm]	$n_{InAs,633}$	Fitted	Comments
BL9777_01	20.58	-	-	-	22.42	263.929	NA	$h_{InAs\text{-}OX}$, h_{InAs}	InAs/Si(111)
BL9777_02	17.77	-	-	-	17.11	275.304	NA	$h_{InAs\text{-}OX}$, h_{InAs}	InAs/Si(111)
BL9777_04	22.81	-	-	-	22.58	287.958	3.938	$h_{InAs\text{-}OX}$, h_{InAs}	InAs/Si(111)
BL9777_04	14.65	-	-	-	23.64	282.836	3.9141	$h_{InAs\text{-}OX}$, h_{InAs}, n_{InAs}	InAs/Si(111)
BL9777_01	20.47	-	85.12	2.0211	22.41	263.941	NA	h_{SiNx}	After SiN_x PECVD
BL9777_01	10.05	-	102.74	1.5644	22.41	263.941	NA	h_{SiNx}, n_{SiNx}	After SiN_x PECVD
BL9777_02	29.97	-	86.81	2.0211	17.11	275.290	NA	h_{SiNx}	After SiN_x PECVD
BL9777_02	13.83	-	106.84	1.5506	17.11	275.290	NA	h_{SiNx}, n_{SiNx}	After SiN_x PECVD
BL9777_01	24.36	15.33	85.12	2.0211	22.41	263.941	NA	h_{SiO2}	After SiO_2 ALD
BL9777_02	25.6	17.95	86.81	2.0211	17.11	275.290	NA	h_{SiO2}	After SiO_2 ALD
BL9777_04	21.11	86.04	0	NA	22.58	287.958	NA	h_{SiO2}	After SiO_2 ALD
BL9777_01	20.34	17.56	85.12	2.0211	22.41	263.941	NA	h_{SiO2}	After failed Piranha

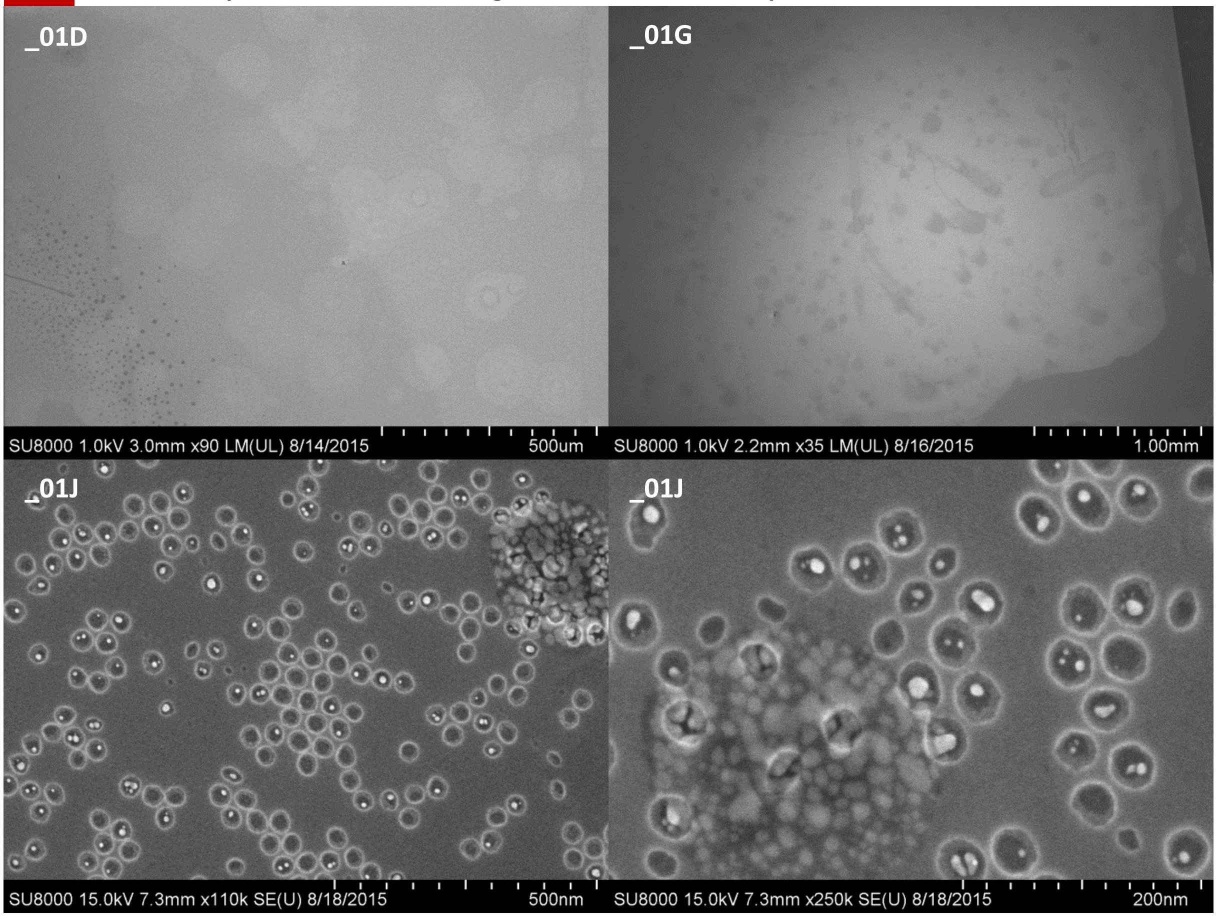
A4.15 Developed B82 pattern of BL9777_01

BL9777_01D – $T_a = 250$°C; $t_a = 60$ min; $h_{R10.5} = 6.8$ nm; $h_{B82} = 44.6$ nm – PP Ash: 3x60s (FC)



APPENDIX A5
Electrodeposition

A5.1 Selected sample overviews illustrating defects after electrodeposition



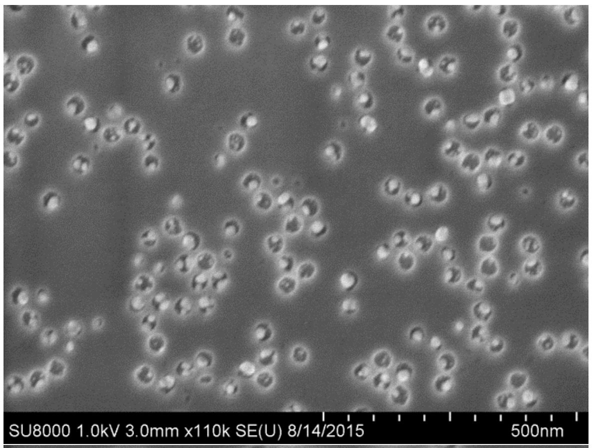
A5.2 Etch, ash and electrodeposition data

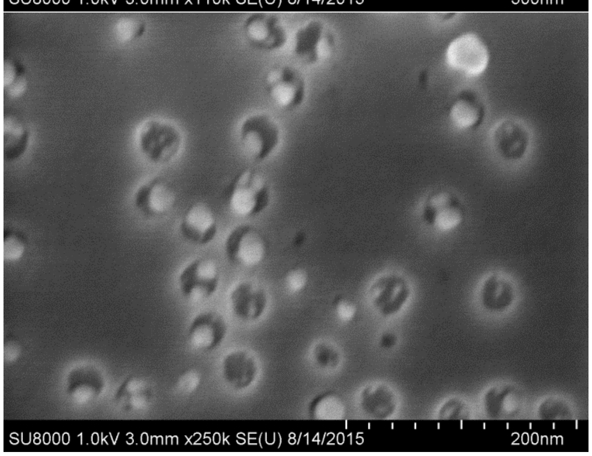
#BL9777_01D

R10.5 RIE:	**9 s**
SiN_x RIE:	**11 s**
ASH, Front (FC):	**2 x 60 s (No)**
ASH, Backside (FC):	**None**

