Final Presentation:
Grayscale lithography for chiral nanophotonic structures

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Engr 241, Spring 2018

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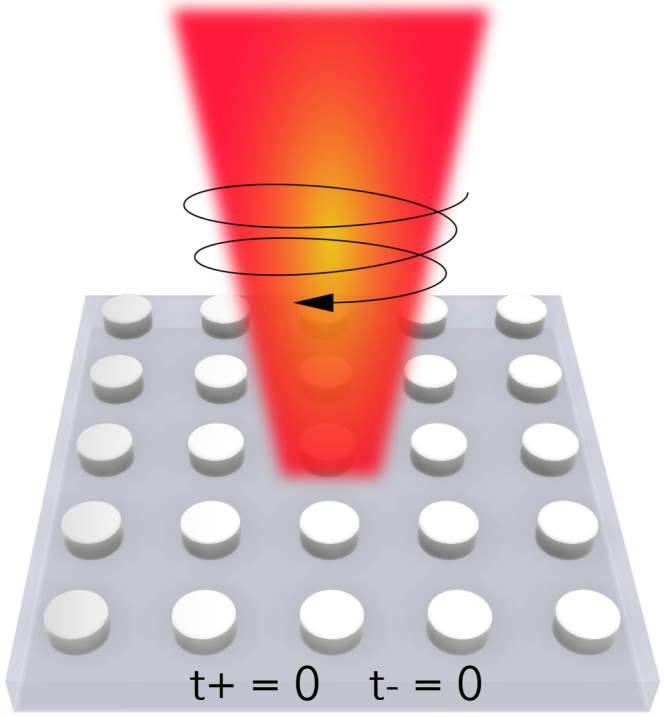
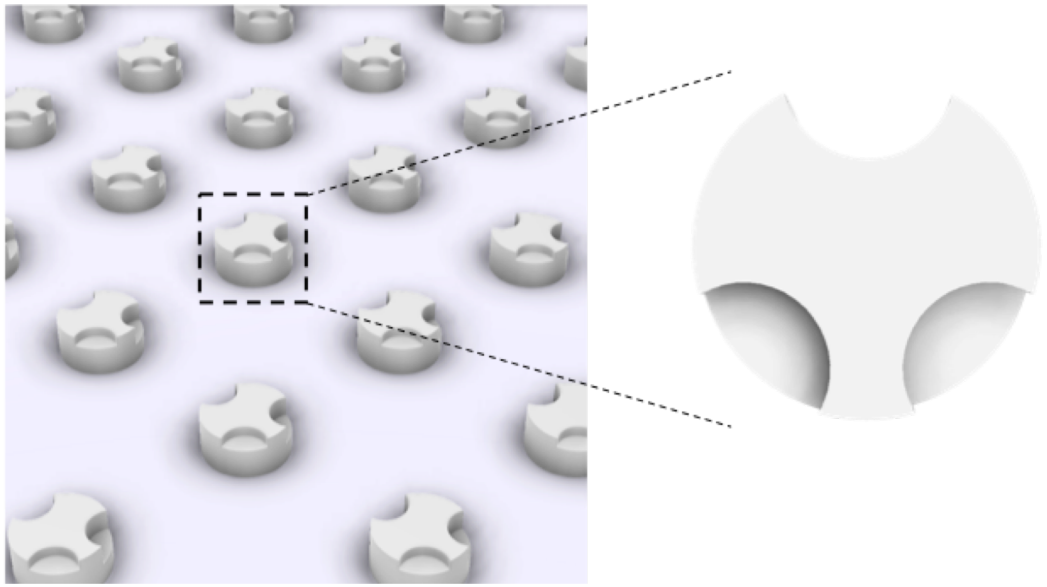
Asymmetric and chiral structures can manipulate light at the nanoscale

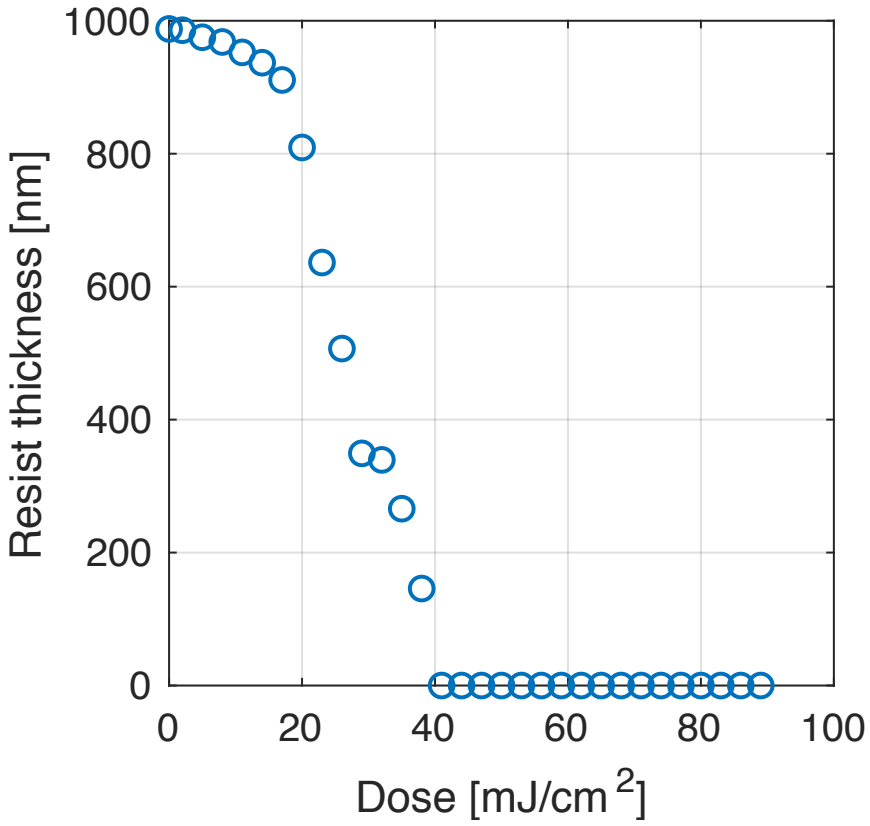




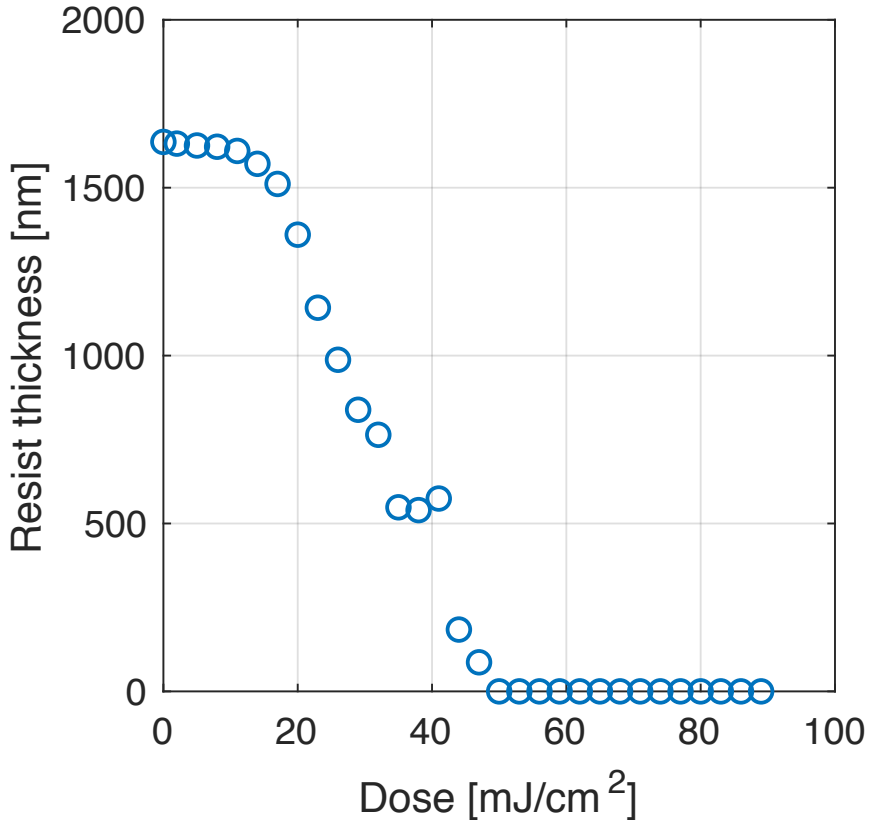
Chiral structures lacking out-of-plane symmetry transmit chiral light selectively

