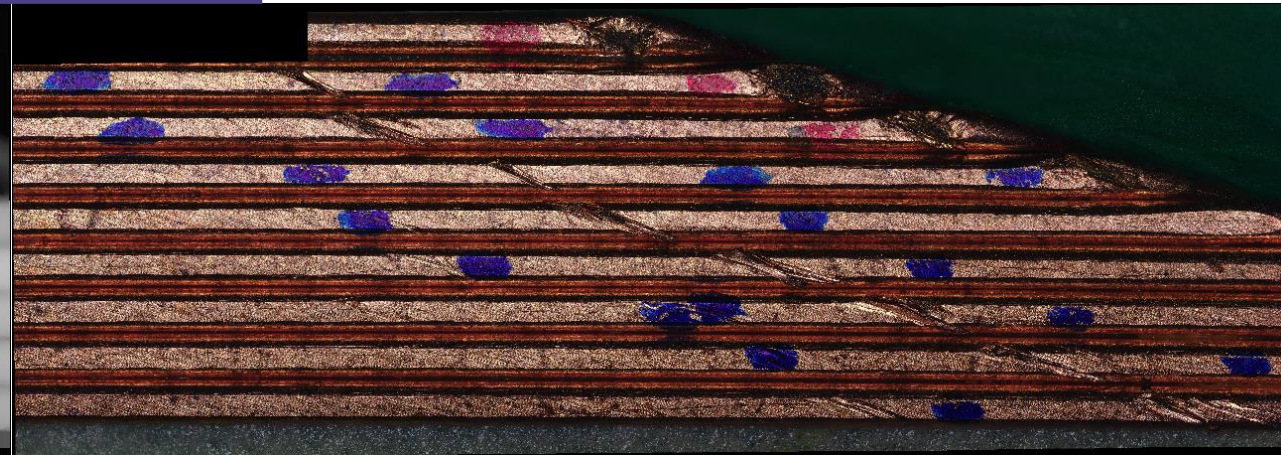
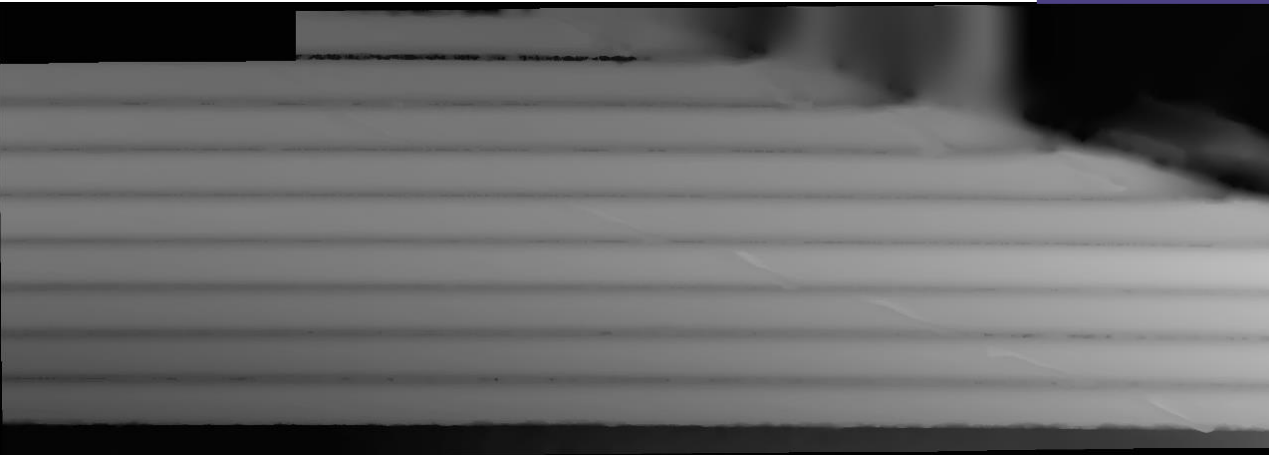


Investigation of HL-LHC coil 254 Damage by Using Polymer Replicas

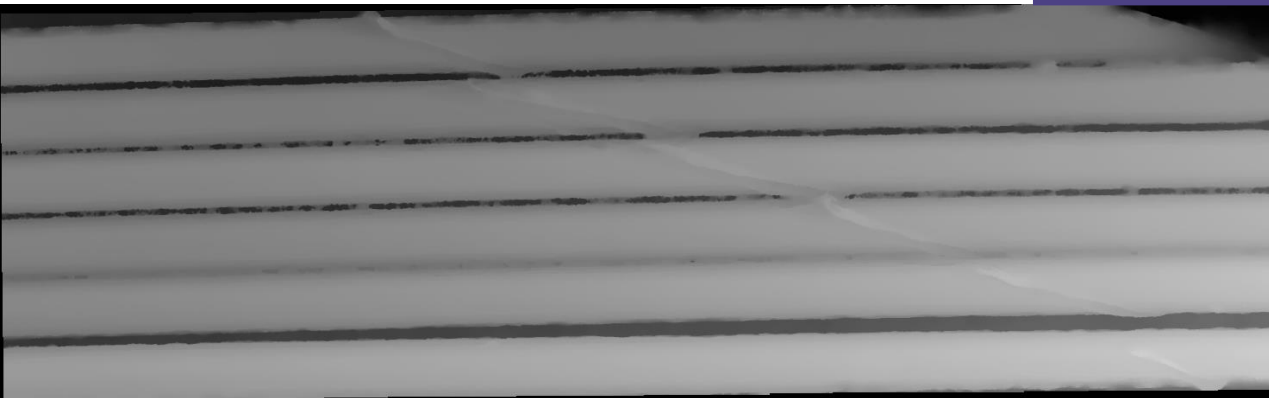
Liora Louis, 06/11/2024

Olympus DSX: Red and Blue Strands

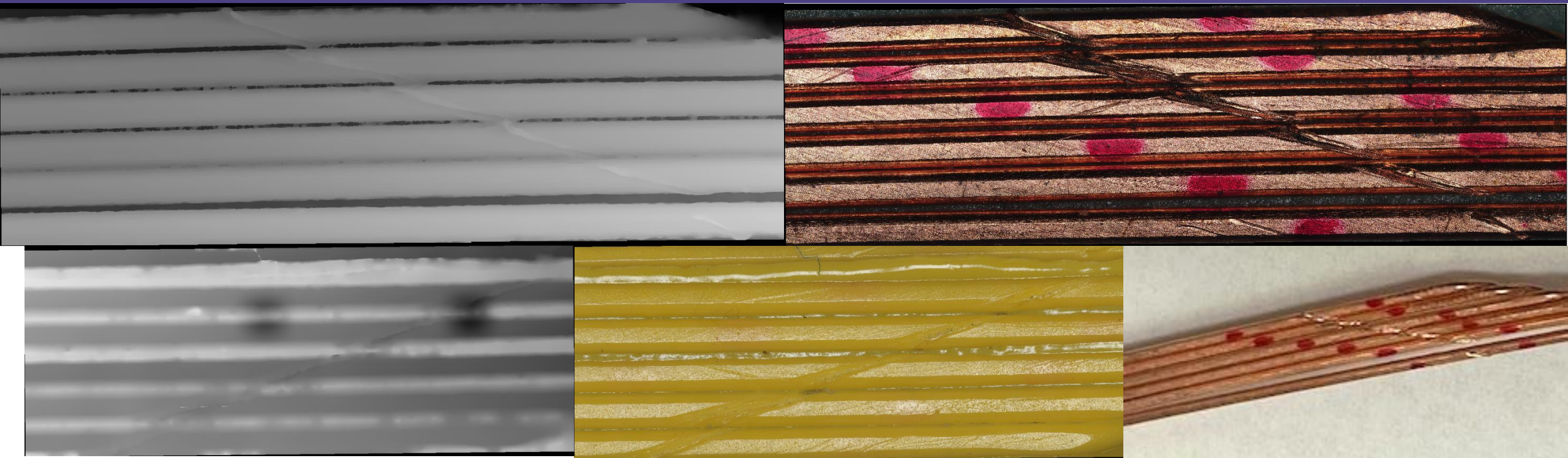
Blue Strands



Red Strands



Olympus DSX: Red Strands

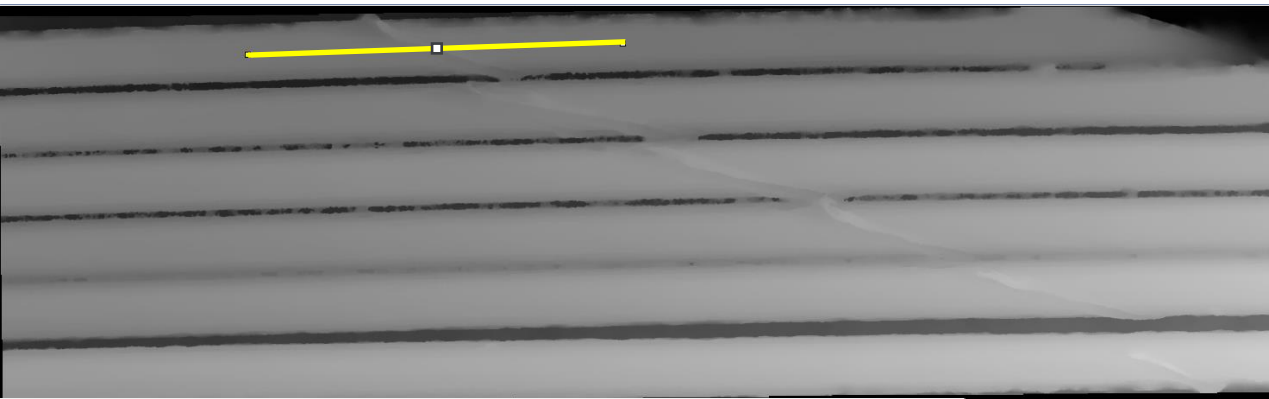


Red Strands:

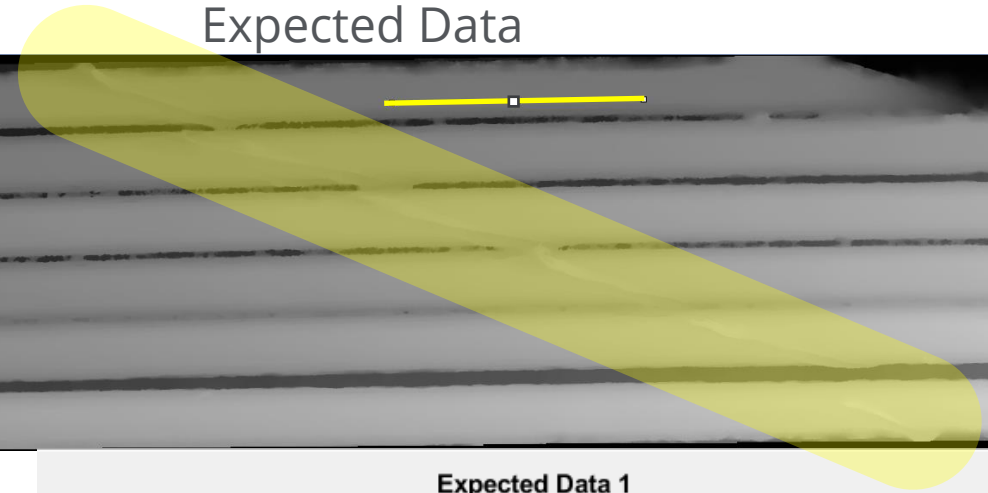
- The calibration value for this image was : $0.03751 \mu\text{m}$
- The deepest cut measured was: $83.78 \mu\text{m}$
- The same scratch measured at $78.79 \mu\text{m}$