Electrodeposition

Current:	**350 mA**
Time:	**10 s**



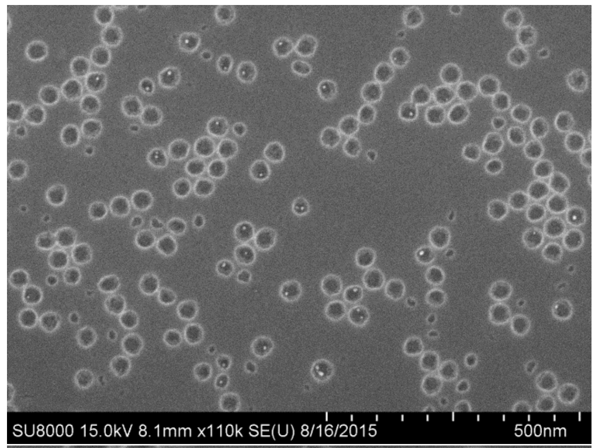


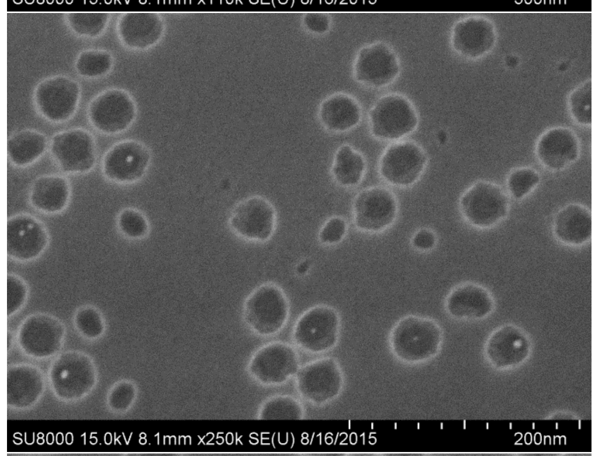
#BL9777_01E

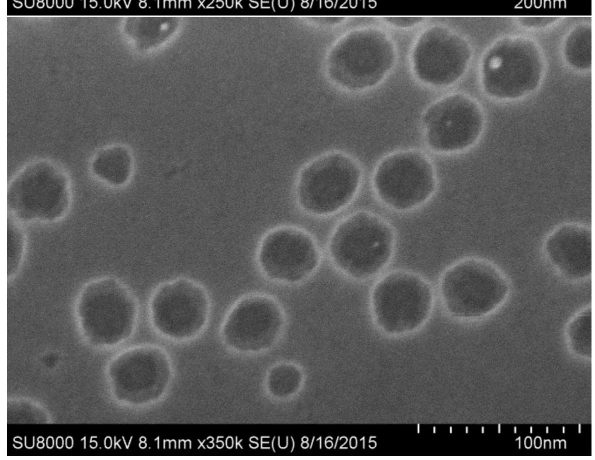
R10.5 RIE:	**9 s**
SiNx RIE:	**13 s**
ASH, Front (FC):	**2x60 s (Yes) + 60 s (No)**
ASH, Backside (FC):	**15 s (No)**

Electrodeposition

Current:	**350 mA**
Time:	**10 s**







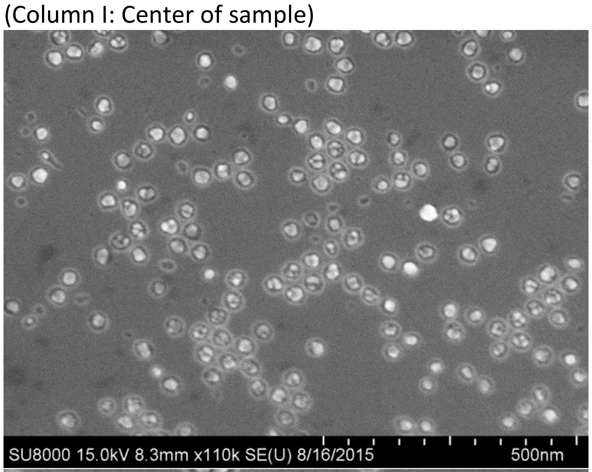
#BL9777_01F

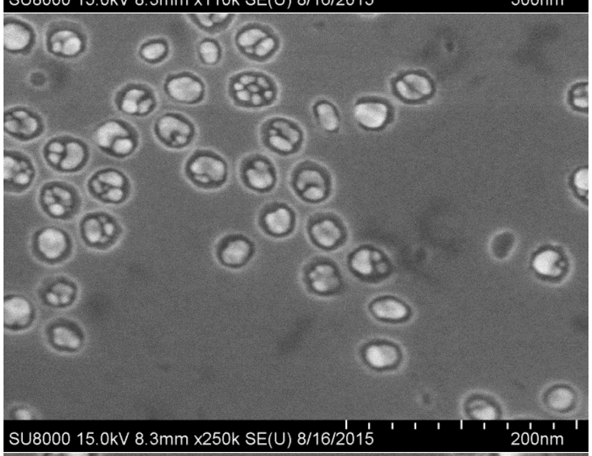
R10.5 RIE	**9 s**
SiNx RIE:	**15 s**
ASH, Front (FC):	**20 s (No)**
ASH, Backside (FC):	**15 s (No)**

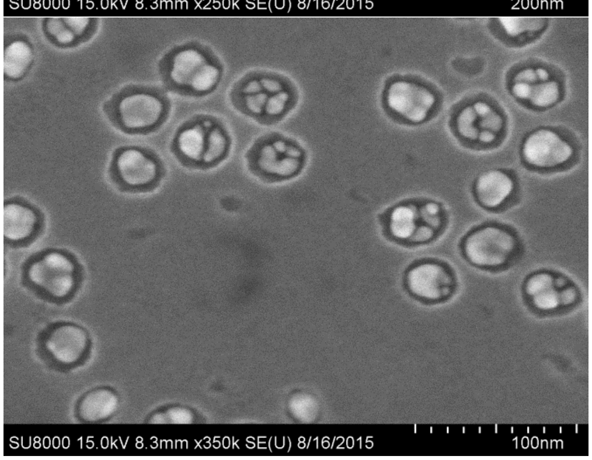
Electrodeposition

Nom. Current:	**350 mA**
Nom. Time:	**10 s**

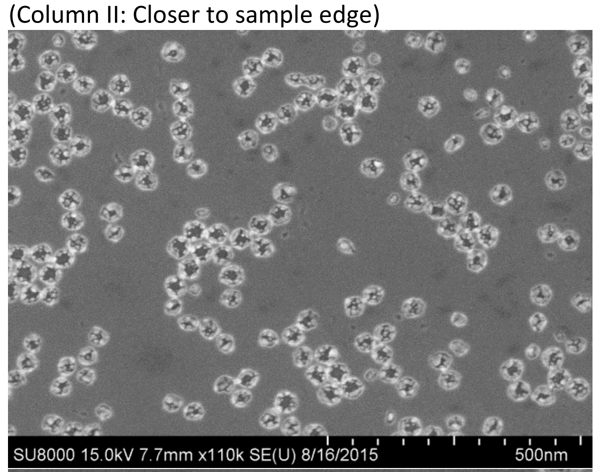
(Column I: Center of sample)

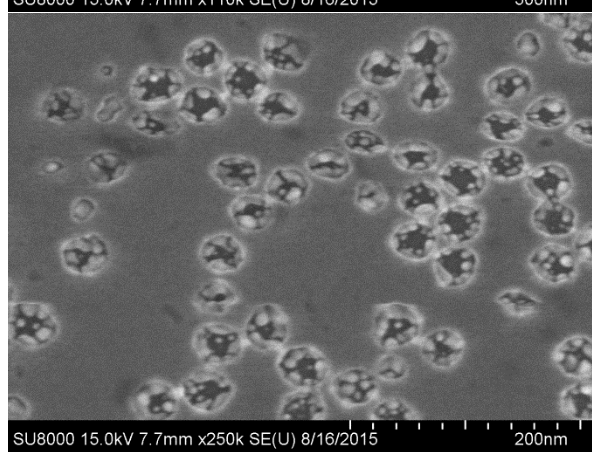






(Column II: Closer to sample edge)