Contrast curves for 3612 resist using Nanospec

1 um of 3612 resist



1.6 um of 3612 resist

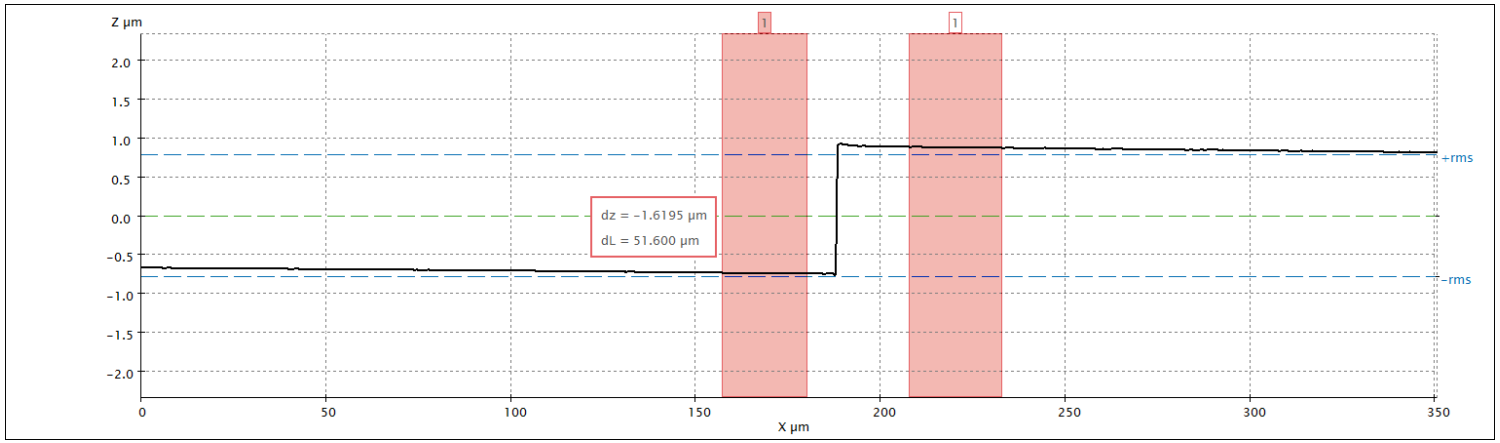


S-neox be used for dose testing

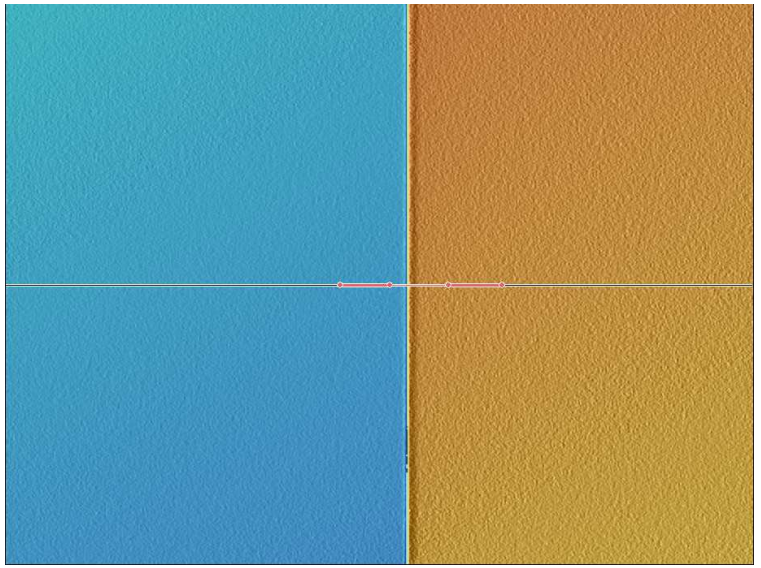
50x interferometer objective yields topology