Red Strands: Scratch 1

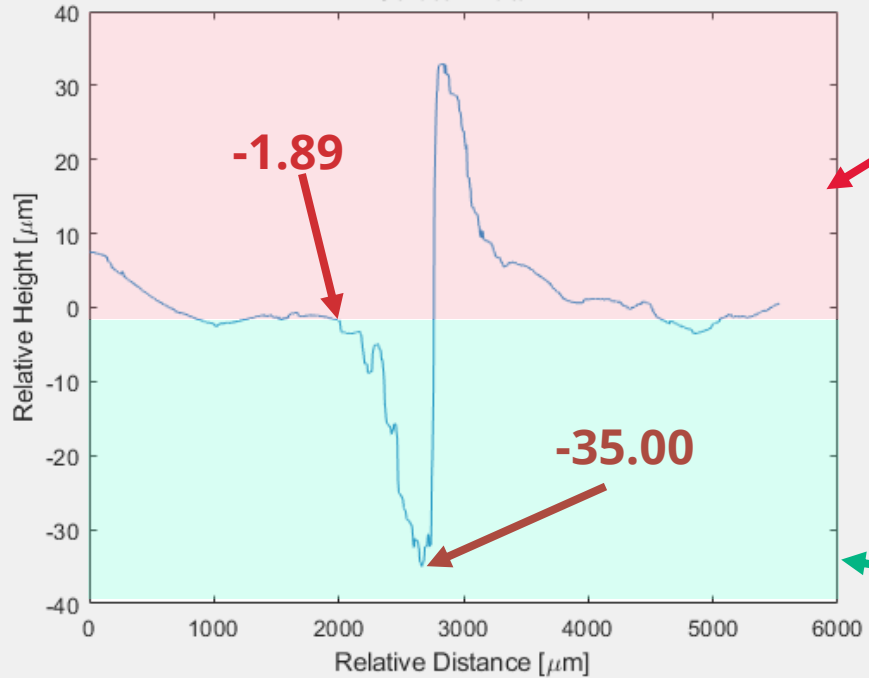
Scratch Data



Expected Data



Scratch Data 1



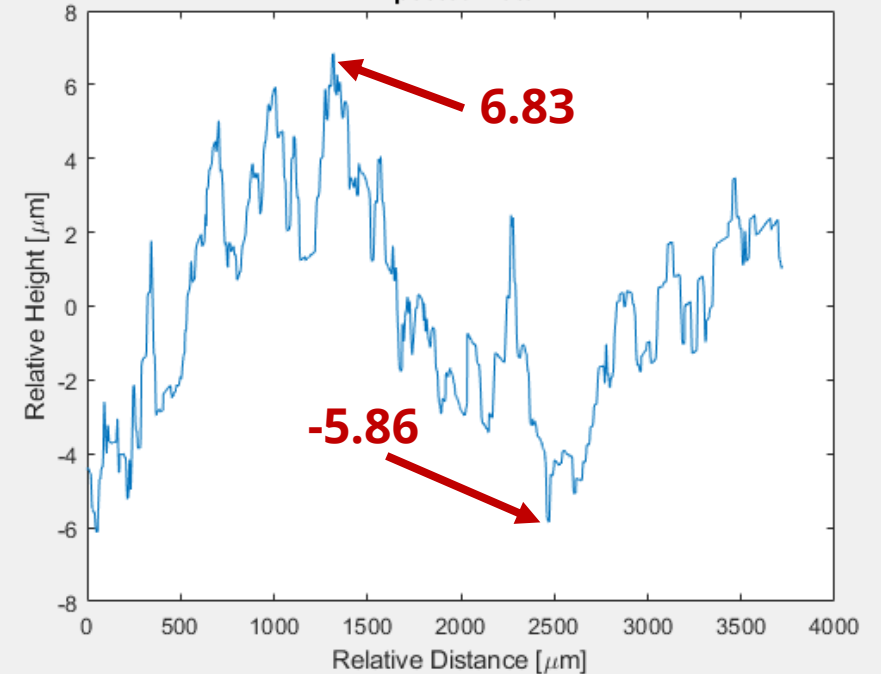
Lifted Material

Scratch 1

- Cut Depth: 33.11 μm
- Expected Standard Deviation: 2.8658 μm over 3.7 mm

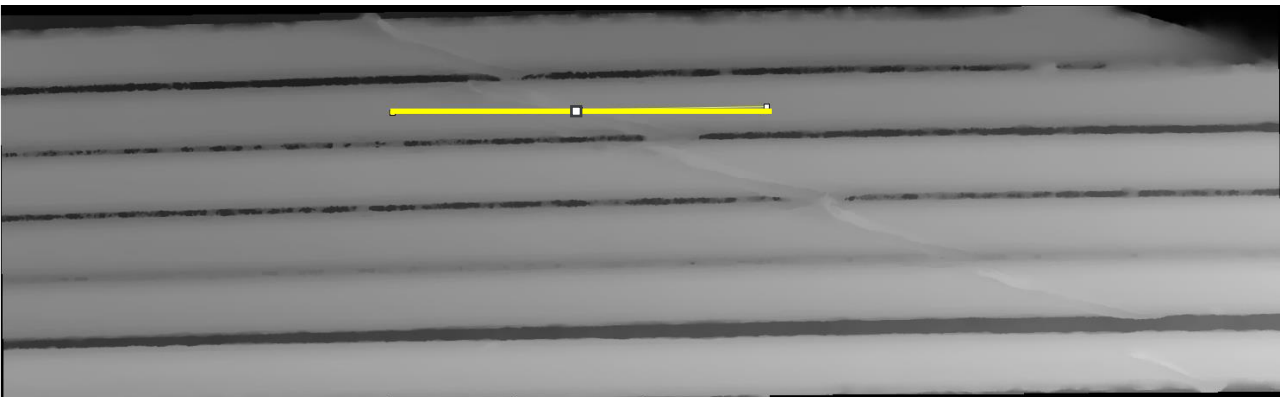
Scratched Area

Expected Data 1

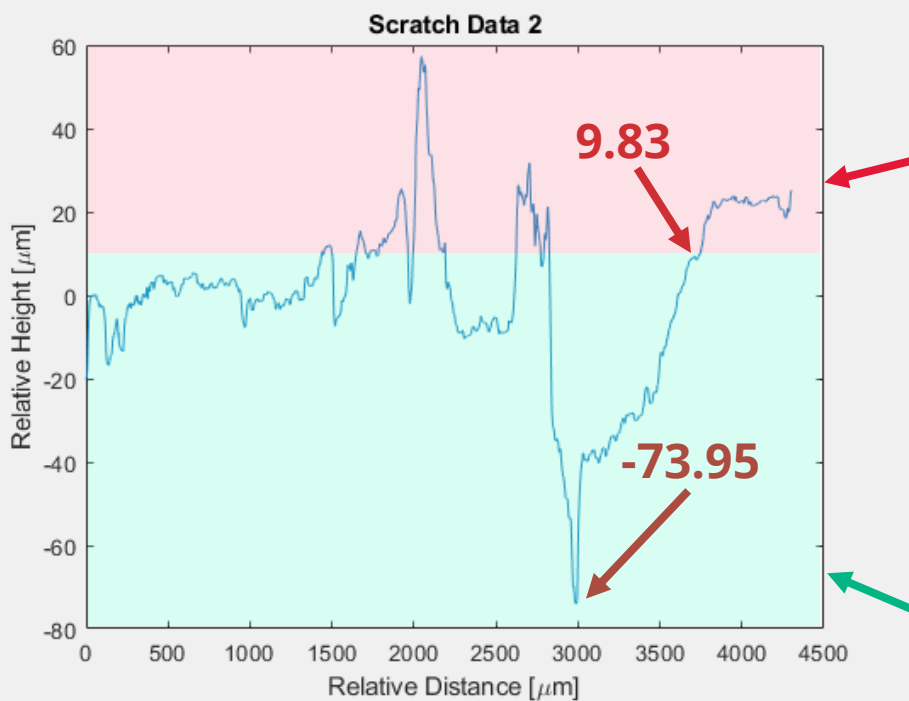
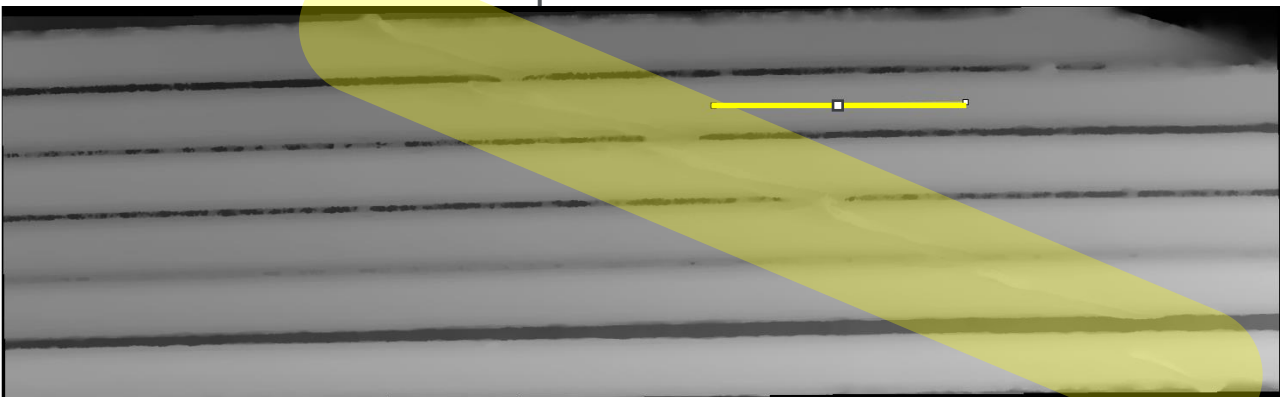