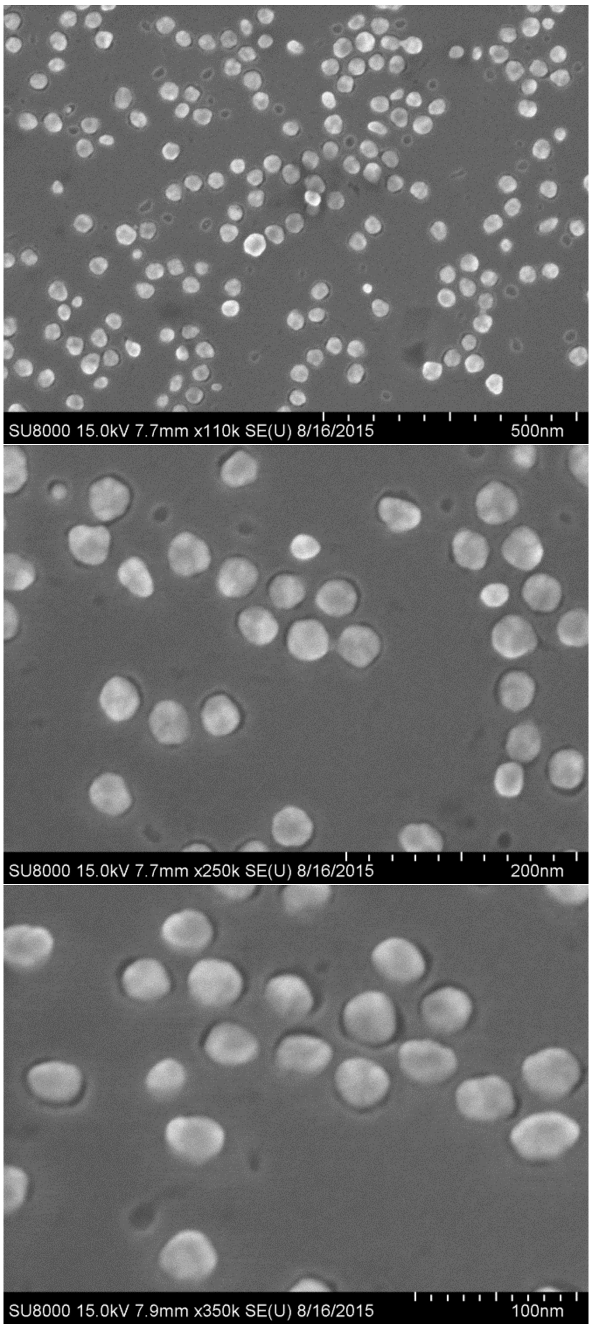
#BL9777_01G

R10.5 RIE	**9 s**
SiNx RIE:	**17 s**
ASH, Front (FC):	**20 s (No)**
ASH, Backside (FC):	**15 s (No)**

Electrodeposition (Performed twice)

Nom. Current:	**450 mA**
Nom. Time:	**10 s + 10 s**

NB: Current fluctuations first time!



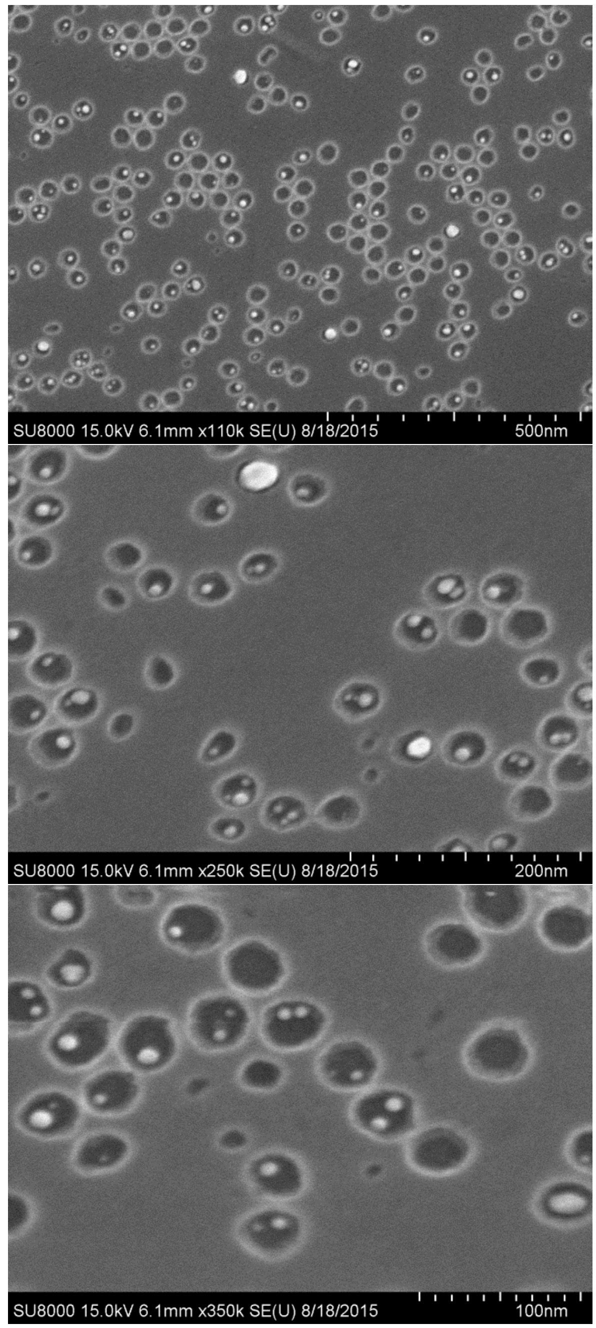
#BL9777_01I

R10.5 RIE	**9 s**
SiNx RIE:	**15 s**
ASH, Front (FC):	**60 s (No)**
ASH, Backside (FC):	**15 s (No)**

Electrodeposition (Performed twice)

Nom. Current:	**1st: 450 mA + 2nd: 240 mA**
Nom. Time:	**~10 s + 10 s**

NB: Timer died first time!



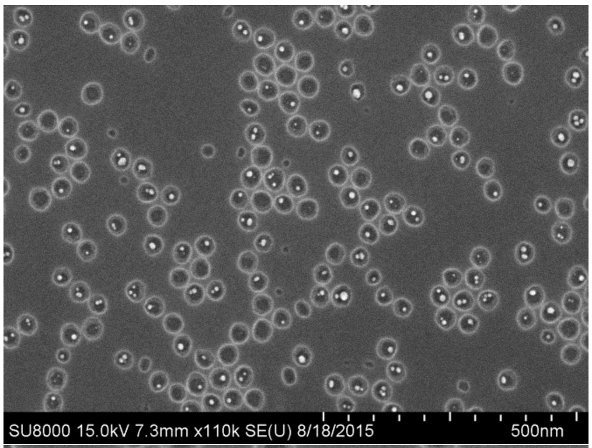
#BL9777_01J

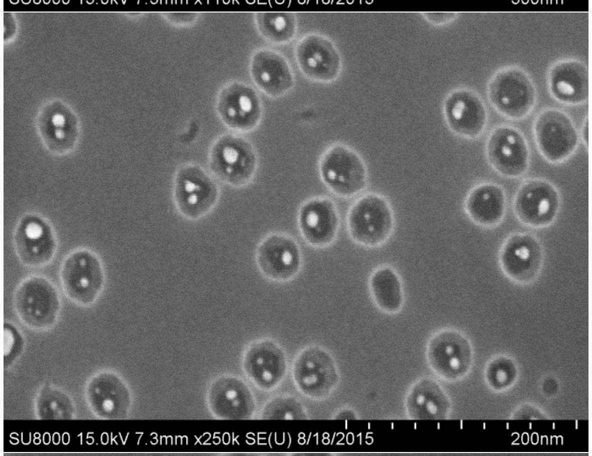
R10.5 RIE	**9 s**
SiNx RIE:	**15 s**
ASH, Front (FC):	**None + 90 s (No)**
ASH, Backside (FC):	**15 s**

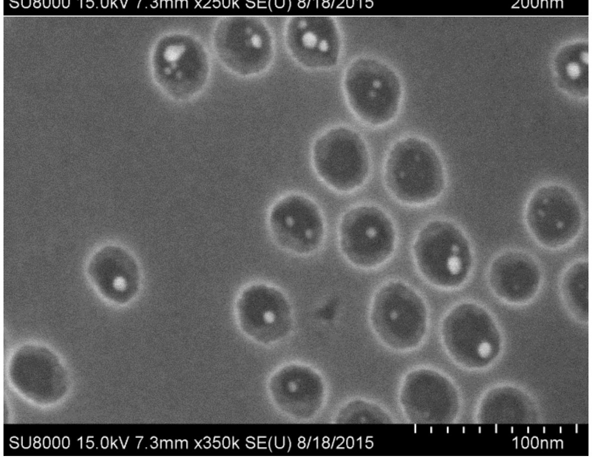
Electrodeposition (Performed twice)

Nom. Current:	**450 mA**
Nom. Time:	**10 s + 10 s**

NB: No ash first time (i.e. polymer still on)