Generally, S-neox is within 100nm of Nanospec measurements

Under the right conditions, the S-neox can measure resist thickness

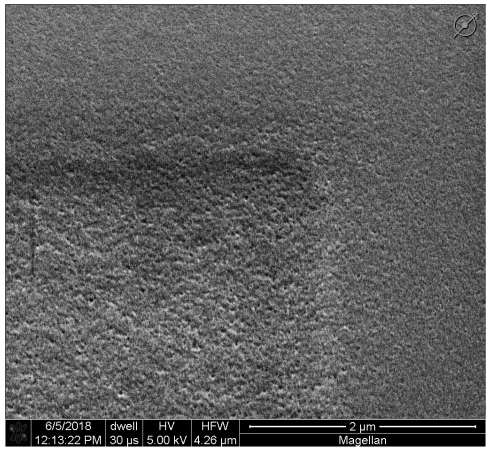


Cursor: dz = -1.6195 μm dL = 51.600 μm

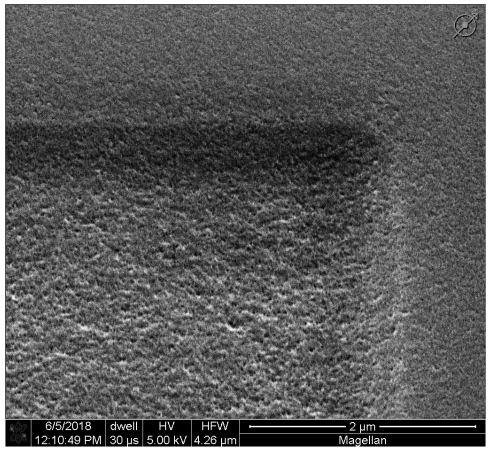


Sidewall characteristics of grayscale

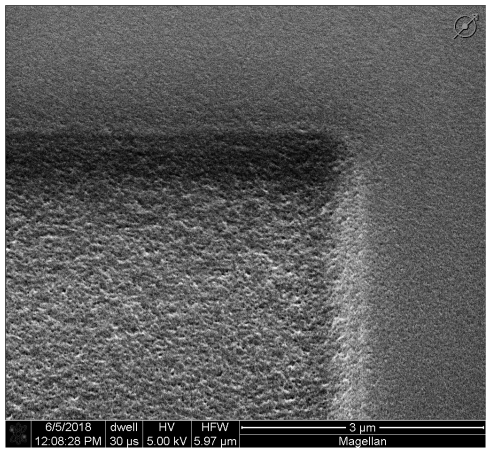
13 mJ/cm^2



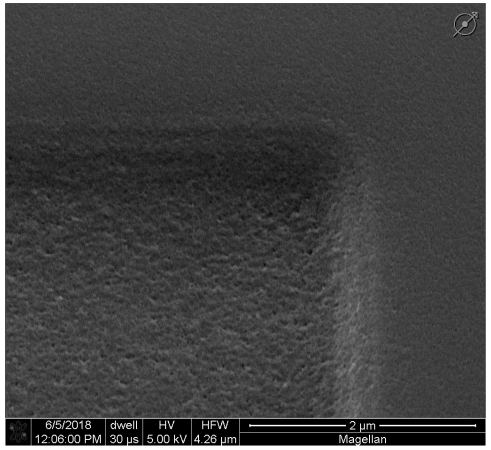
16 mJ/cm^2



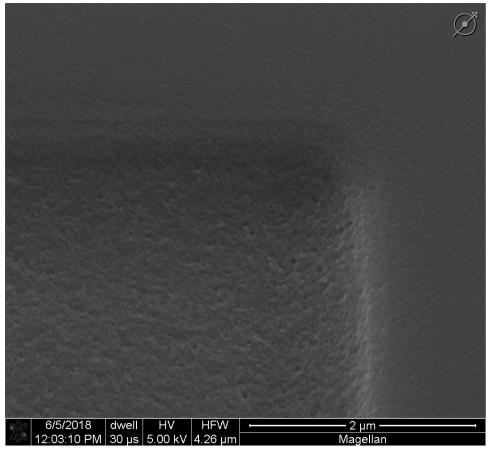
19 mJ/cm^2



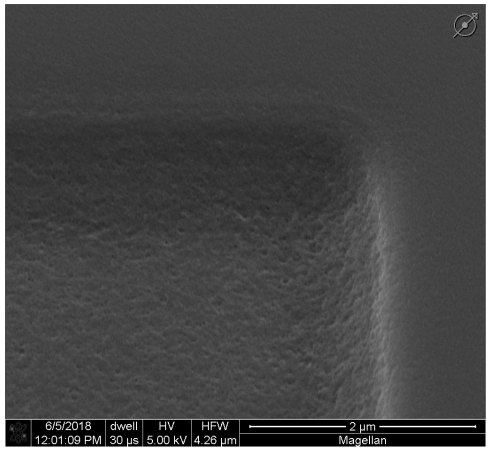
22 mJ/cm^2



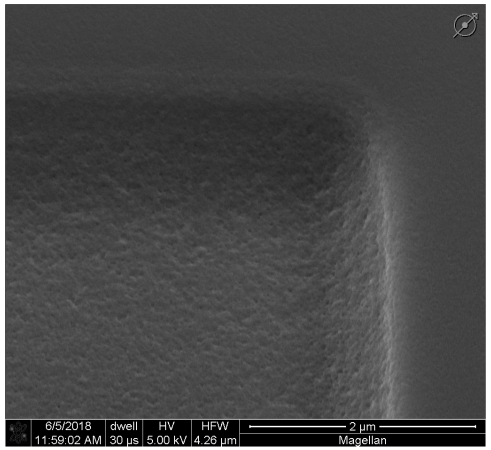
22 mJ/cm^2



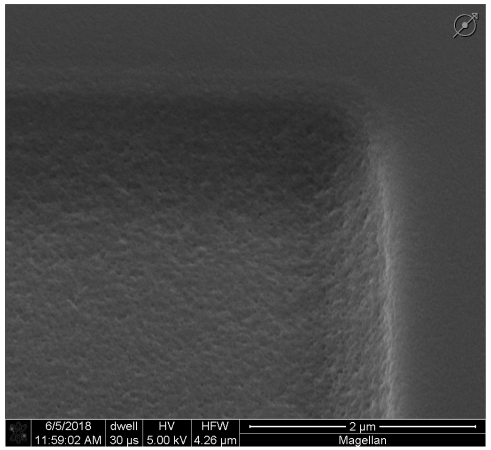
25 mJ/cm^2



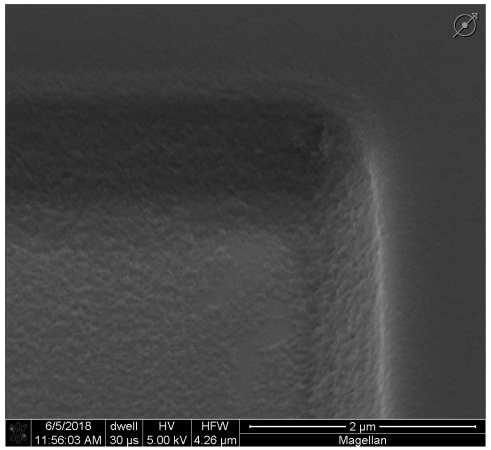
28 mJ/cm^2



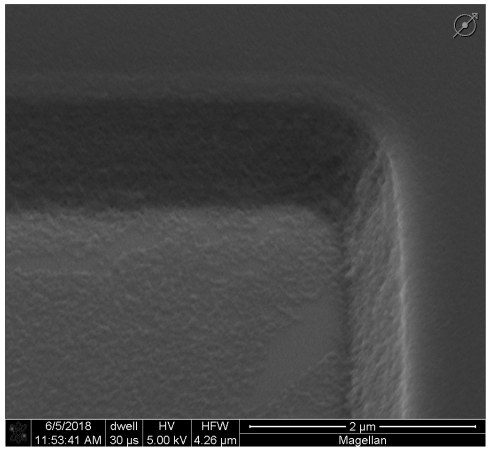
31 mJ/cm^2



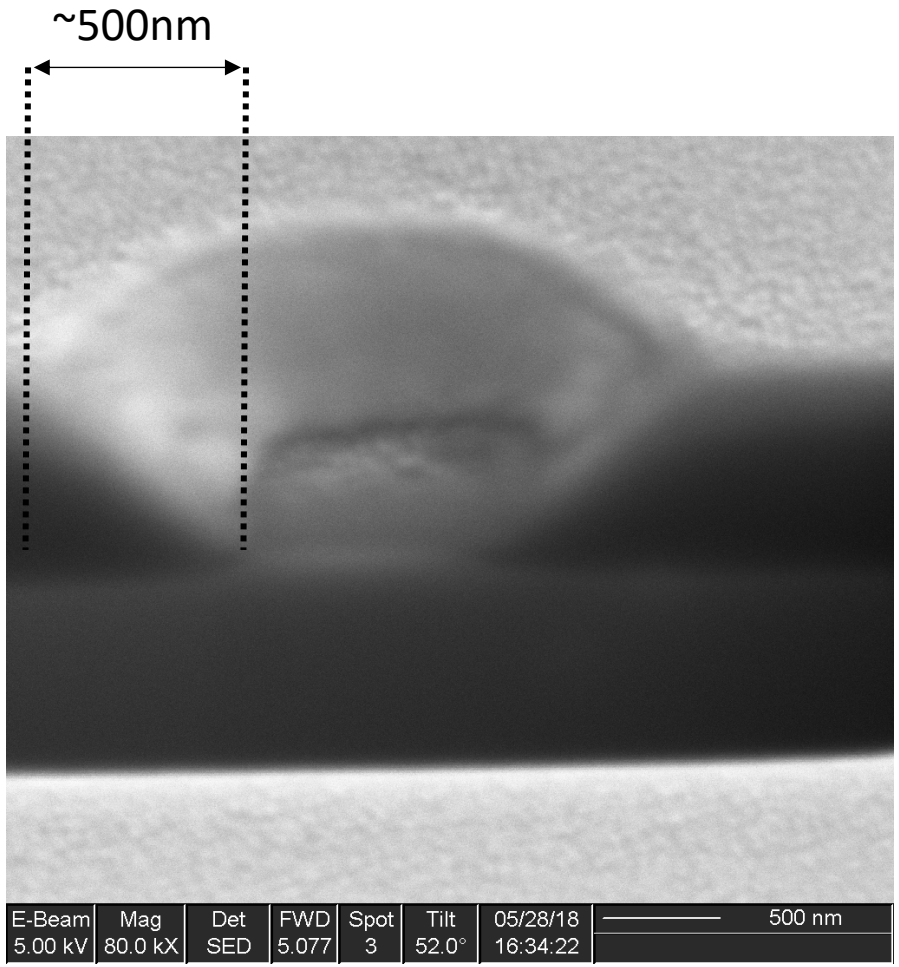
34 mJ/cm^2