Red Strands : Scratch 2

Scratch Data

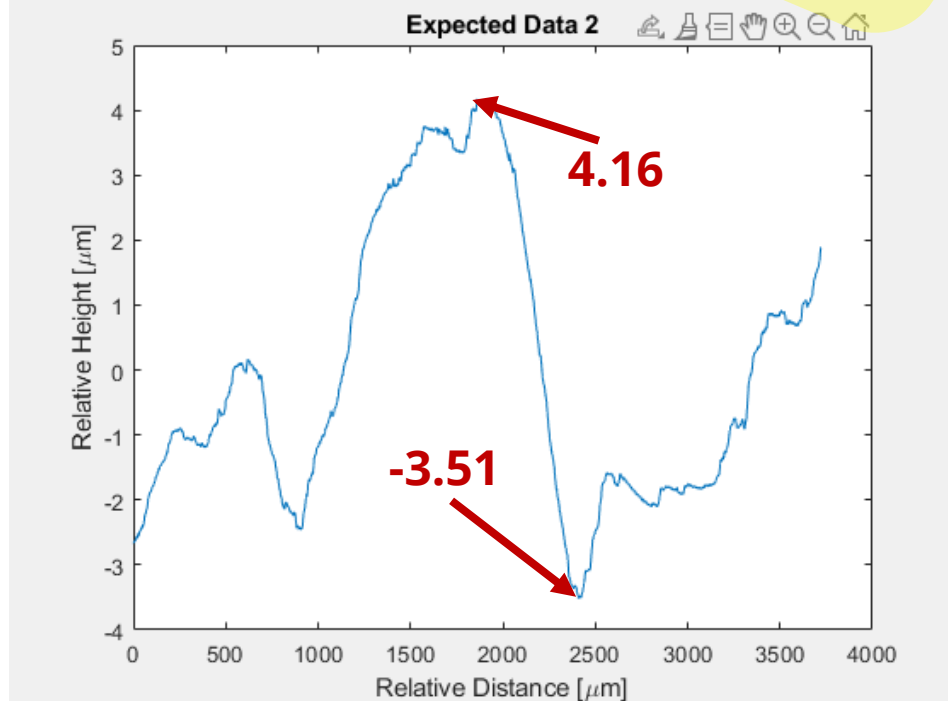


Expected Data



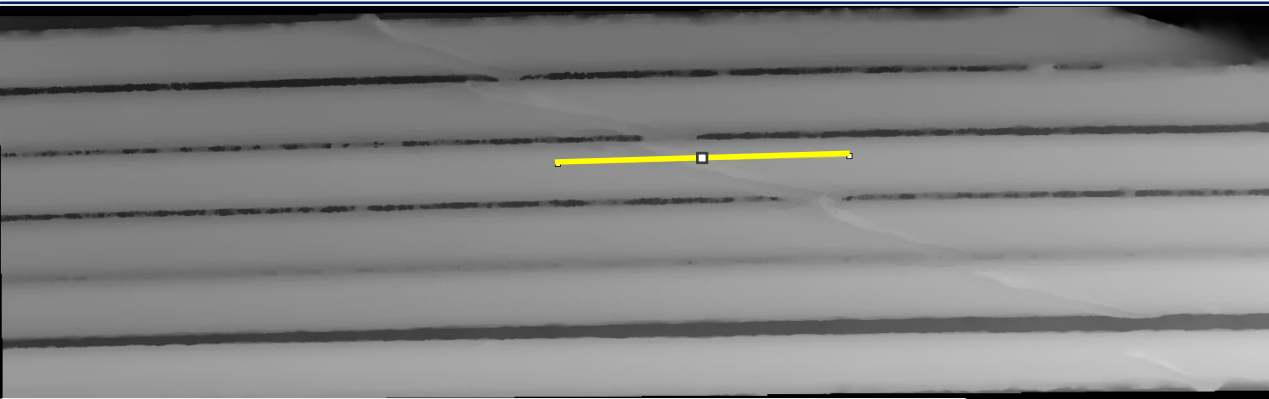
Scratch 2

- Cut Depth: 83.78 μm
- Expected Standard Deviation: 2.1304 μm over 3.7 mm

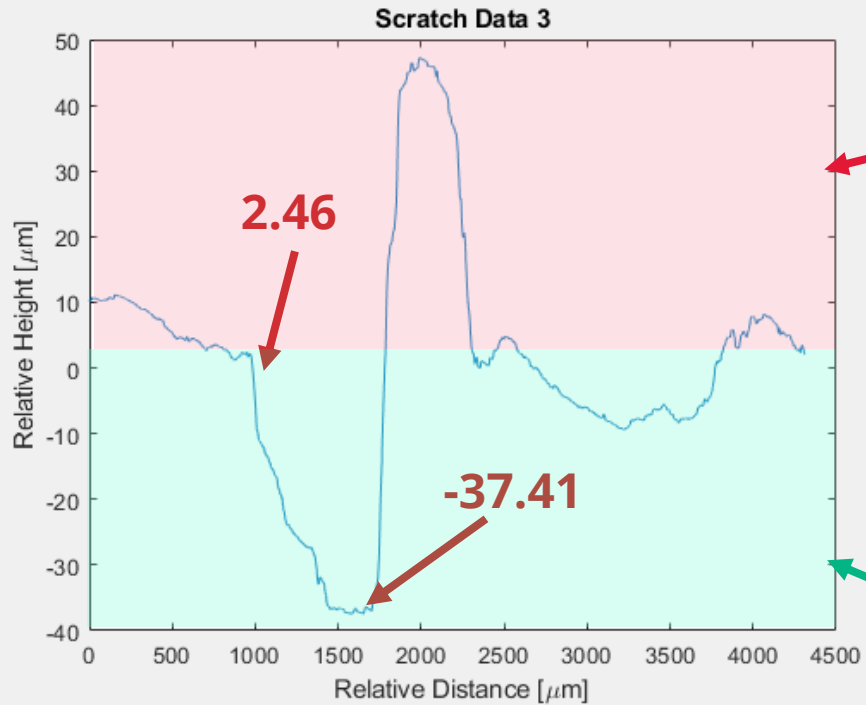
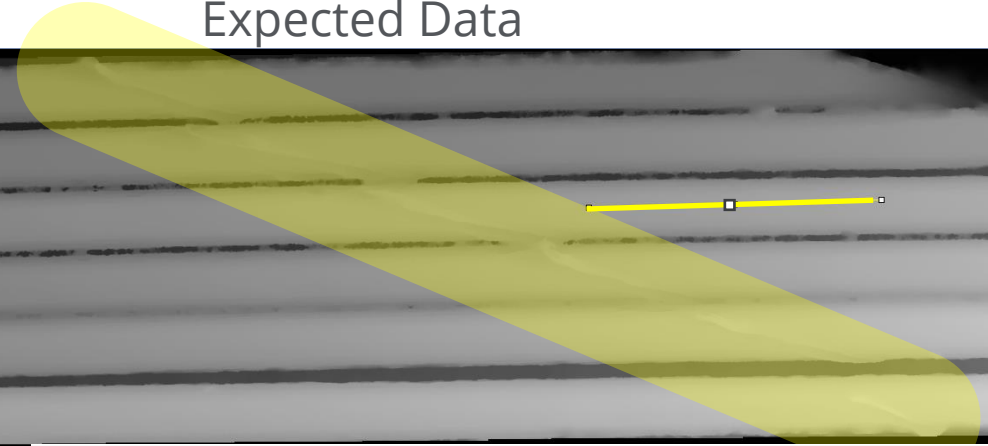


Red Strands : Scratch 3

Scratch Data



Expected Data

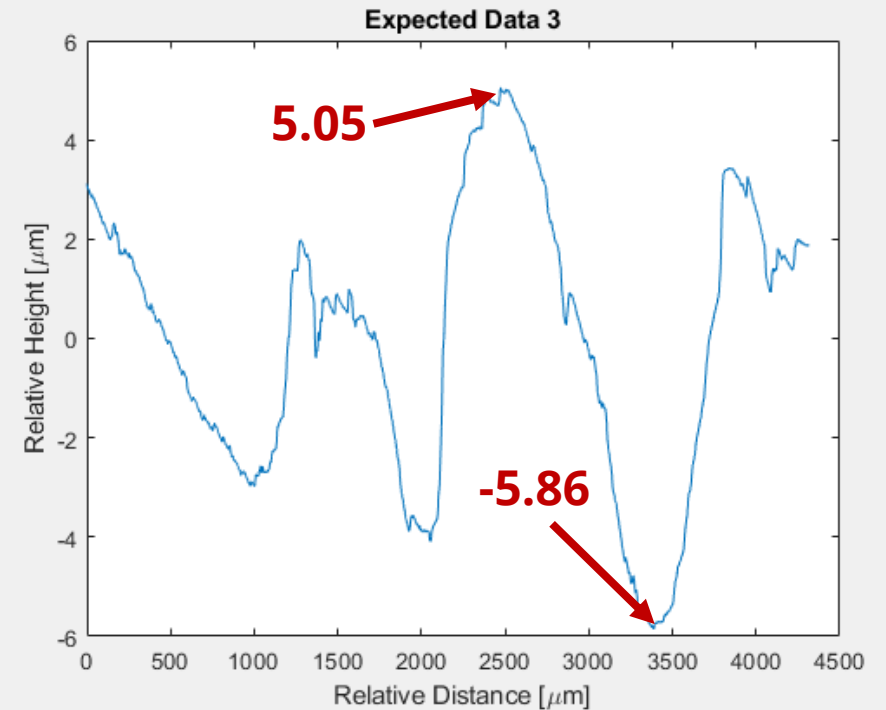


Lifted Material

Scratch 3

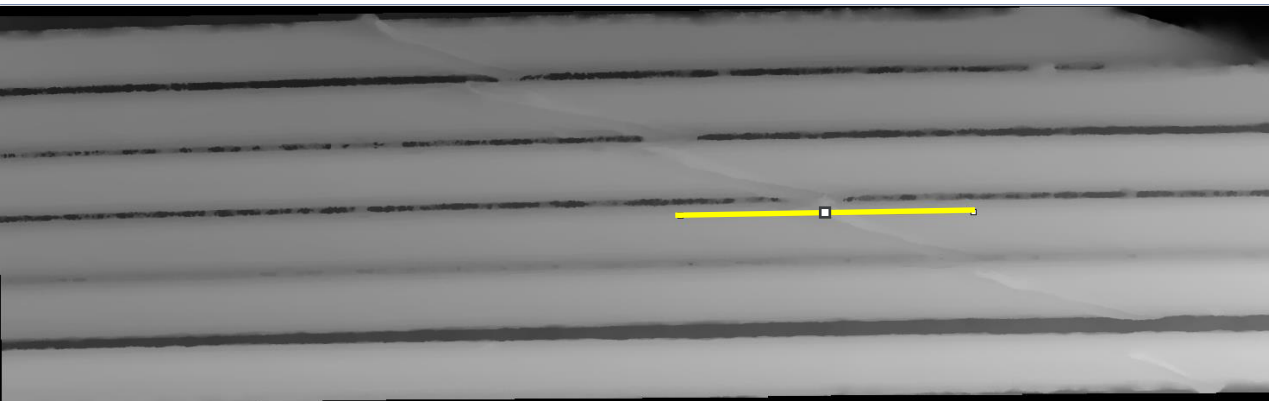
- Cut Depth: 28.8 μm
- Expected Standard Deviation: 2.8086 μm over 4.3 mm