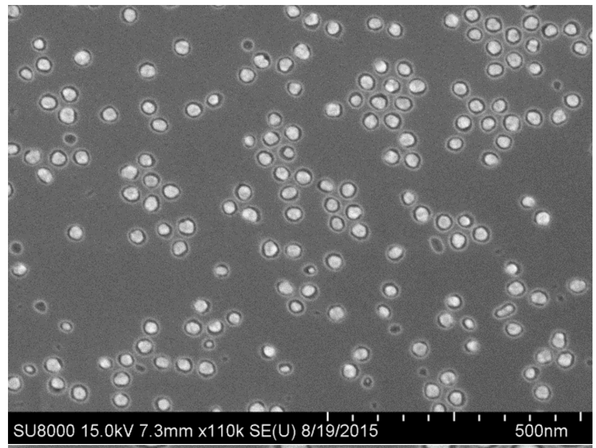


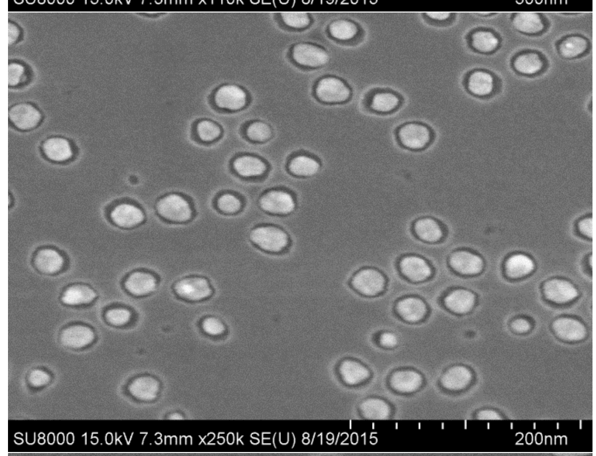
#BL9777_01K

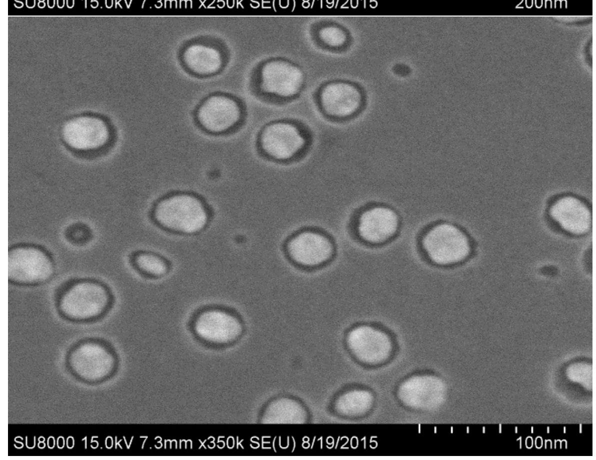
R10.5 RIE	**9 s**
SiNx RIE:	**15 s**
ASH, Front (FC):	**2 x 60 s (No)**
ASH, Backside (FC):	**15 s**

Electrodeposition

Nom. Current:	**450 mA**
Nom. Time:	**10 s**







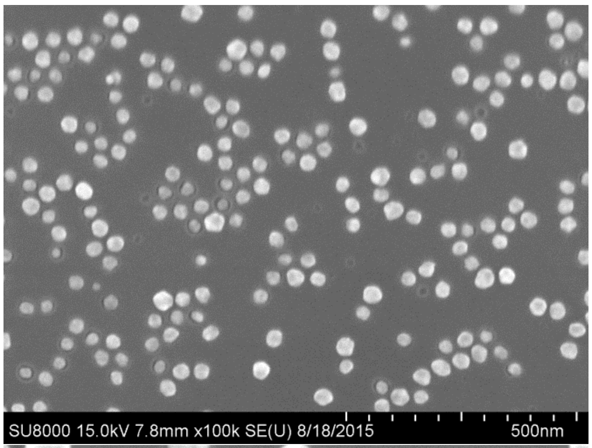
#BL9777_01L

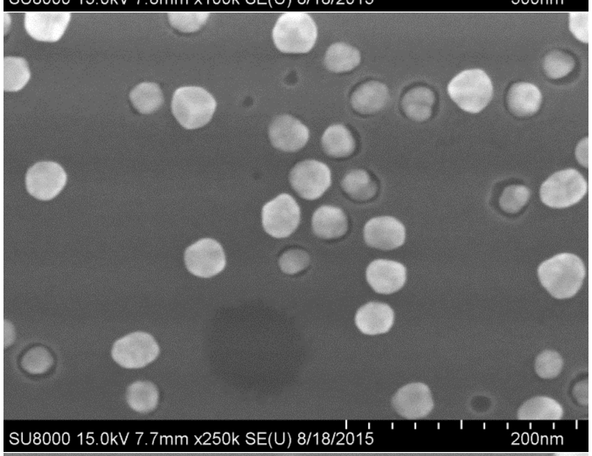
R10.5 RIE	**9 s**
SiNx RIE:	**15 s**
ASH, Front (FC):	**2 x 60 s (No)**
ASH, Backside (FC):	**15 s**

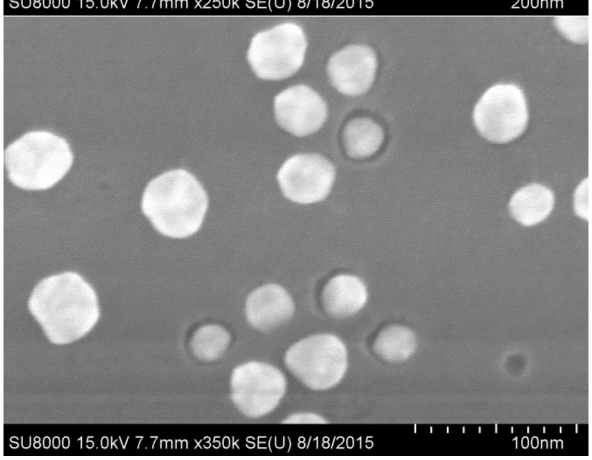
Electrodeposition (Performed twice)

Nom. Current:	**< 450 mA**
Nom. Time:	**10 s + 5 s**

NB: Low current first time!





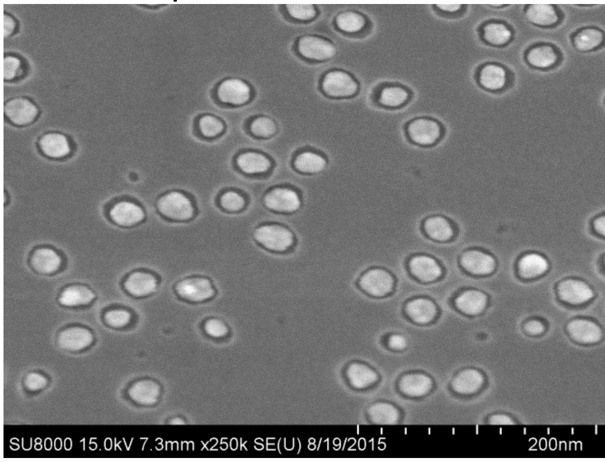


APPENDIX A6

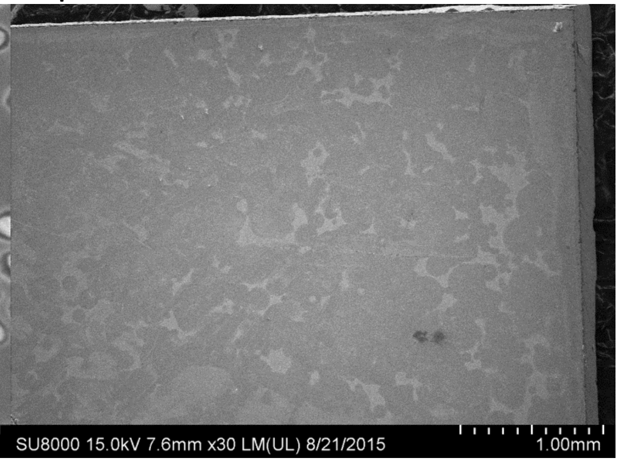
Metal-Organic Vapour-Phase Epitaxy (MOVPE)