37 mJ/cm^2

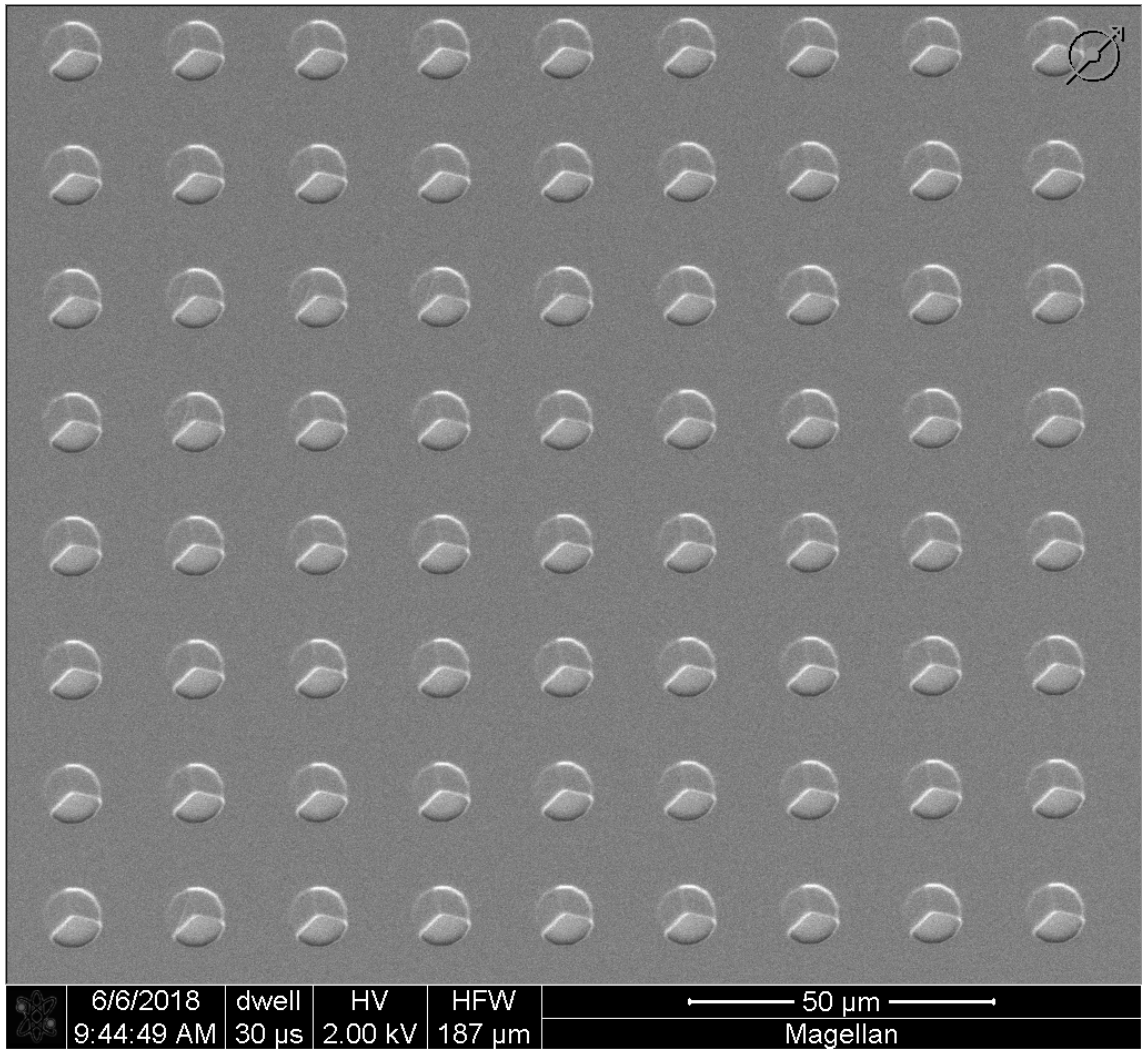


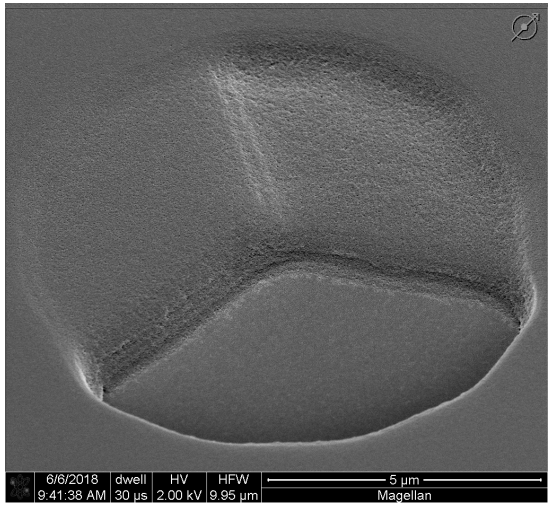
Sidewall is significant in resolution-limited, grayscale features



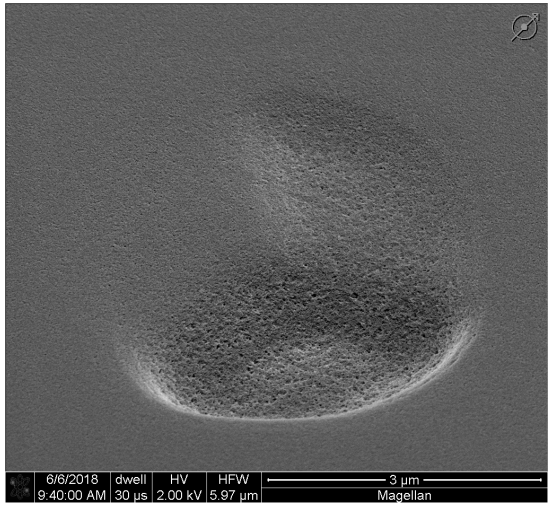
Cross-section of 2um circle
30 mJ/cm2 (underexposed)

Chiral design in photoresist



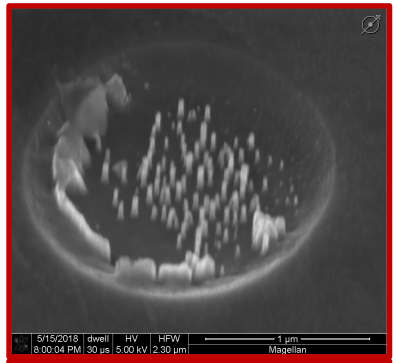
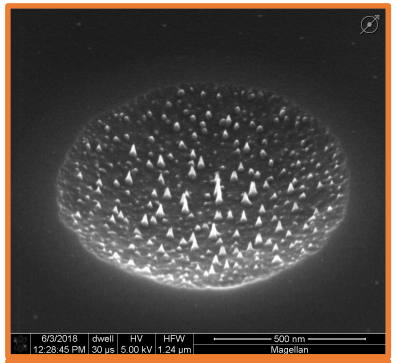
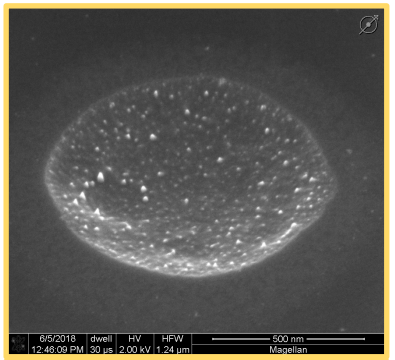
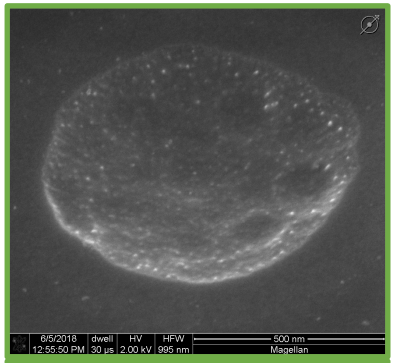
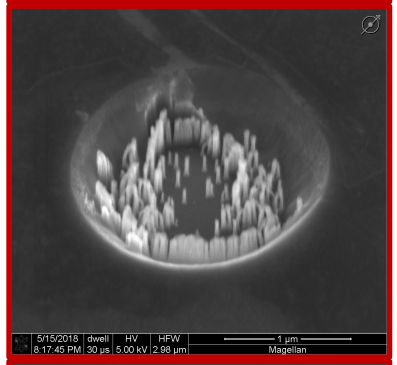
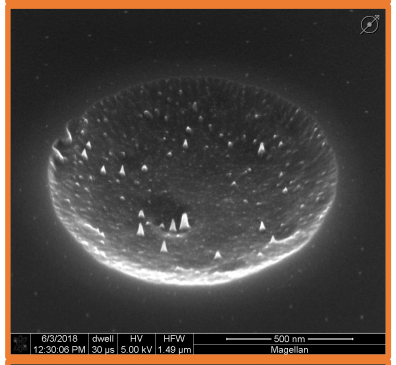
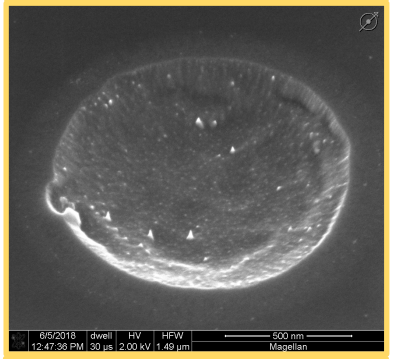
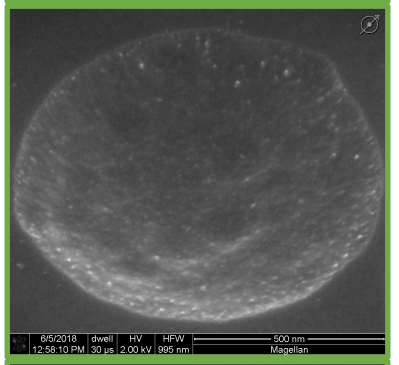
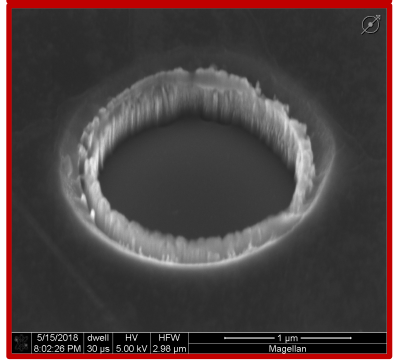
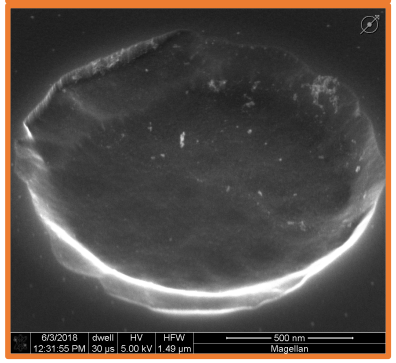
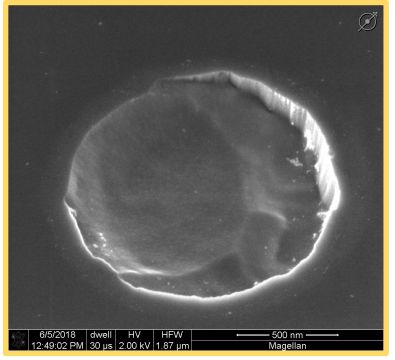
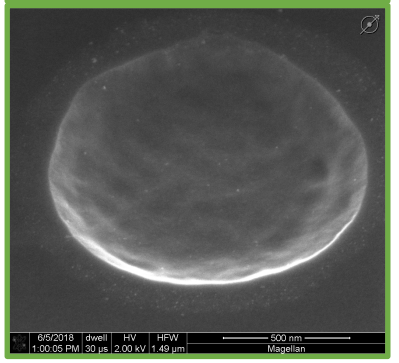