Scratch Area

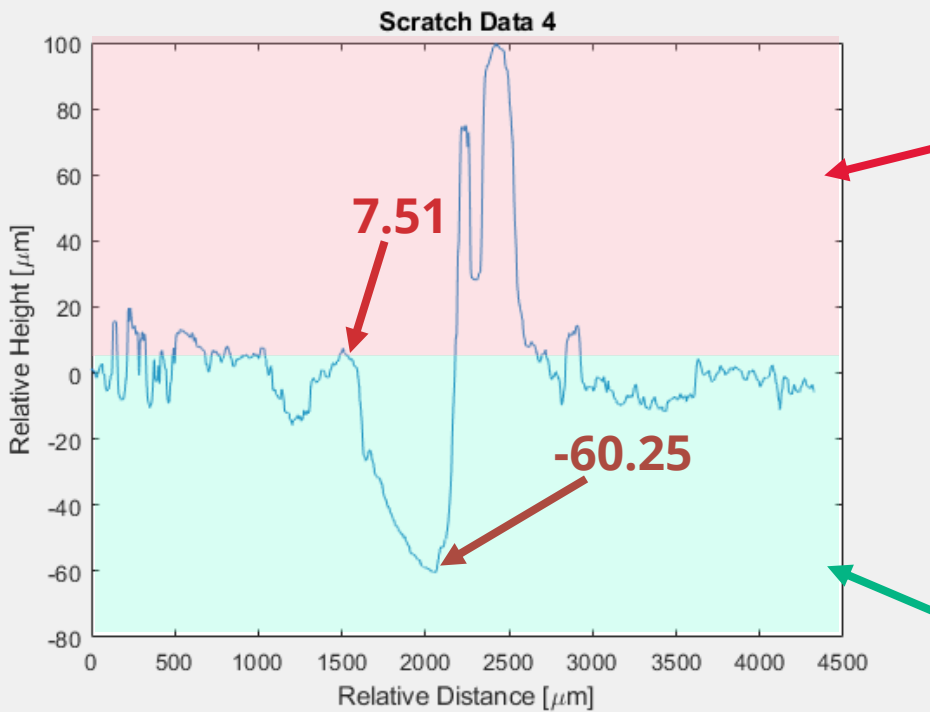
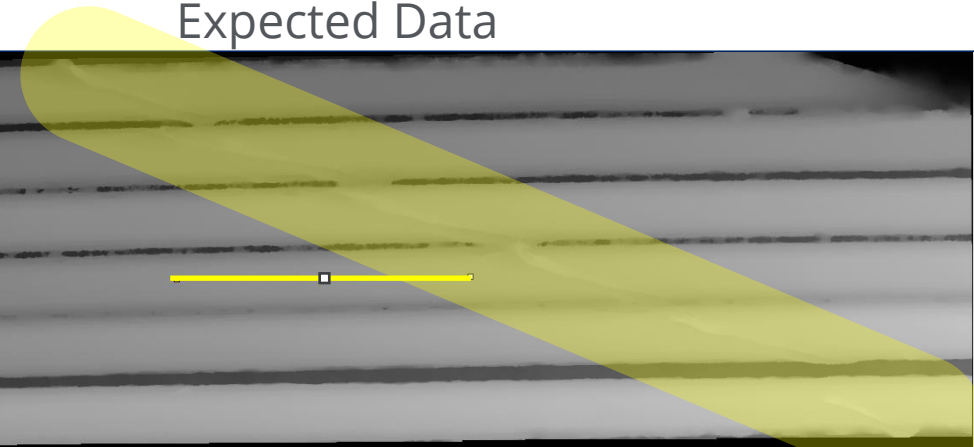


Red Strands : Scratch 4

Scratch Data



Expected Data

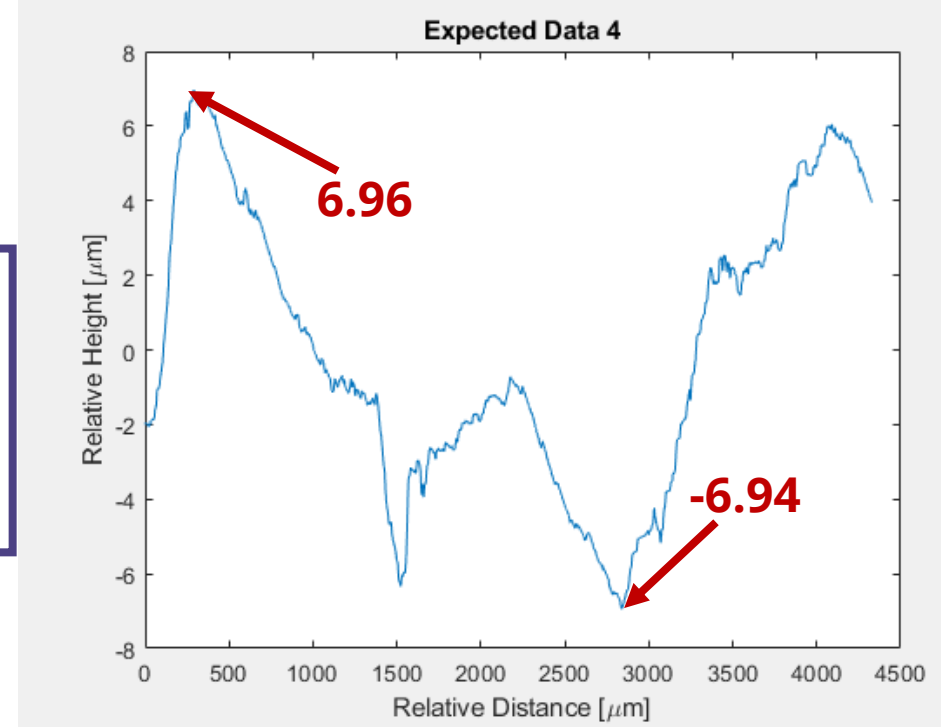


Lifted Material

Scratch 4

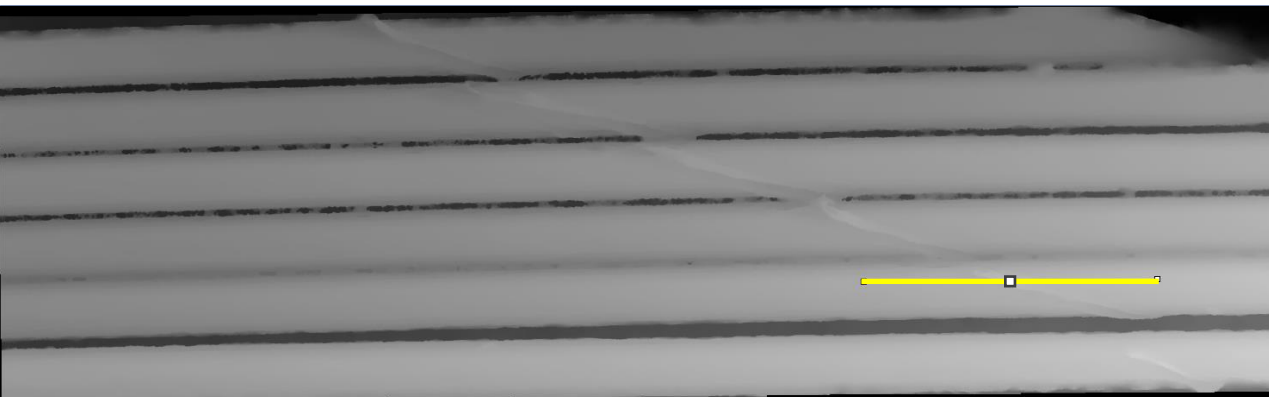
- Cut Depth: 67.76 μm
- Expected Standard Deviation: 3.766 μm over 4.3 mm

Scratch Area

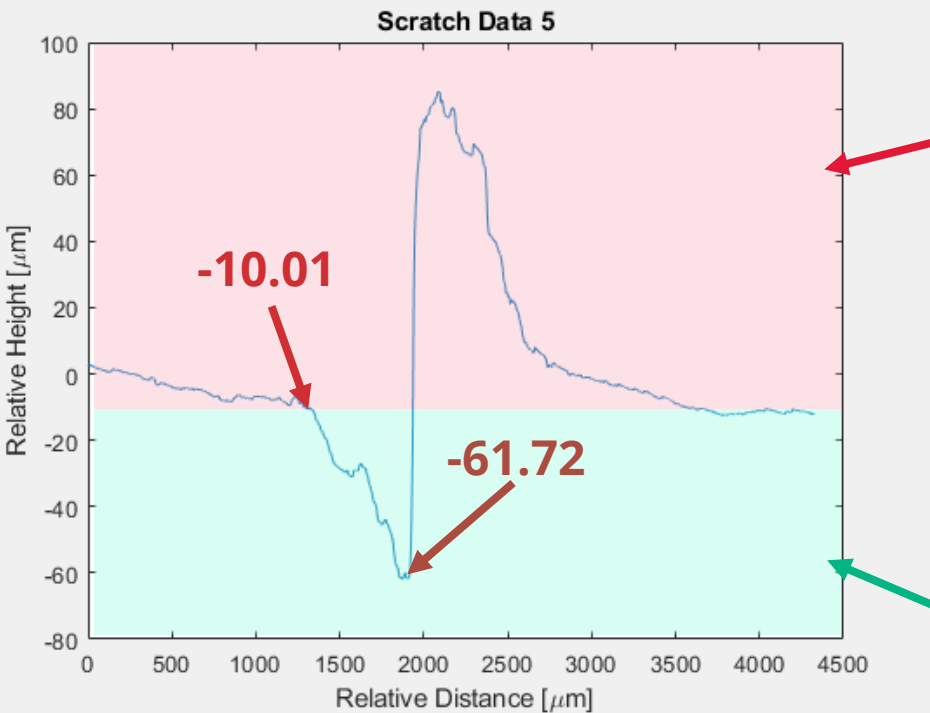
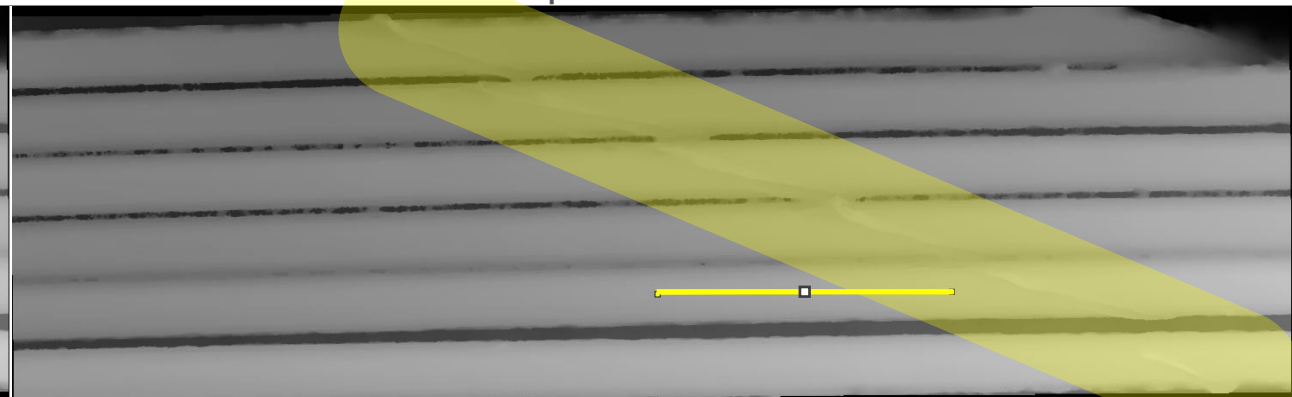