MOVPE RUN #10551 - Sample #BL9777_01K

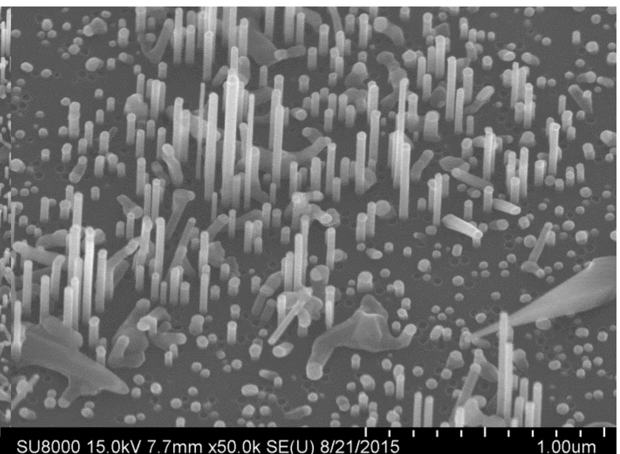
After electrodeposition

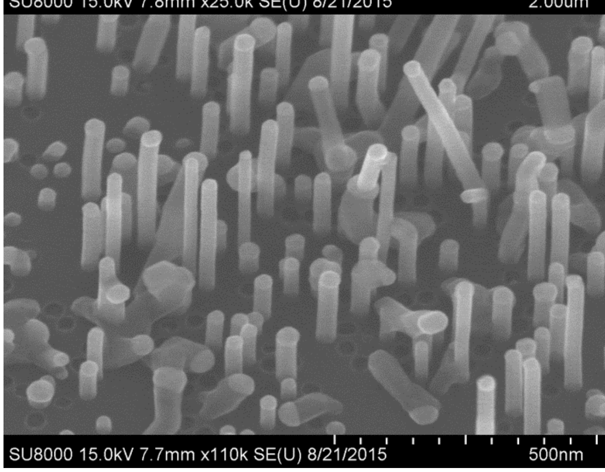


Sample overview after MOVPE

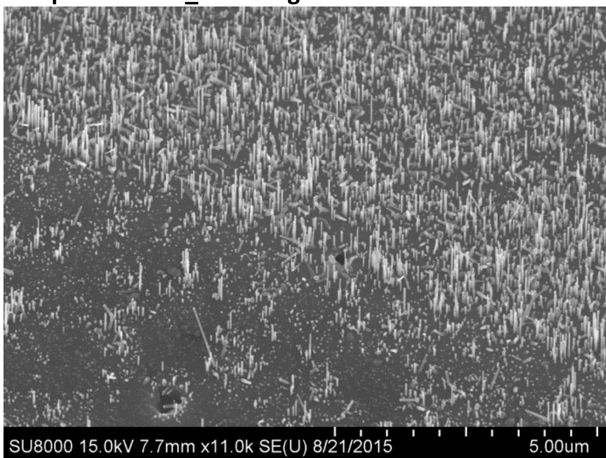


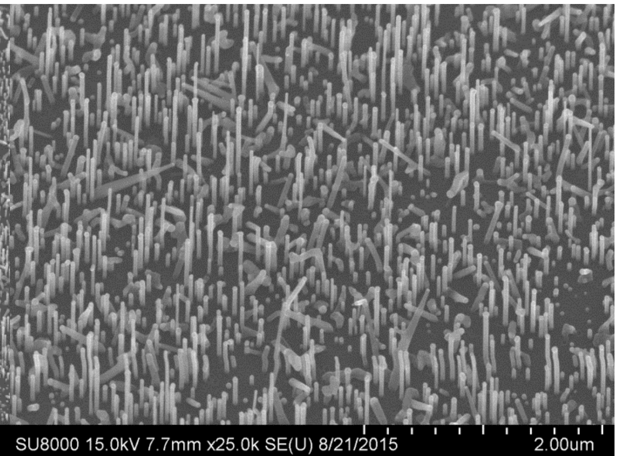
Sample #BL9777_01K - Center

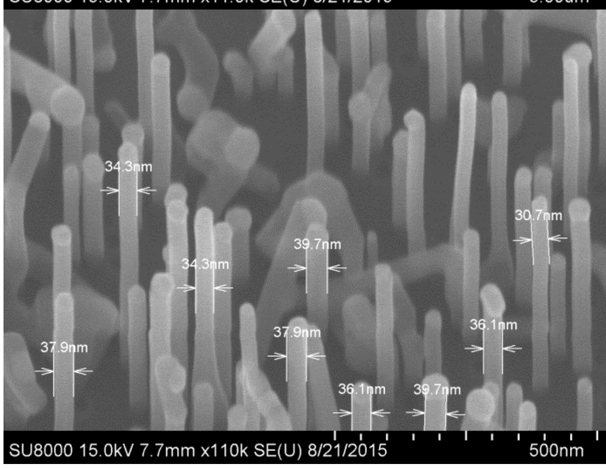




Sample #BL9777_01K - Edge

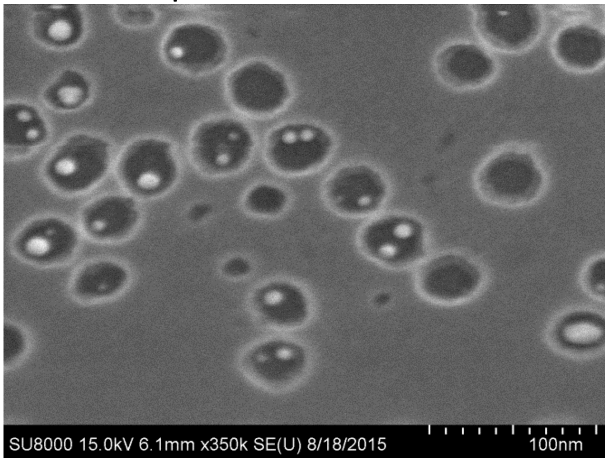




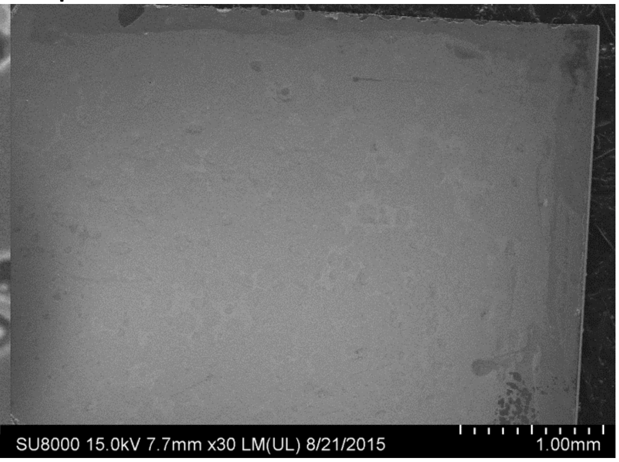