10 um:
20-50
mJ/cm^2



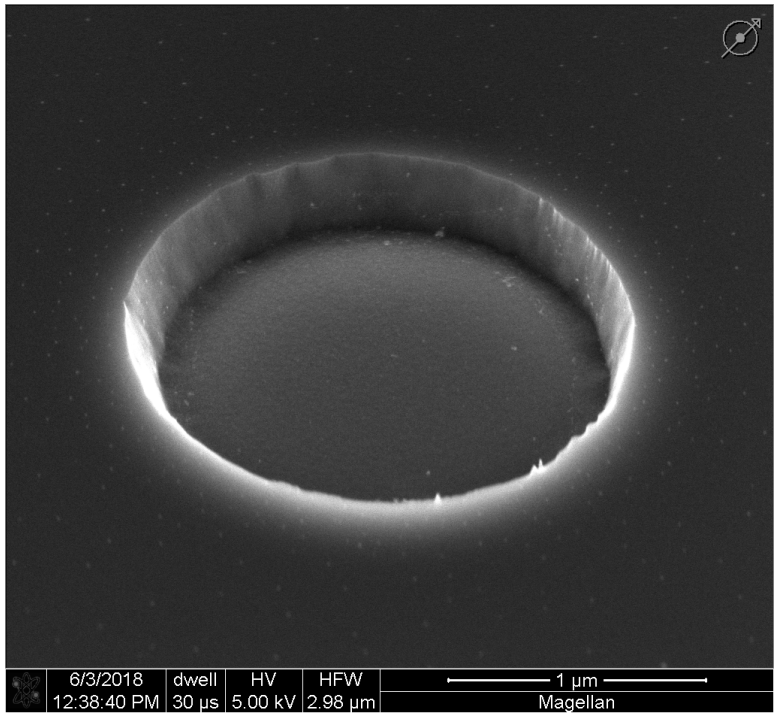
5 um:
15-40
mJ/cm^2

Etching resolution-limited features (2 µm nominally)

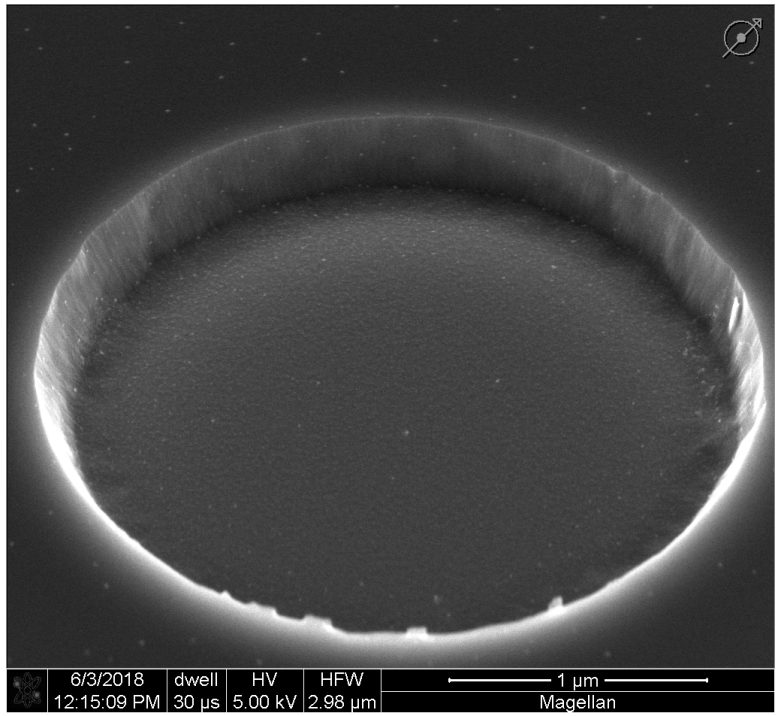
	Etch immediately	Post one 20 nm descum	Post two 20 nm descum	Post bake + one 20 nm descum
13 mJ/cm^2				
16 mJ/cm^2				
19 mJ/cm^2				