Red Strands : Scratch 5

Scratch Data



Expected Data

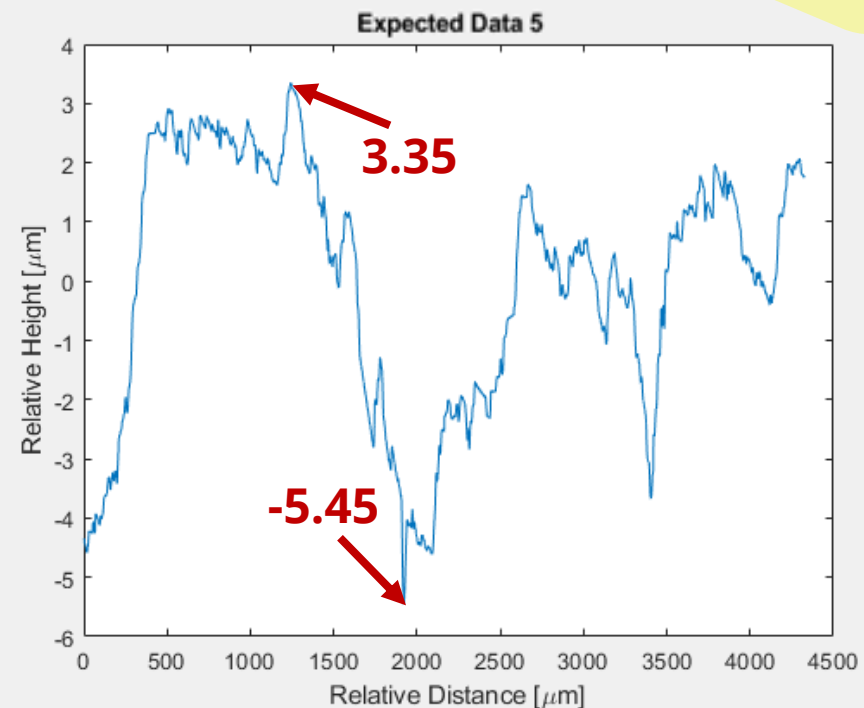


Lifted Material

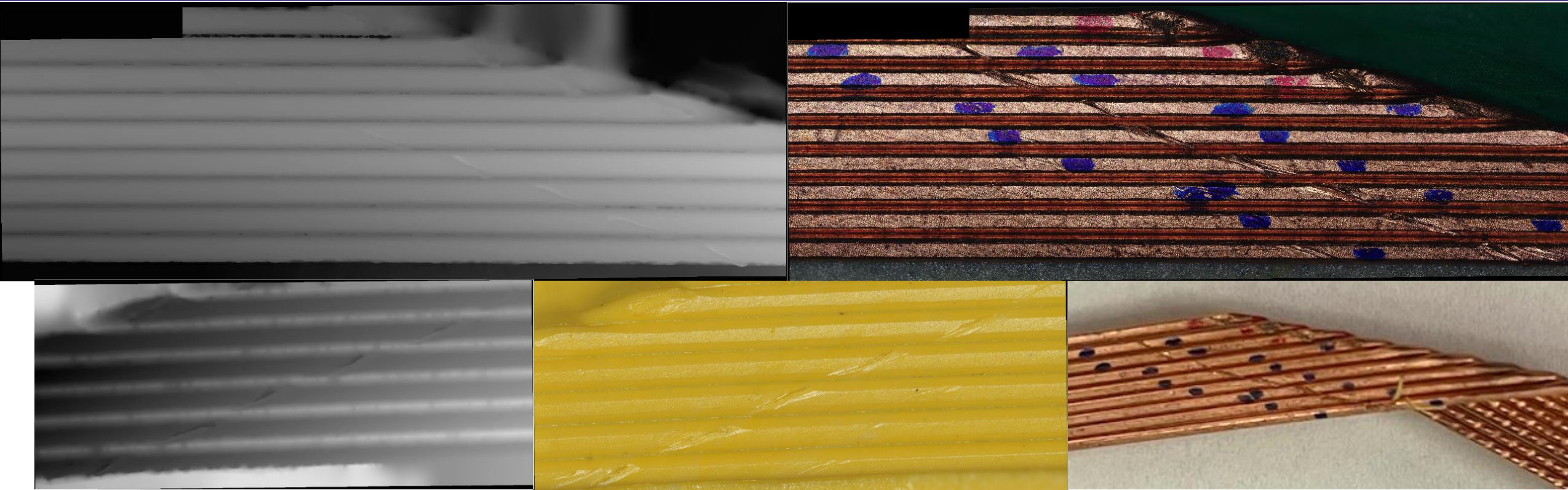
Scratch 5

- Cut Depth: 51.71 μm
- Expected Standard Deviation: 2.14 μm over 4.3 mm

Scratch Area



Olympus DSX: Blue Strands



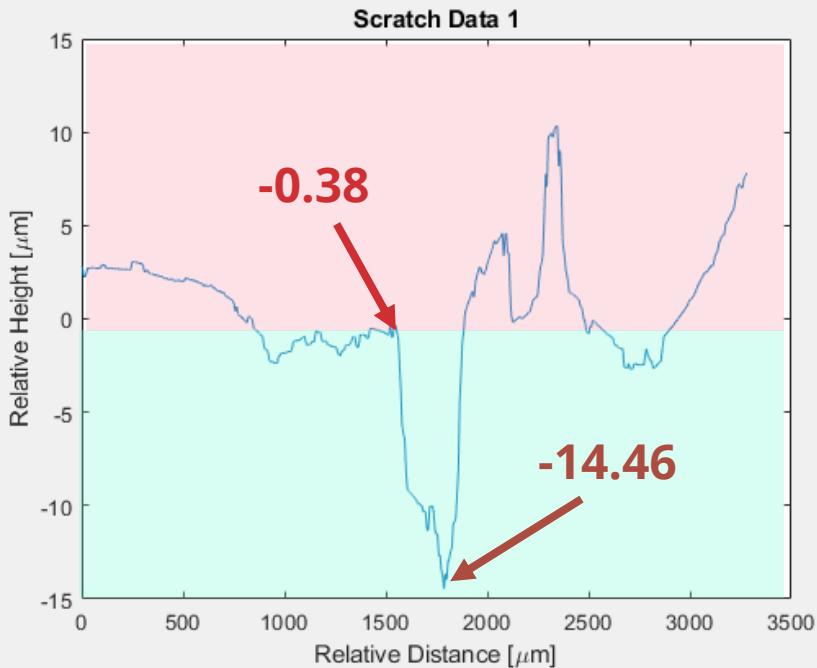
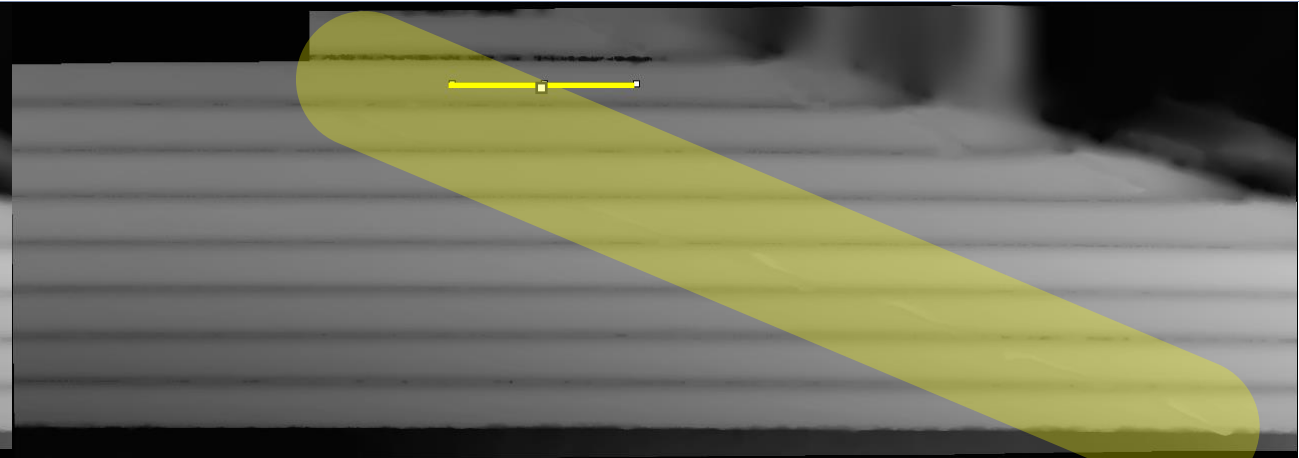
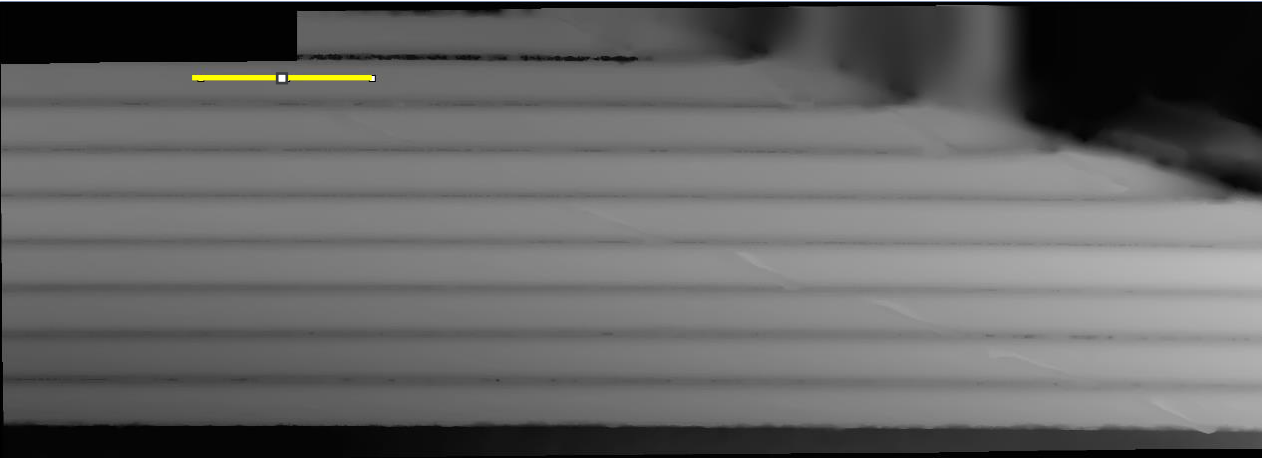
Blue Strands:

- The calibration value for this image was : $0.02363 \mu\text{m}$
- The deepest cut measured was: $44.42 \mu\text{m}$
- The same scratch measured at $46.35 \mu\text{m}$

Blue Strands : Scratch 1

Scratch Data

Expected Data

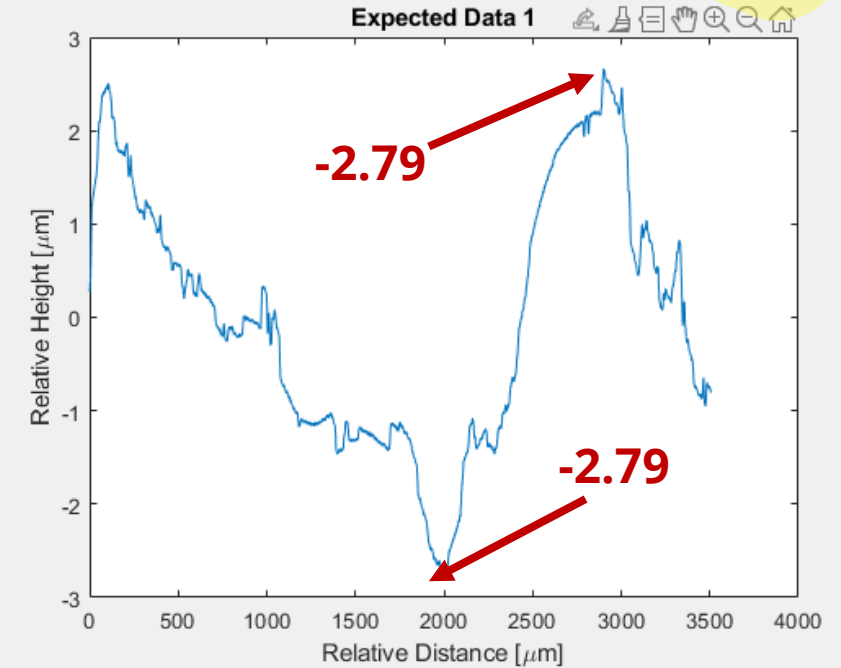


Lifted Material

Scratch 1

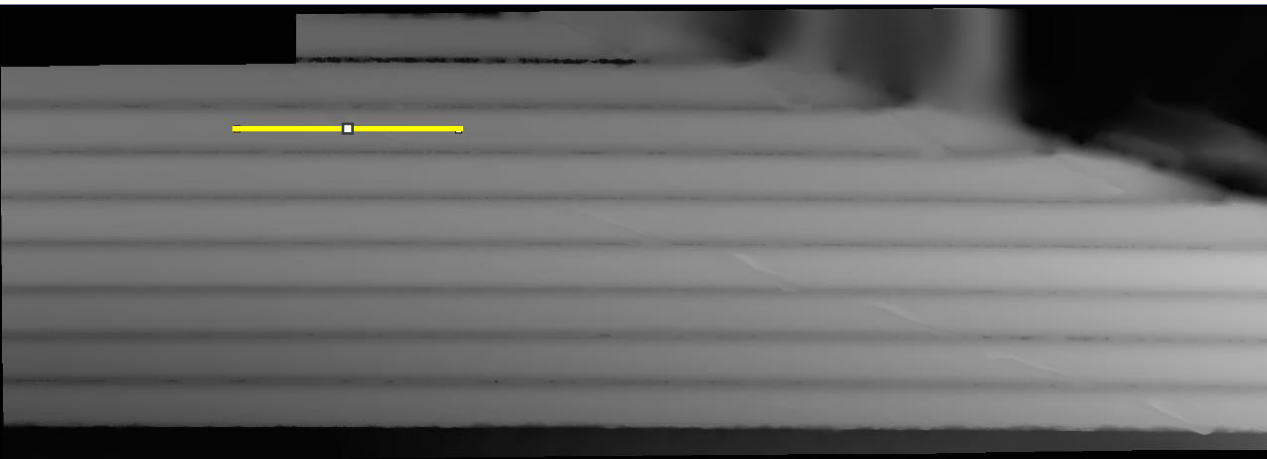
- Cut Depth: 14.08 μm
- Expected Standard Deviation: 1.3673 μm over 3.5 mm