MOVPE RUN #10551 - Sample #BL9777_01I

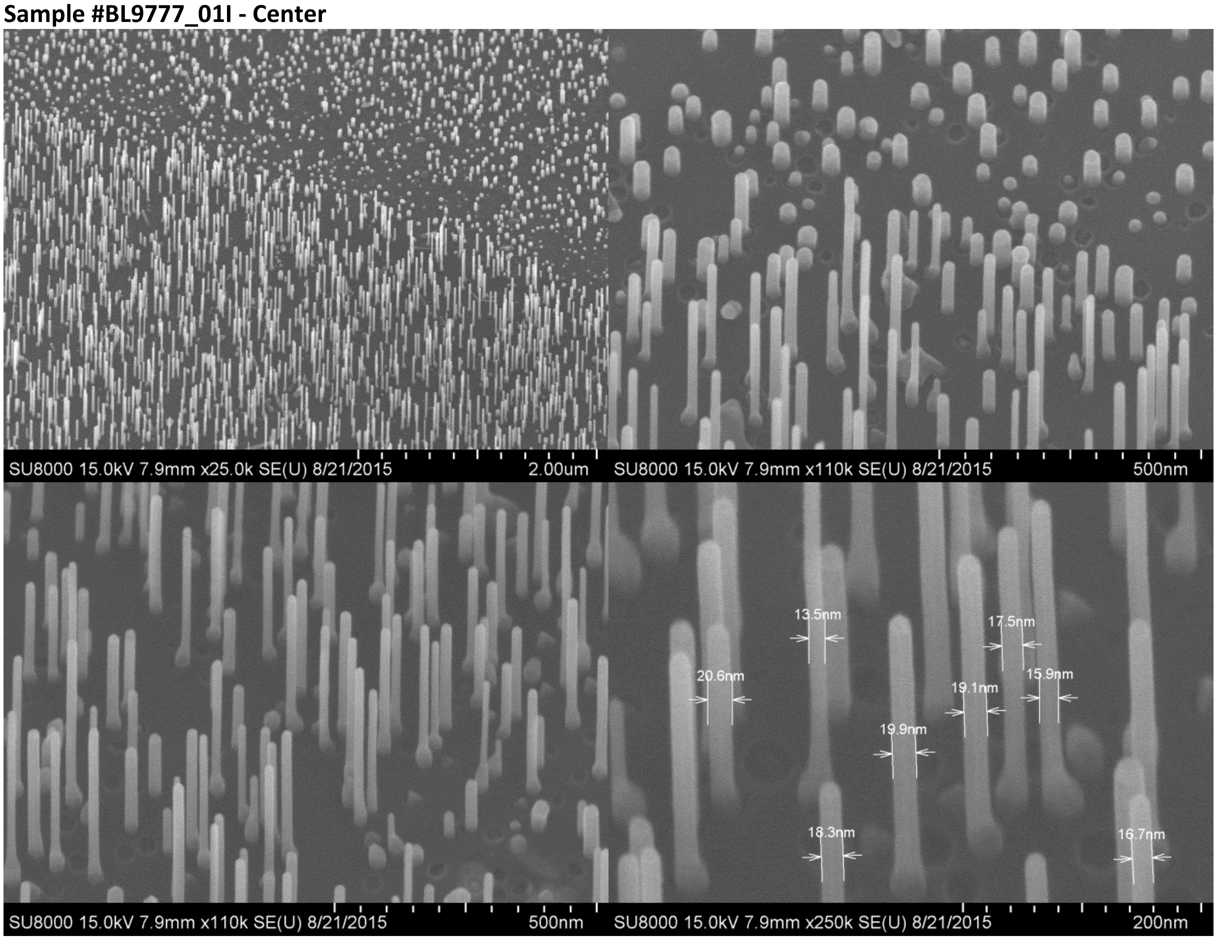
After electrodeposition

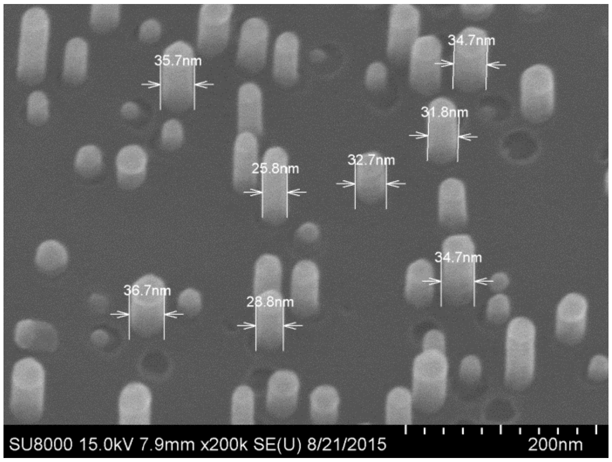


Sample overview after MOVPE

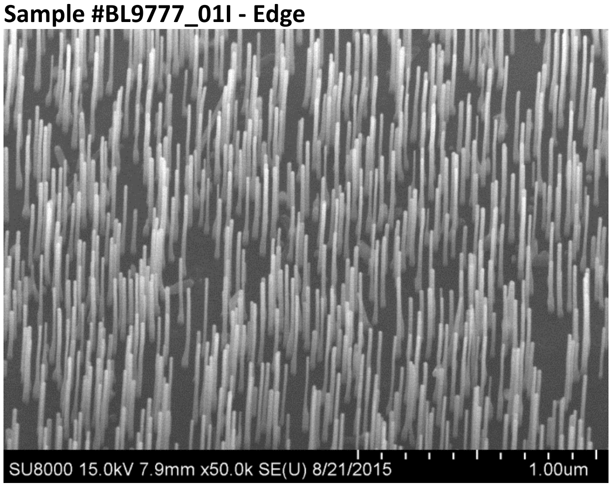


Sample #BL9777_01I - Center

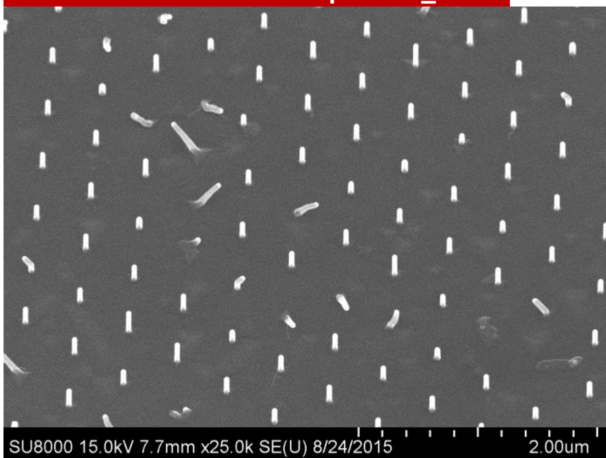


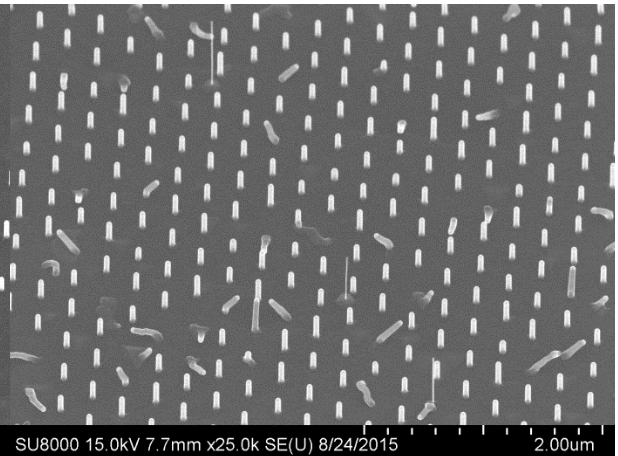


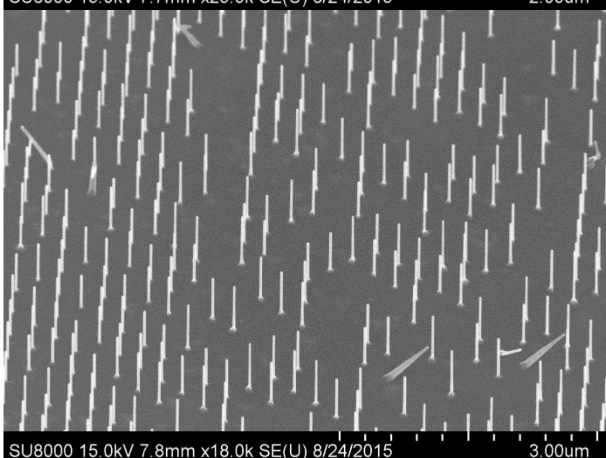
Sample #BL9777_01I - Edge

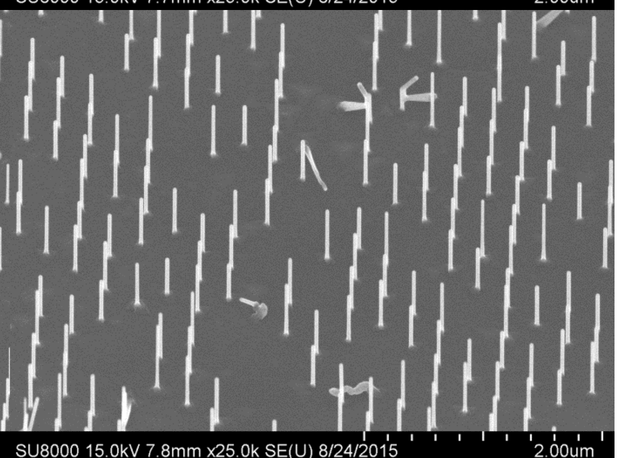


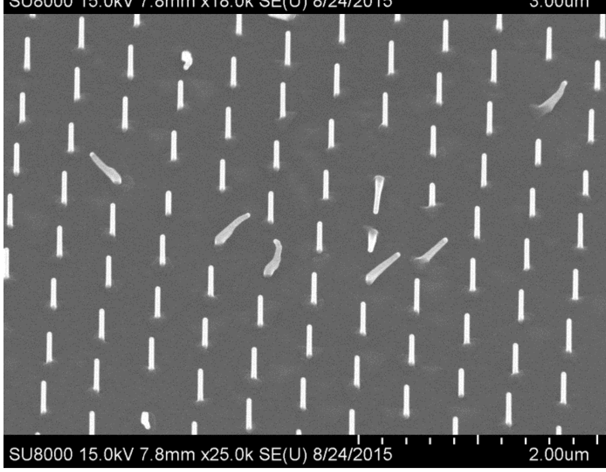