Dose-to-clear varies for structures approaching resolution limit

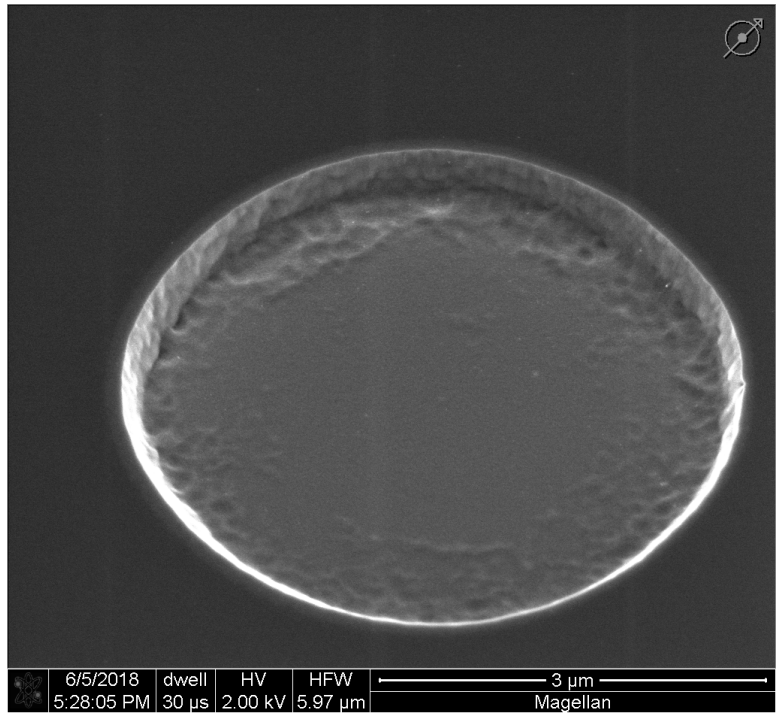
2 µm, 54 mJ/cm^2



3 µm,, 48 mJ/cm^2

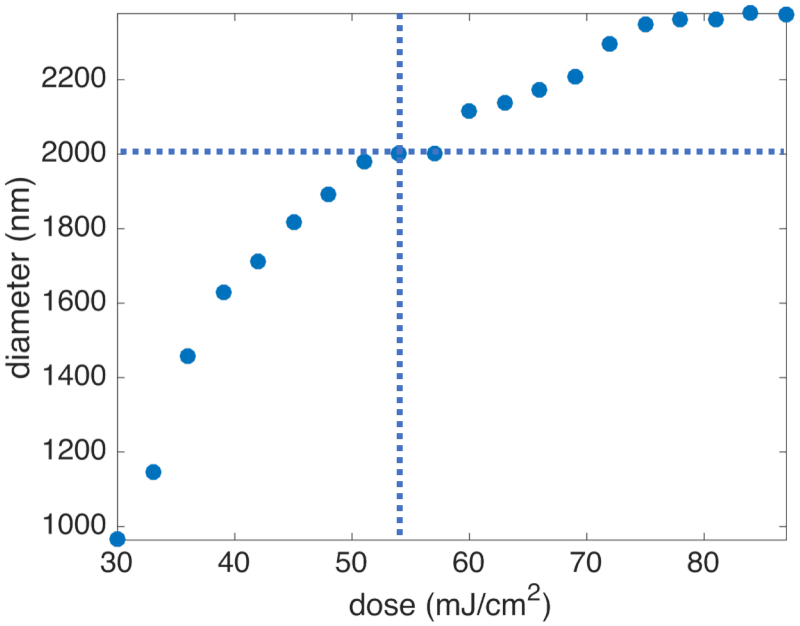


5 µm, 32 mJ/cm^2

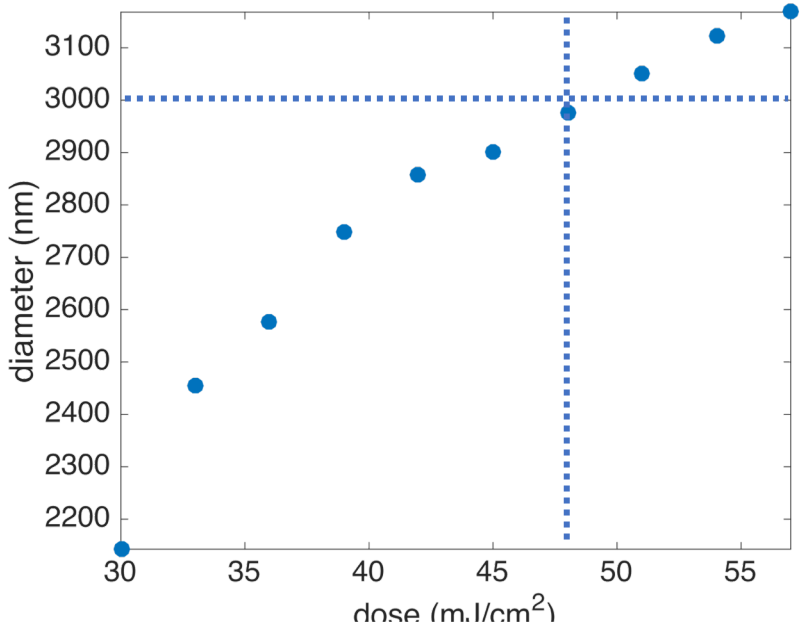


Diameter varies with dose

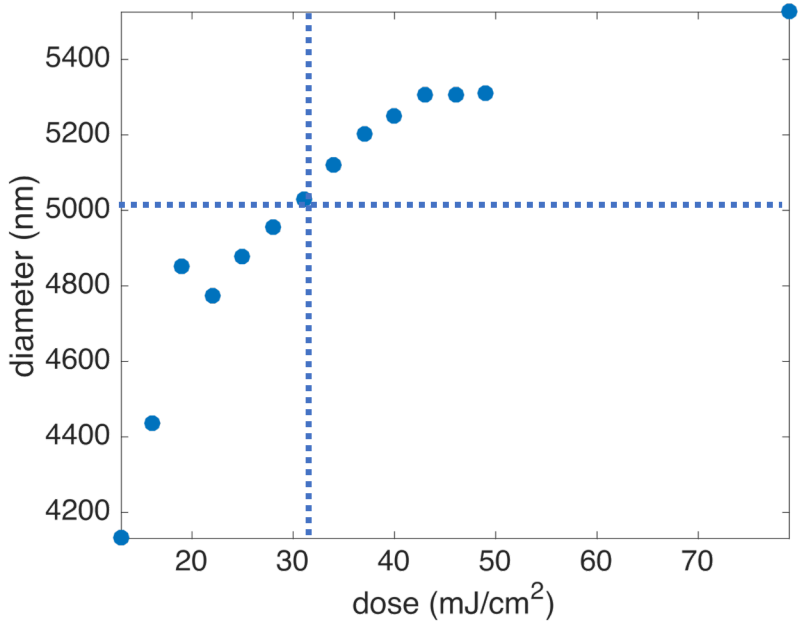
2 µm



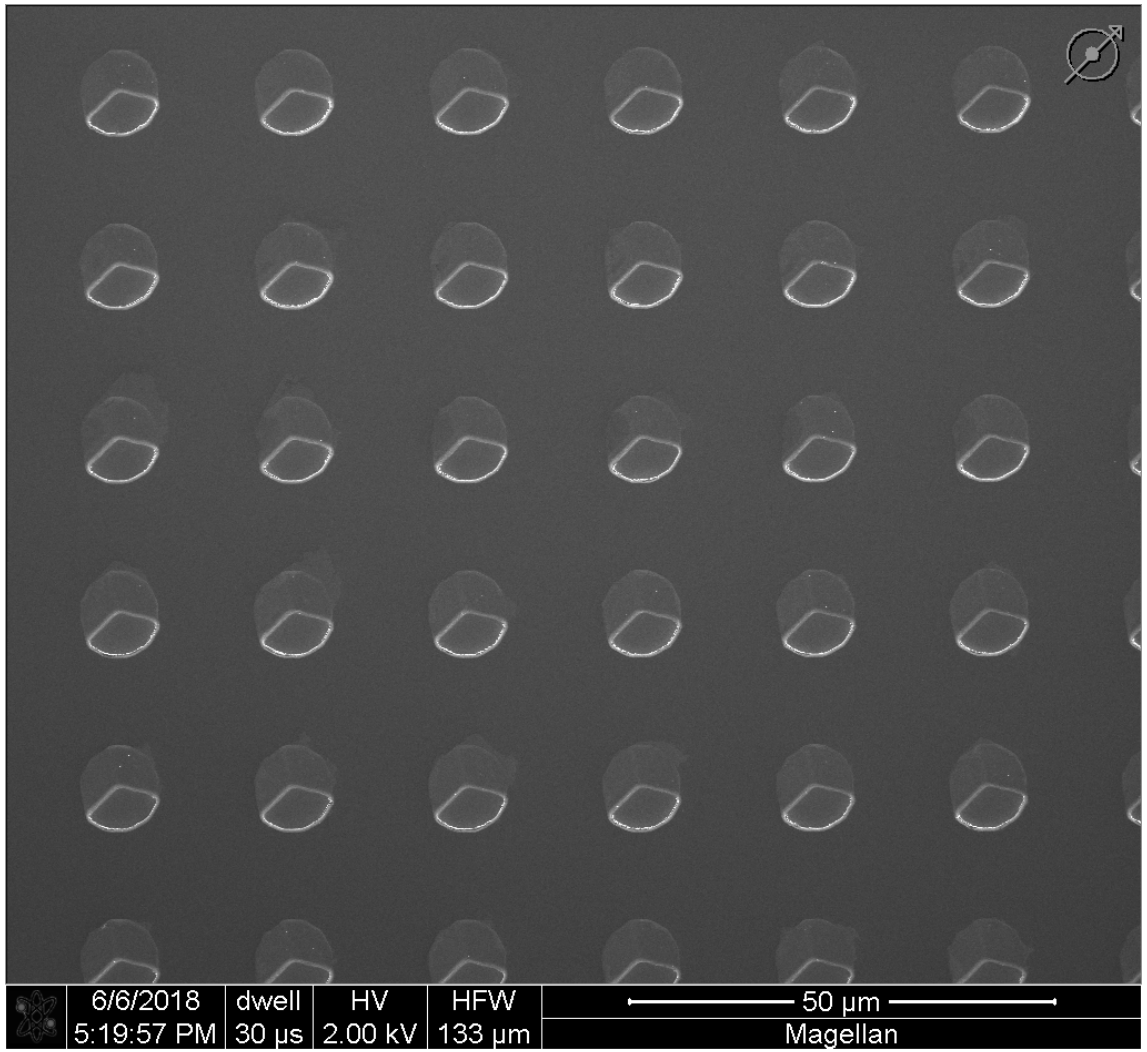
3 µm

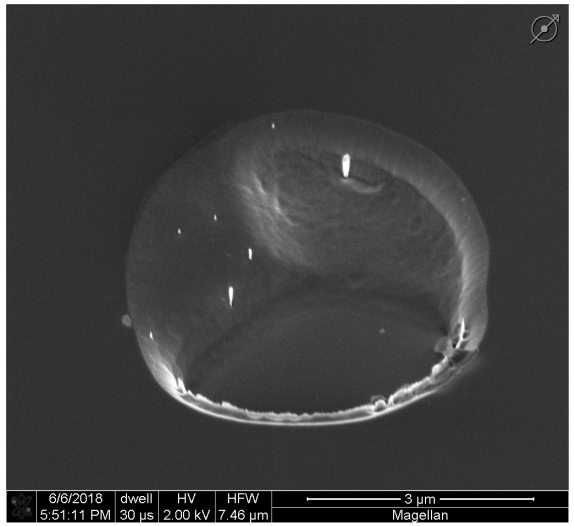


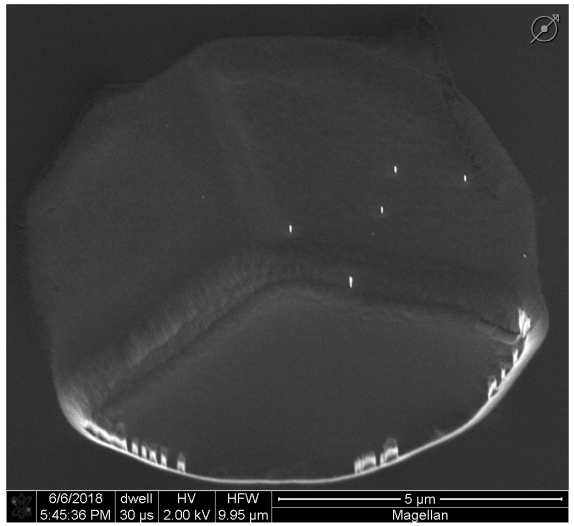
5 µm



Etching chiral design at 5 and 3 um







Future Work

AFM to accurately measure depths of low-dose features

Optimization of bake and descum process

Alignment of overlapping <5um features

Development for 1-dimensional period grating metamaterials

Conclusions:
Grayscale lithography for chiral nanophotonic structures

Grayscale range using 3612

- 15-40 mJ/cm^2 with granularity of 2 mJ/cm^2

Dose scaling of features in the Heidelberg