Scratch Area

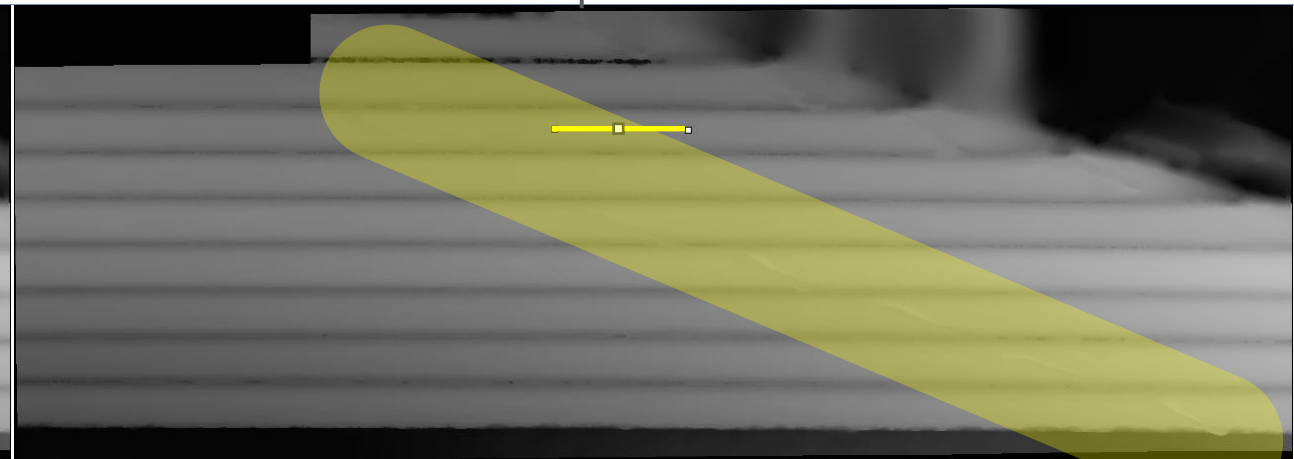


Blue Strands : Scratch 2

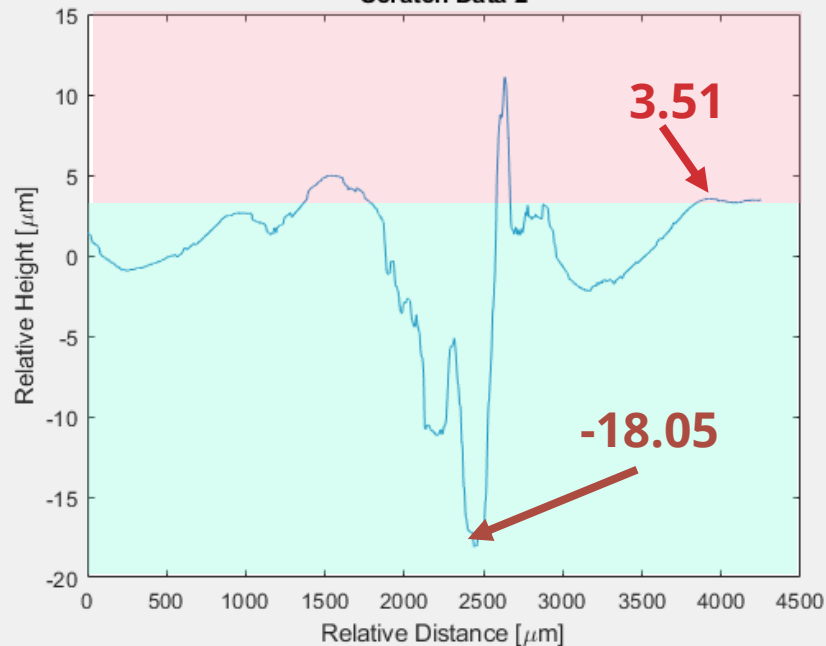
Scratch Data



Expected Data



Scratch Data 2



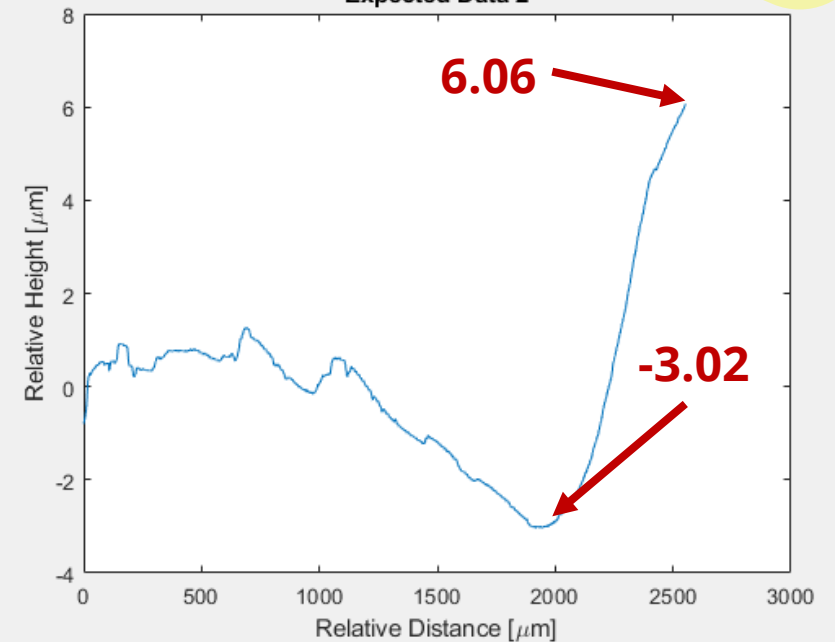
Lifted Material

Scratch 2

- Cut Depth: 21.56 μm
- Expected Standard Deviation: 1.9534 μm over 2.6 mm

Scratch Area

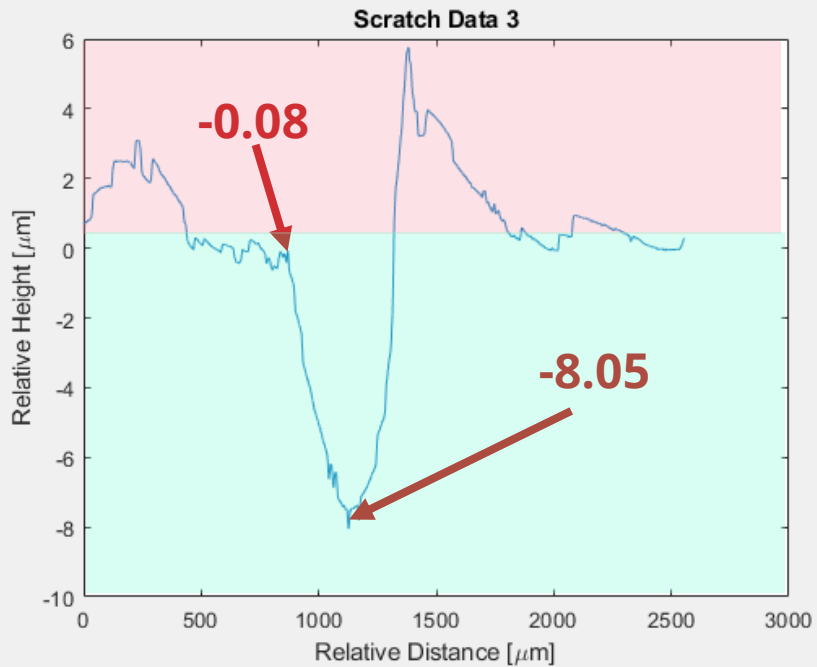
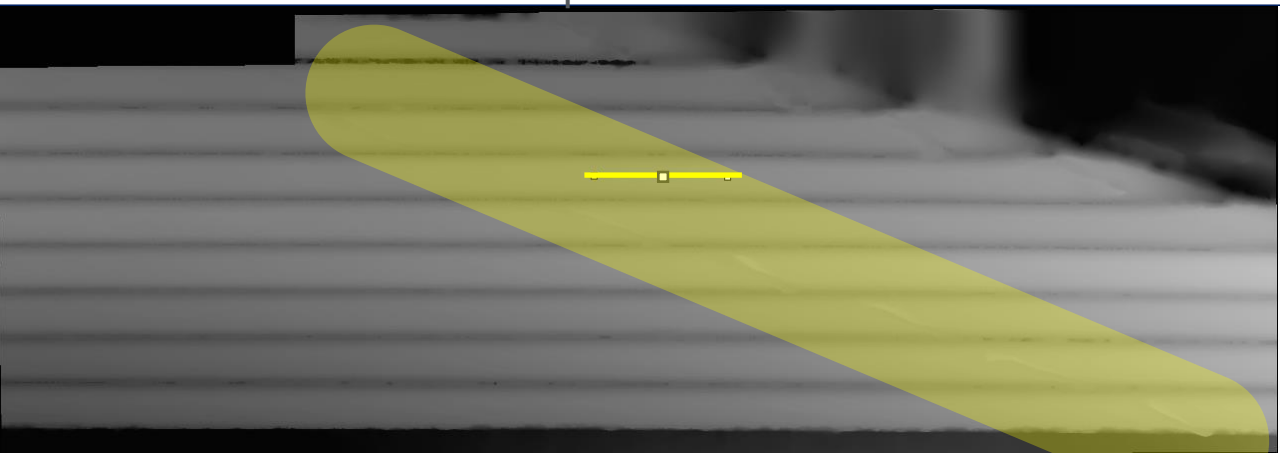
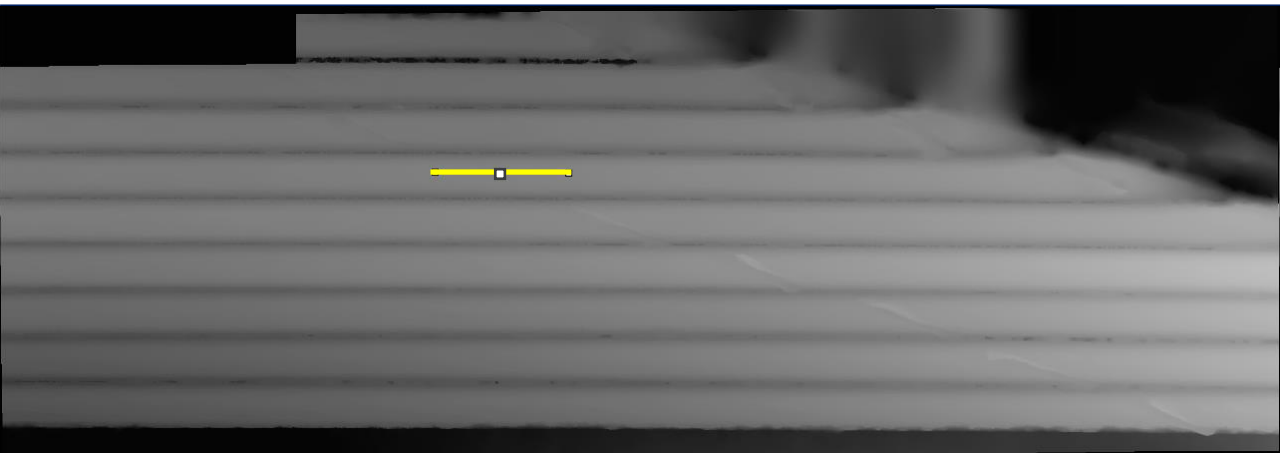
Expected Data 2