MOVPE RUN #10551 - Sample #GT_10551





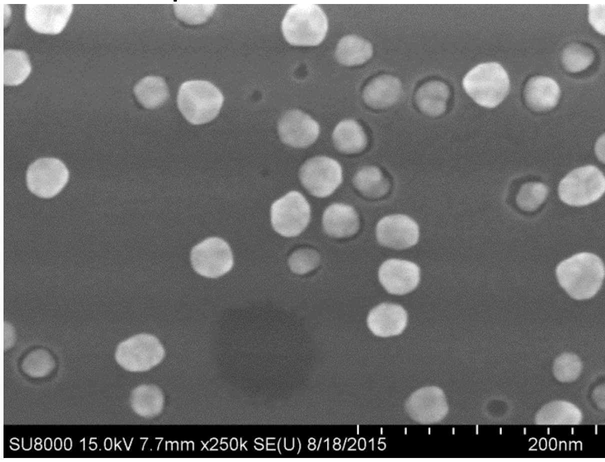




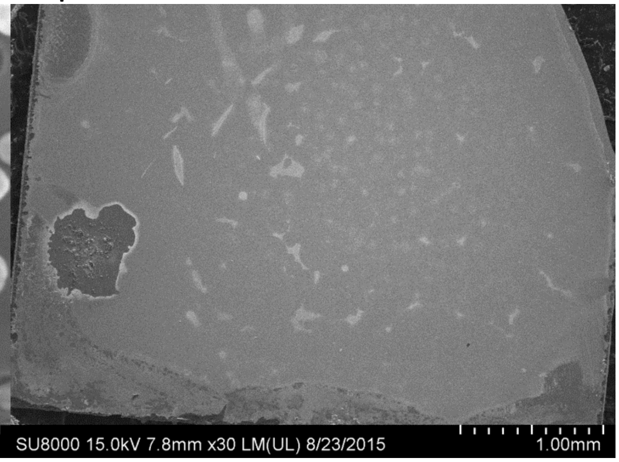


MOVPE RUN #10552 - Sample #BL9777_01L

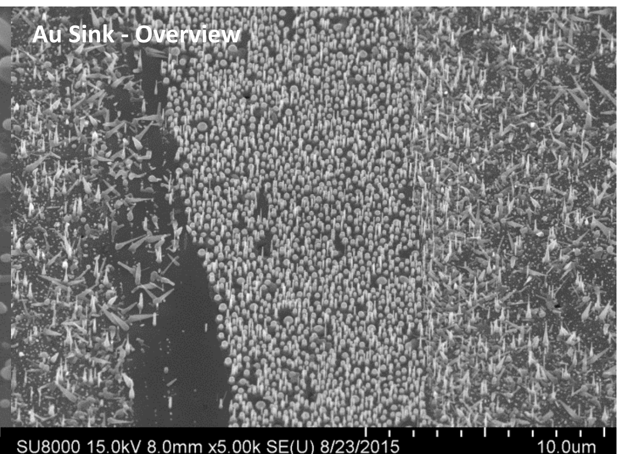
After electrodeposition

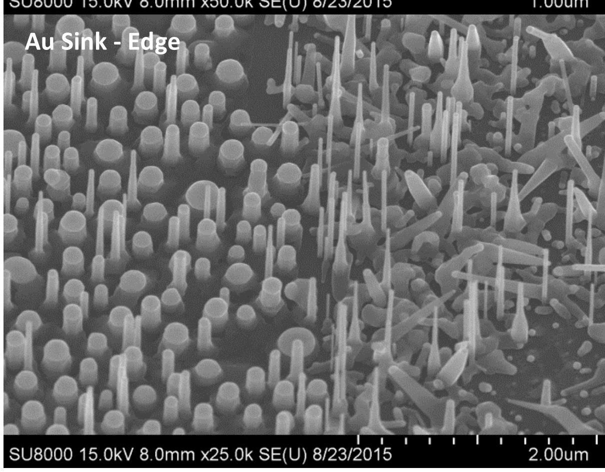


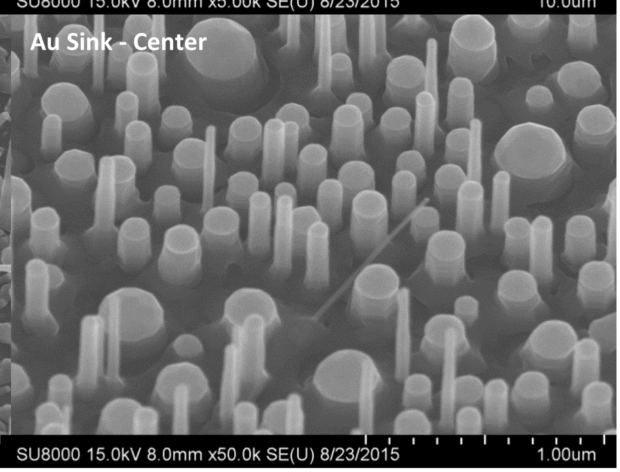
Sample overview after MOVPE



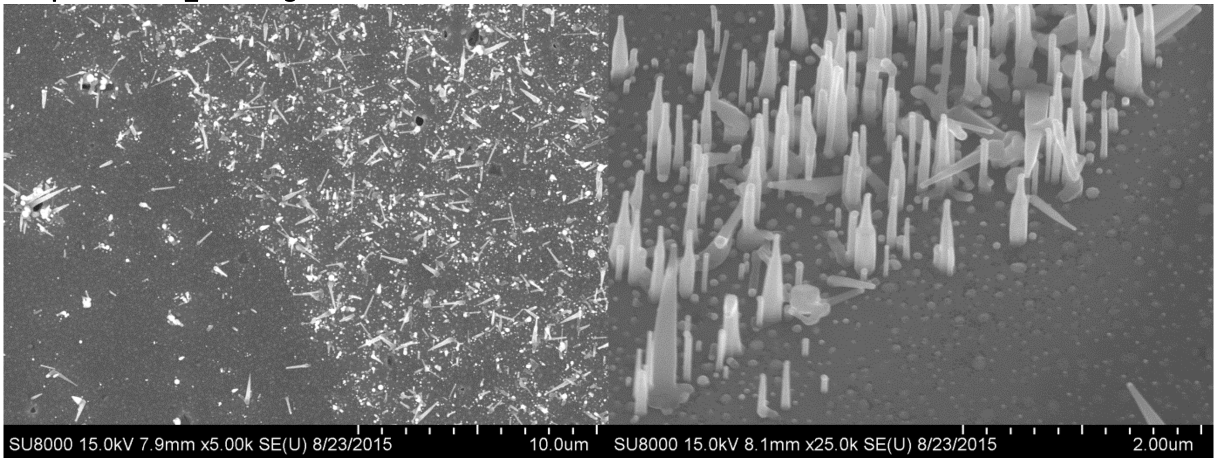
Sample #BL9777_01L - Center





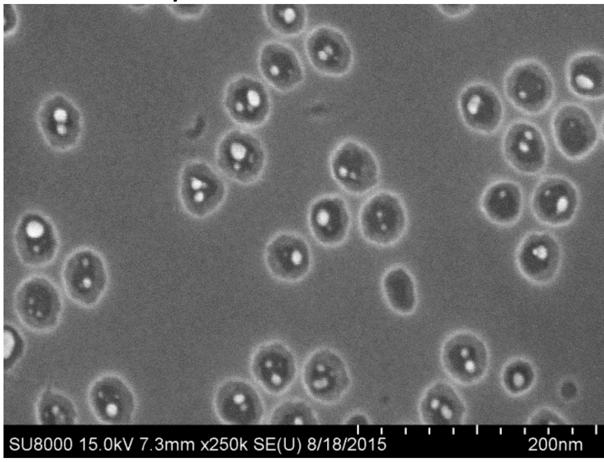