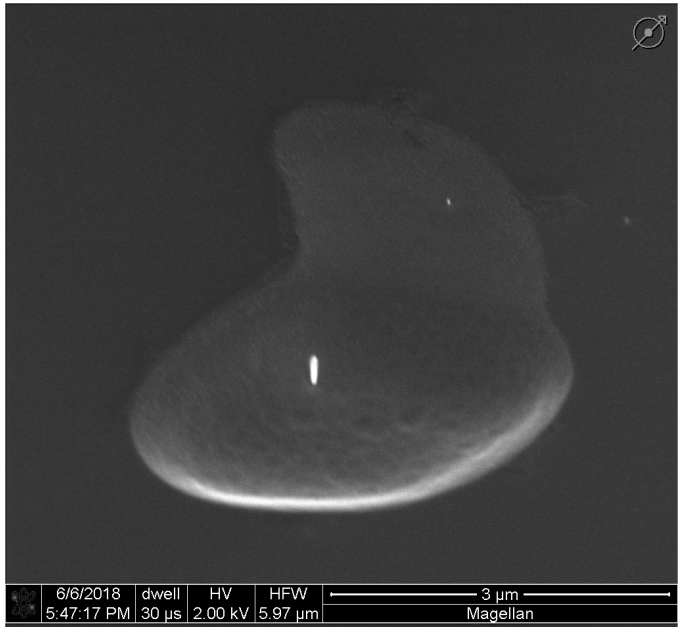
- Below 5um, dose should be reduced to avoid overexposure

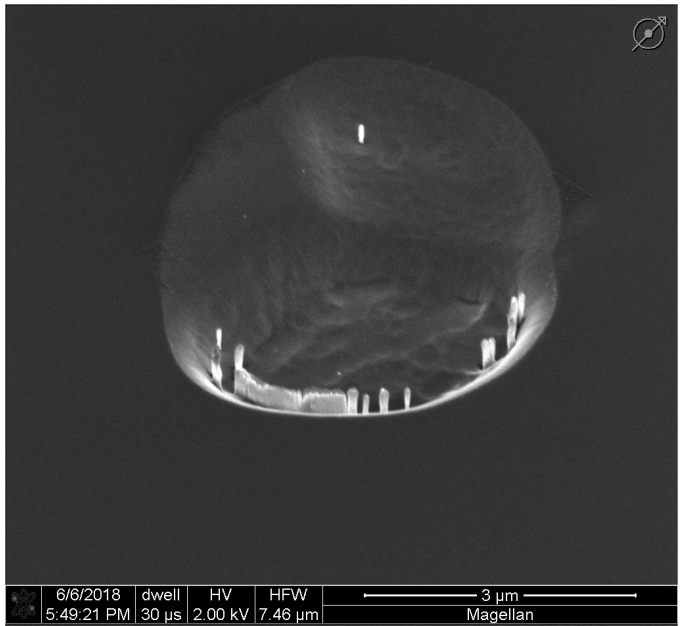
Grayscale of resolution-limited features

- Sidewall may affect a significant area of small features
- Descum and post-etch clean necessary

Resolution limits use for 2D periodic structures at optical frequencies

Clean, 1um features possible with appropriate etching parameters


6/6/2018
5:47:17 PM
dwell
30 µs
HV
2.00 kV
HFW
5.97 µm
3 µm
Magellan


6/6/2018
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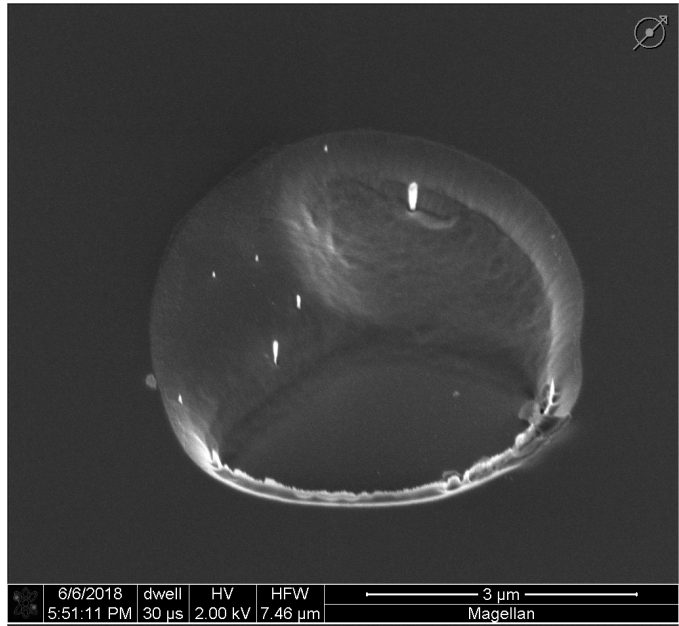
dwell
30 µs
HV
2.00 kV
HFW
7.46 µm
3 µm
Magellan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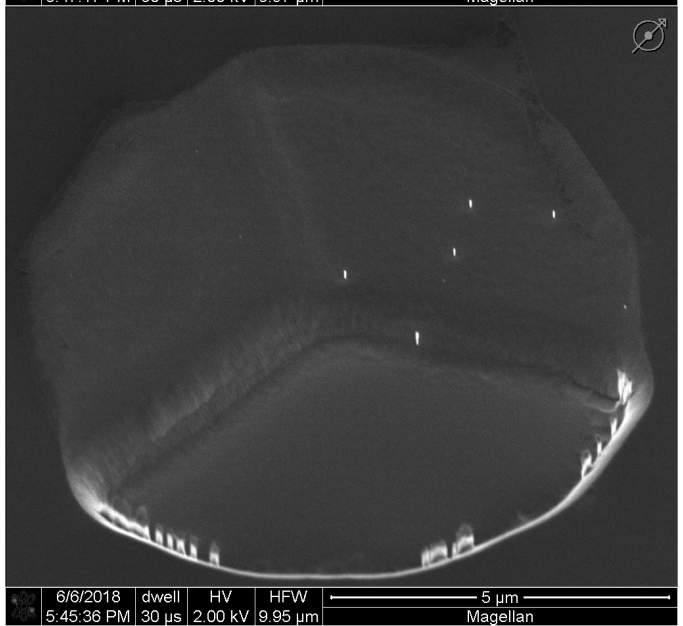
dwell
30 µs
HV
2.00 kV
HFW
7.46 µm
3 µm
Magellan


6/6/2018
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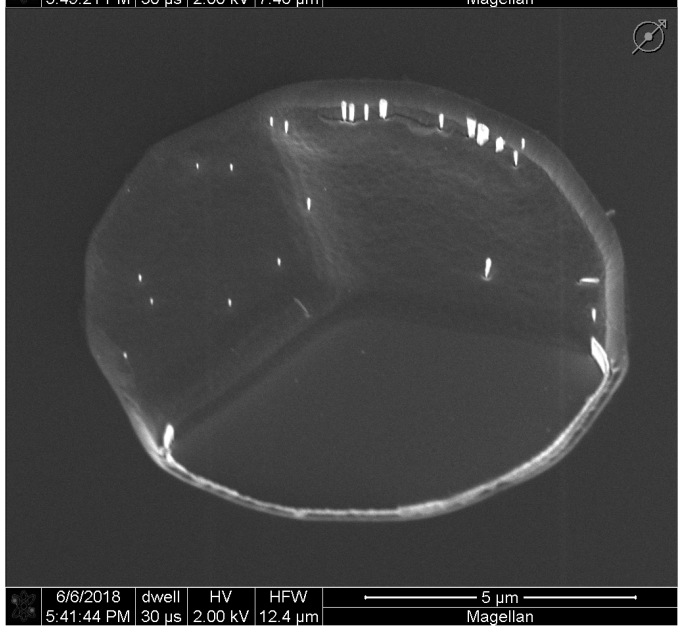
dwell
30 µs
HV
2.00 kV
HFW
9.95 µm
5 µm
Magellan