Blue Strands : Scratch 3

Scratch Data

Expected Data

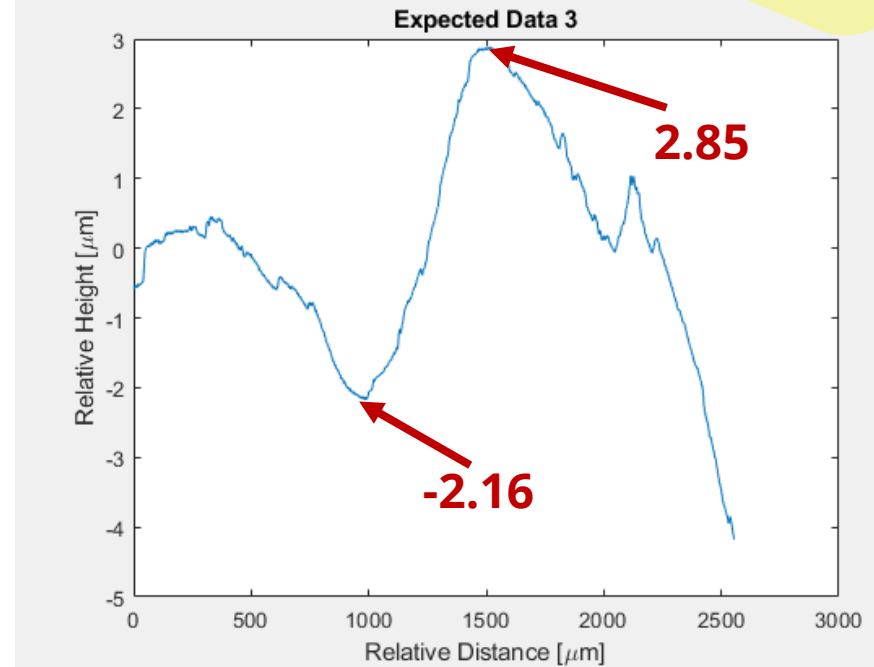


Lifted Material

Scratch 3

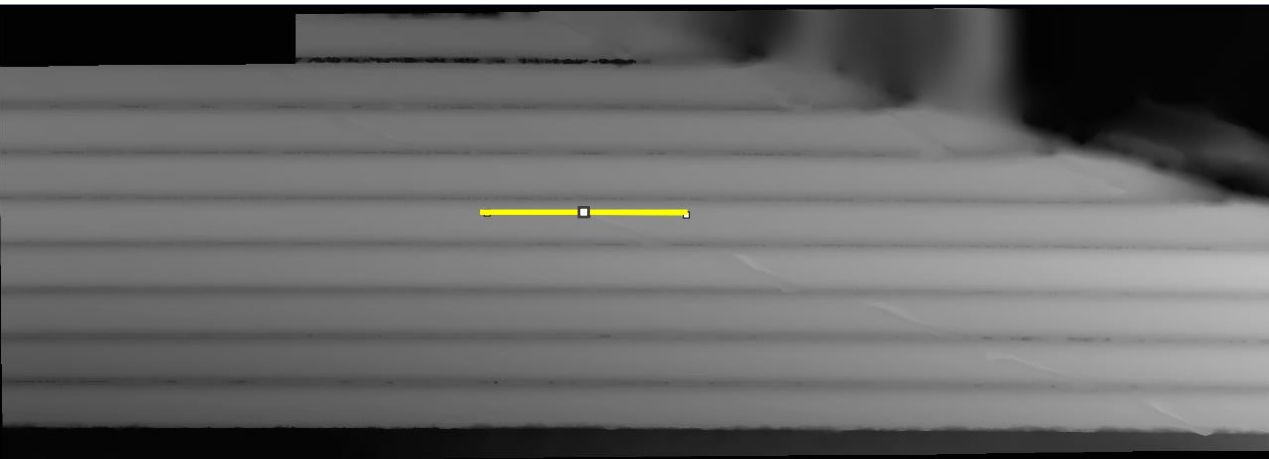
- Cut Depth: 7.97 μm
- Expected Standard Deviation: 1.5235 μm over 2.6 mm

Scratch Area

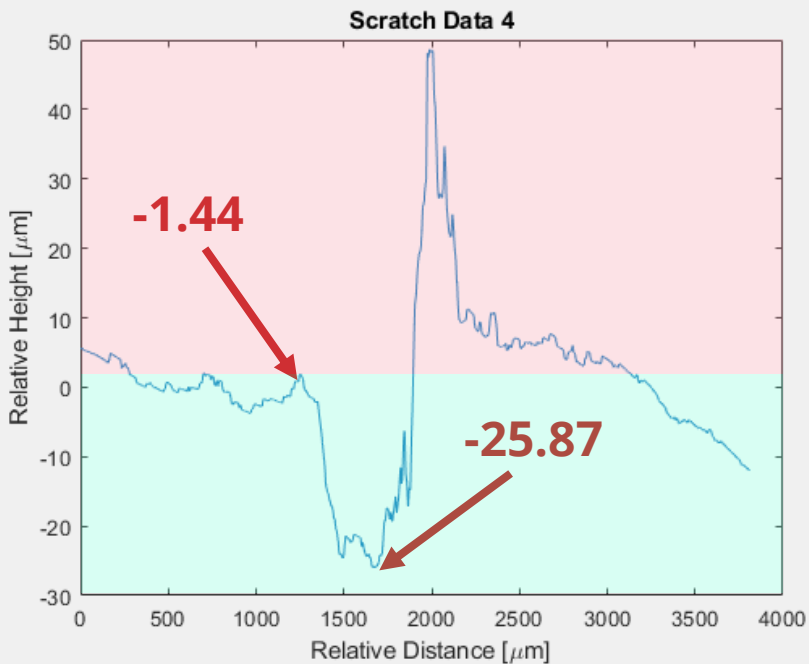
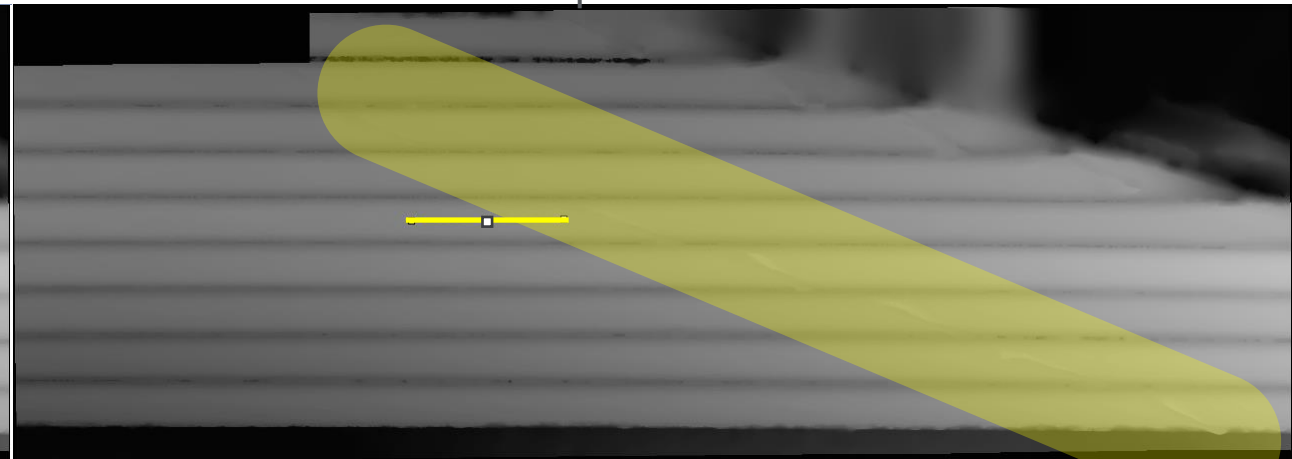