Sample #BL9777_01L - Edge

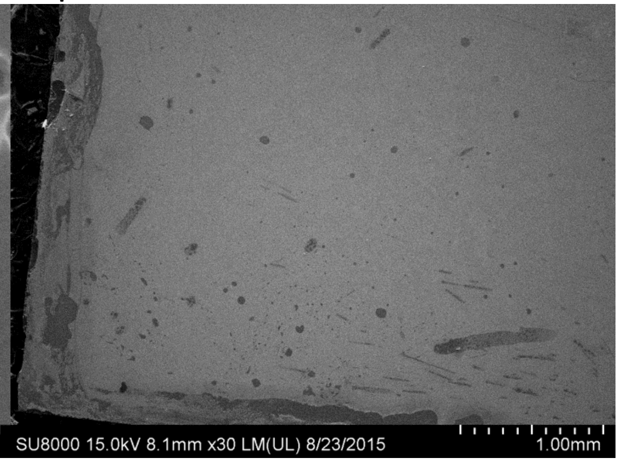


MOVPE RUN #10552 - Sample #BL9777_01J

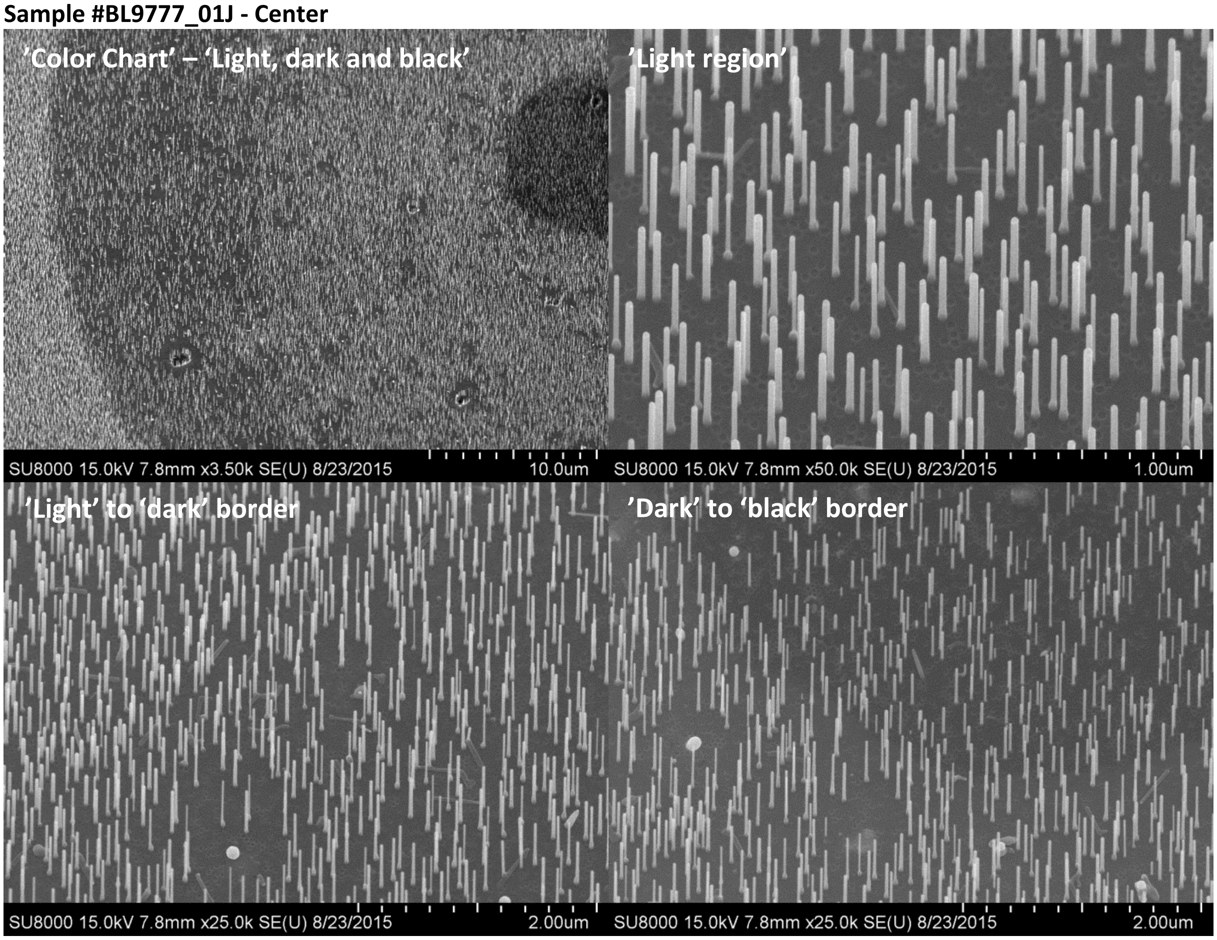
After electrodeposition

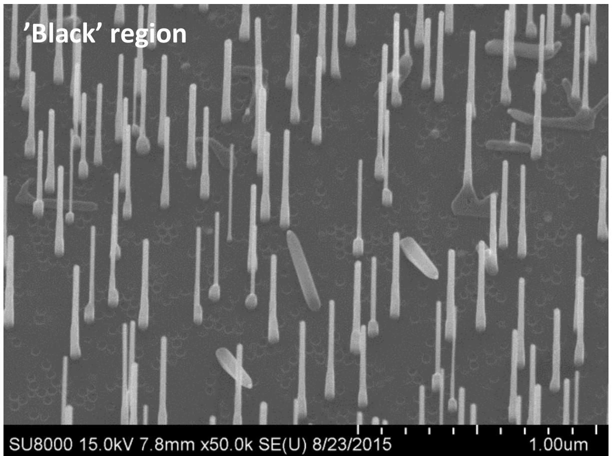


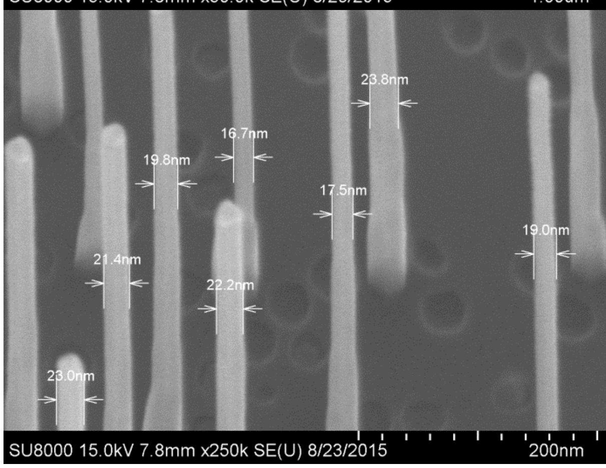
Sample overview after MOVPE

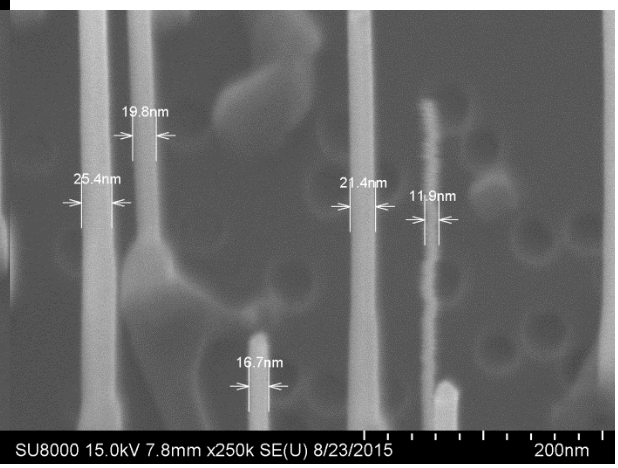


Sample #BL9777_01J - Center

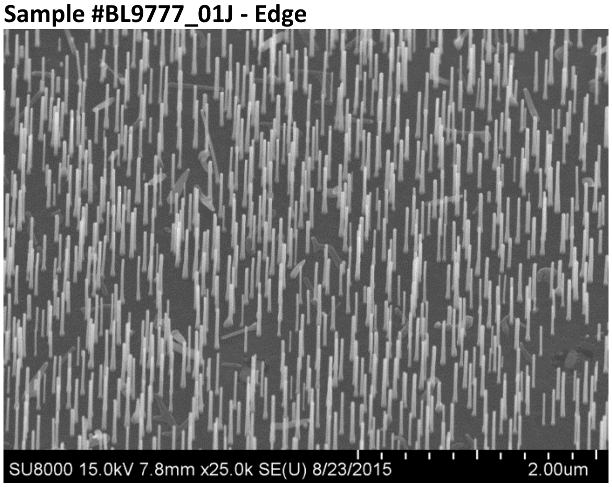








Sample #BL9777_01J - Edge



MOVPE RUN #10552 - Sample #GT_10552