6/6/2018
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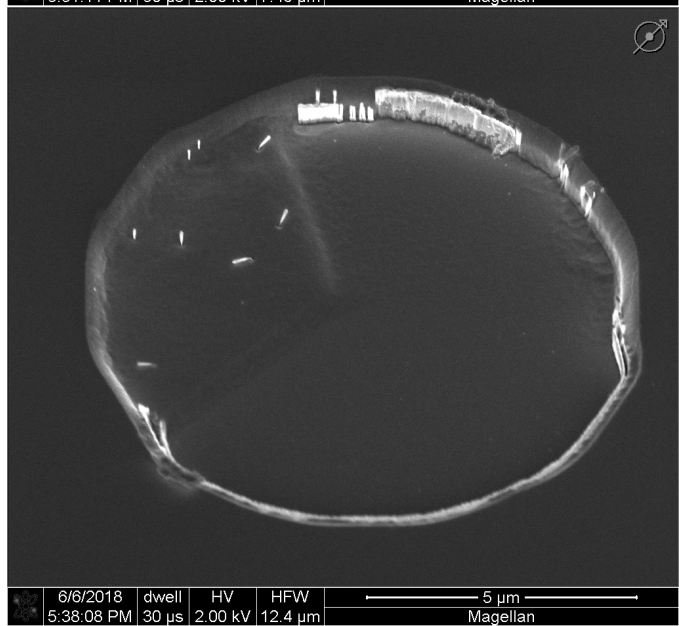
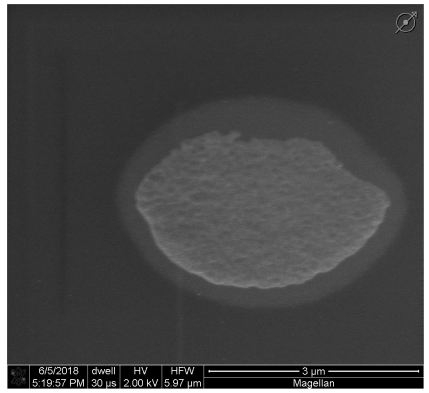
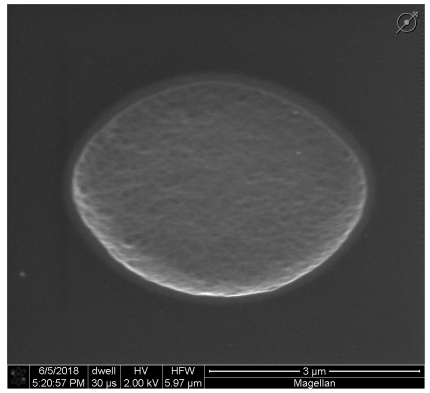
dwell
30 µs
HV
2.00 kV
HFW
12.4 µm
5 µm
Magellan


6/6/2018
5:38:08 PM
dwell
30 µs
HV
2.00 kV
HFW
12.4 µm
5 µm
Magellan


6/5/2018 5:19:57 PM | dwell 30 µs | HV 2.00 kV | HFW 5.97 µm | 3 µm | Magellan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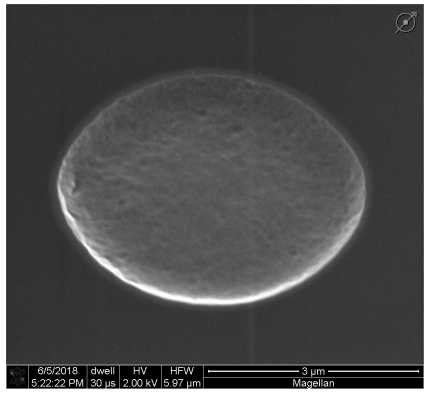
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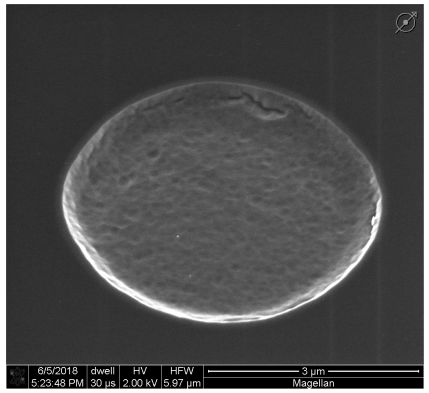
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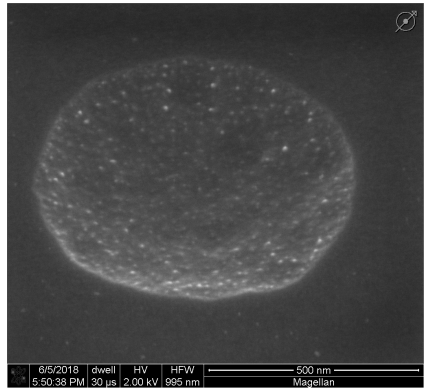
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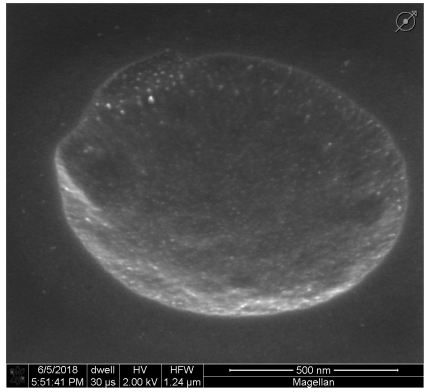
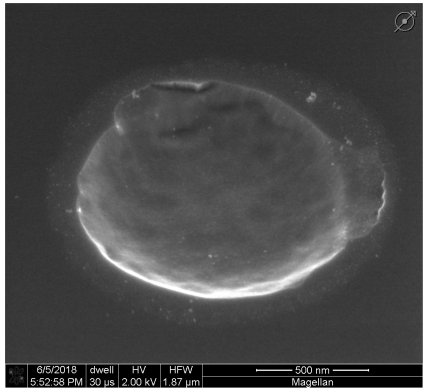
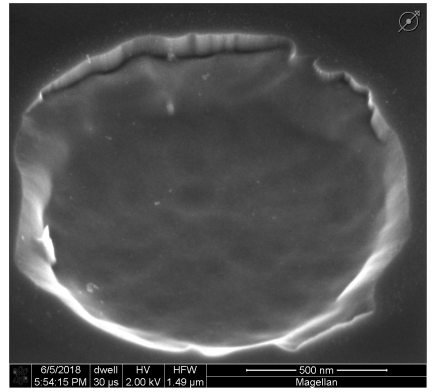
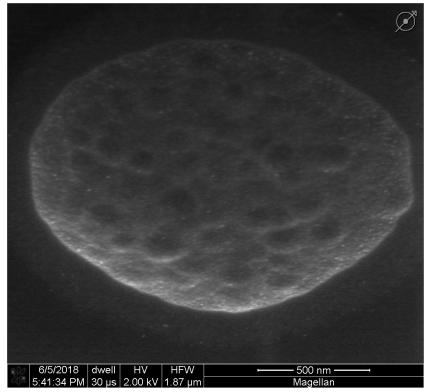
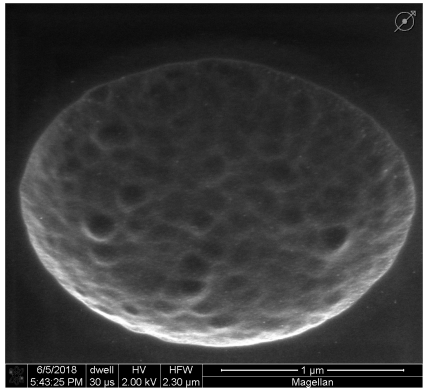
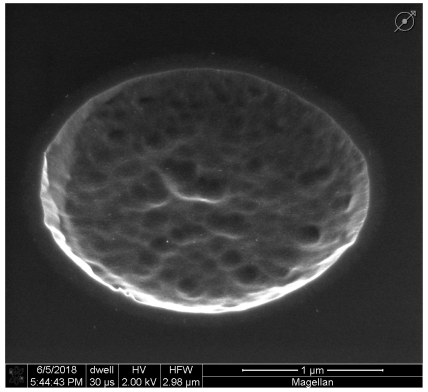

6/5/2018 5:51:41 PM | dwell 30 µs | HV 2.00 kV | HFW 1.24 µm | 500 nm | Magellan

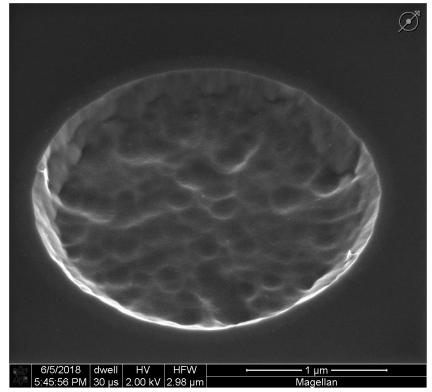

6/5/2018 5:52:58 PM | dwell 30 µs | HV 2.00 kV | HFW 1.87 µm | 500 nm | Magellan


6/5/2018 5:54:15 PM | dwell 30 µs | HV 2.00 kV | HFW 1.49 µm | 500 nm | Magellan


6/5/2018 5:41:34 PM | dwell 30 µs | HV 2.00 kV | HFW 1.67 µm | 500 nm | Magellan


6/5/2018 5:43:25 PM | dwell 30 µs | HV 2.00 kV | HFW 2.30 µm | 1 µm | Magellan


6/5/2018 5:44:43 PM | dwell 30 µs | HV 2.00 kV | HFW 2.98 µm | 1 µm | Magellan


6/5/2018 5:45:56 PM | dwell 30 µs | HV 2.00 kV | HFW 2.98 µm | 1 µm | Magellan