Blue Strands : Scratch 4

Scratch Data



Expected Data

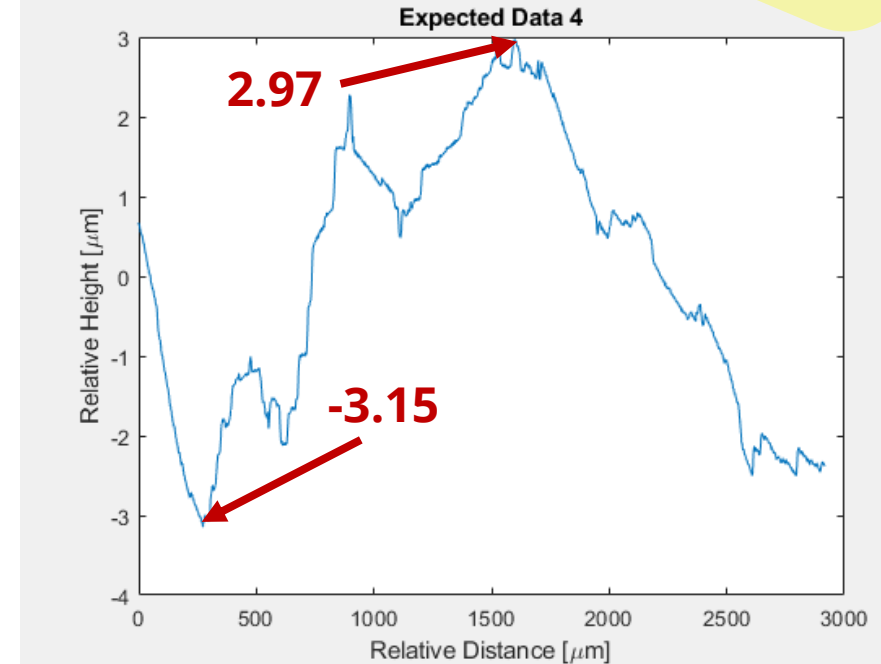


Lifted Material

Scratch 4

- Cut Depth: 24.43 μm
- Expected Standard Deviation: 1.718 μm over 2.9 mm

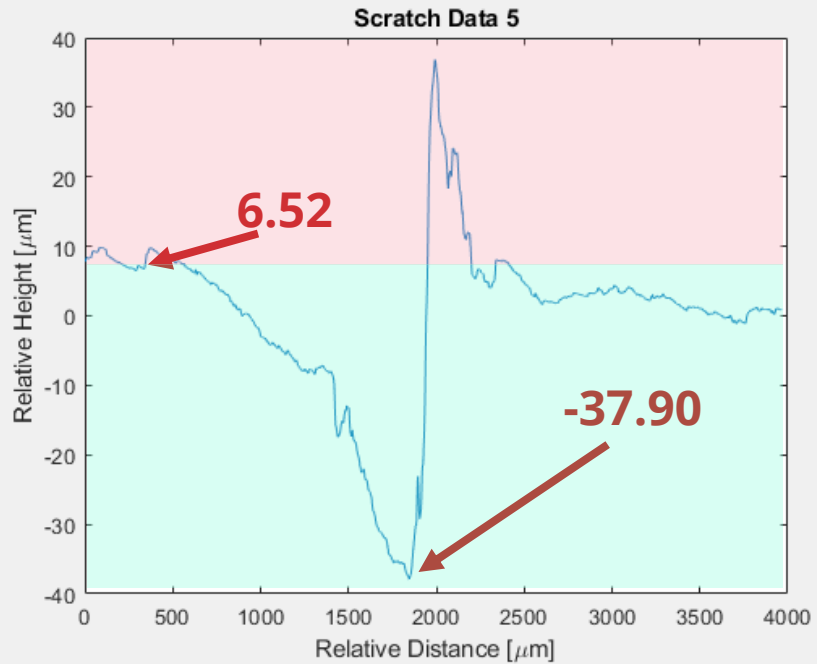
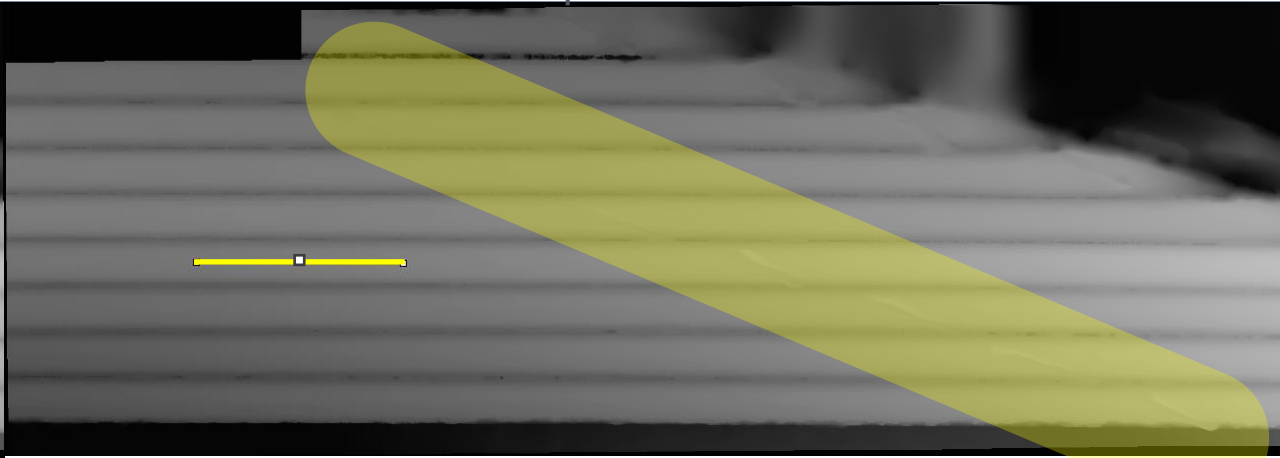
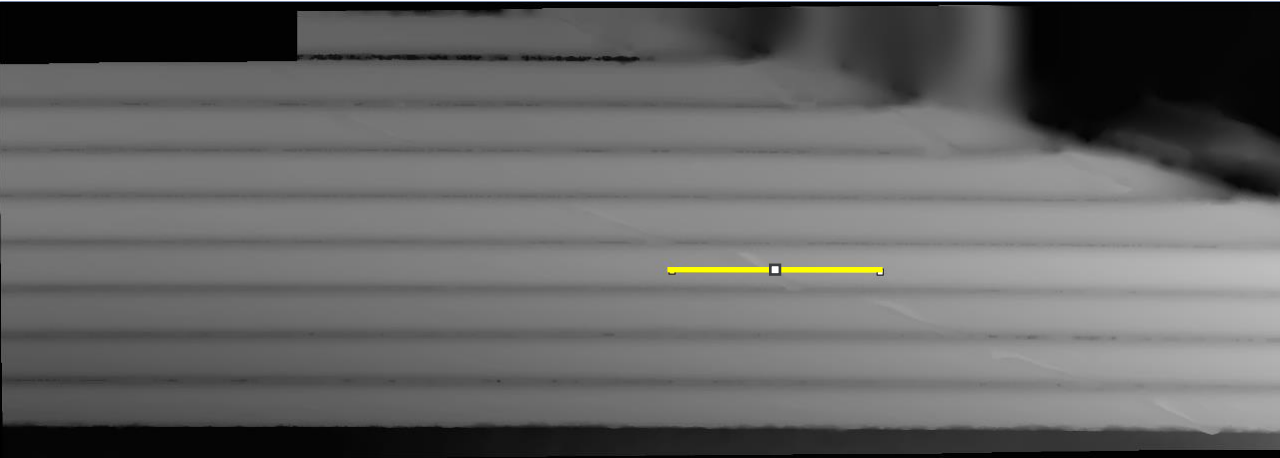
Scratch Area



Blue Strands : Scratch 5

Scratch Data

Expected Data

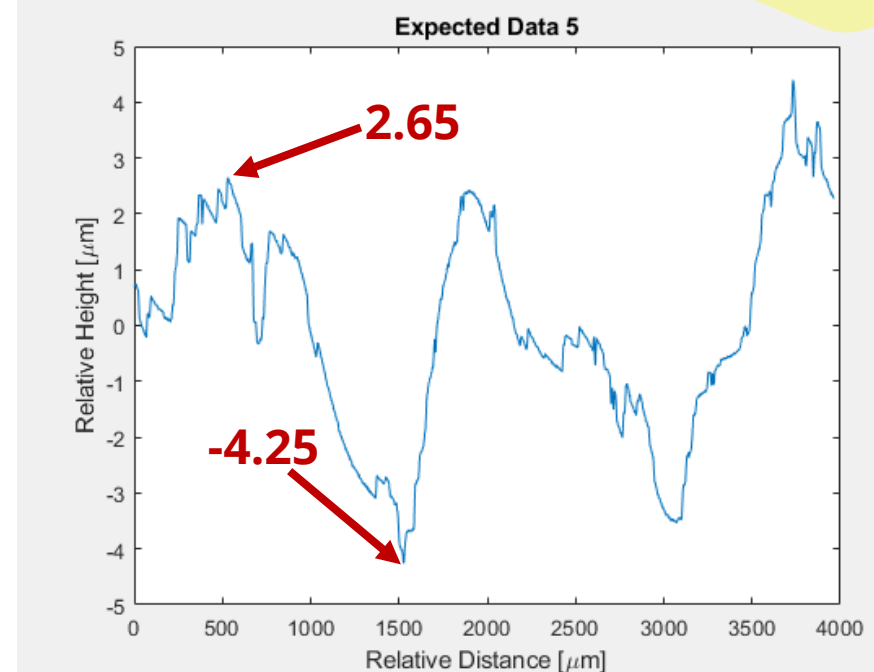


Lifted Material

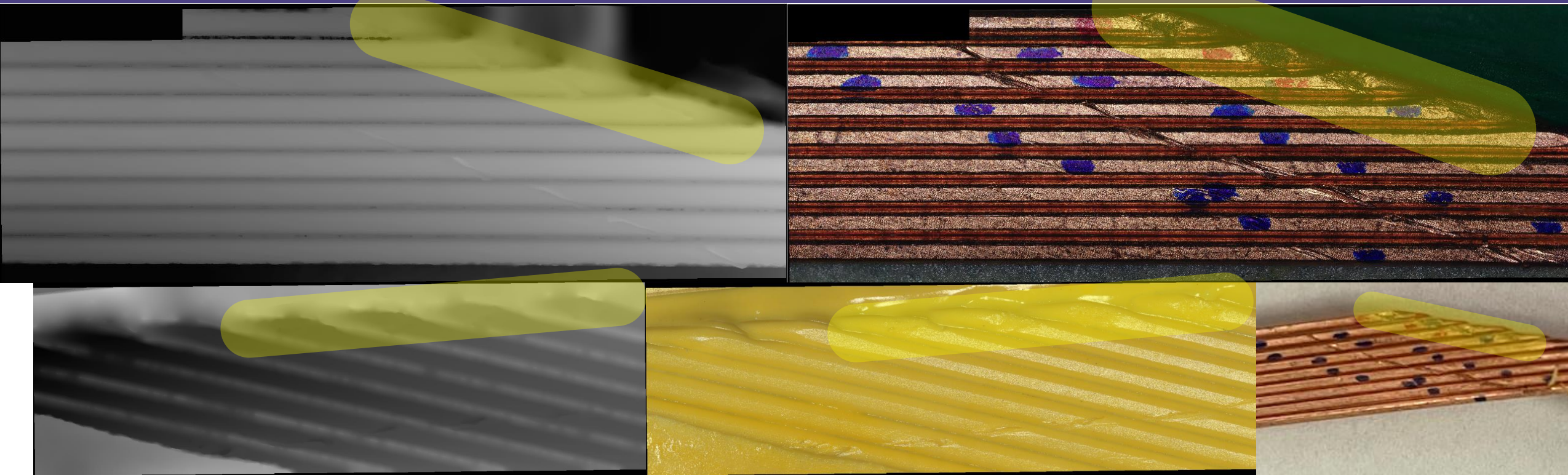
Scratch 5

- Cut Depth: 44.42 μm
- Expected Standard Deviation: 1.9307 μm over 4 mm

Scratch Area



Olympus DSX: Blue Strands-Red Region



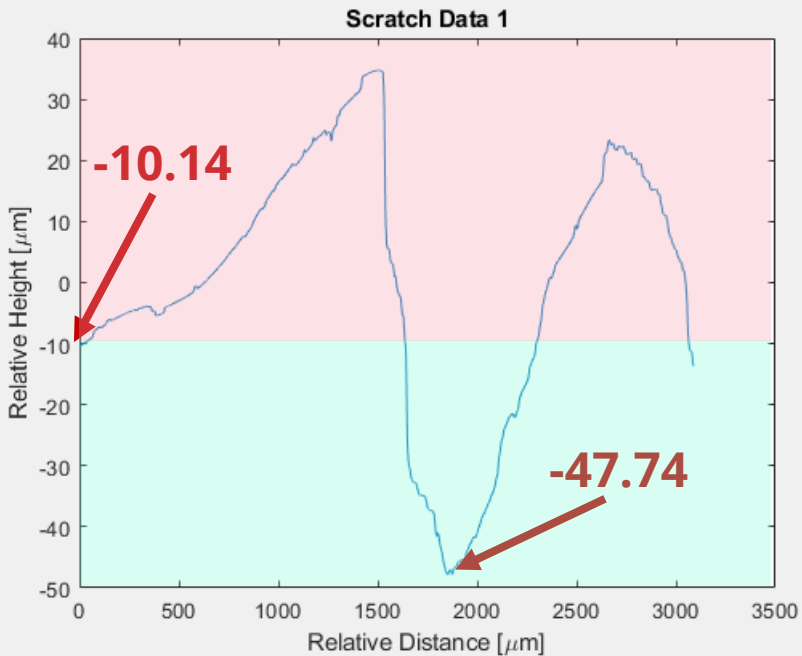
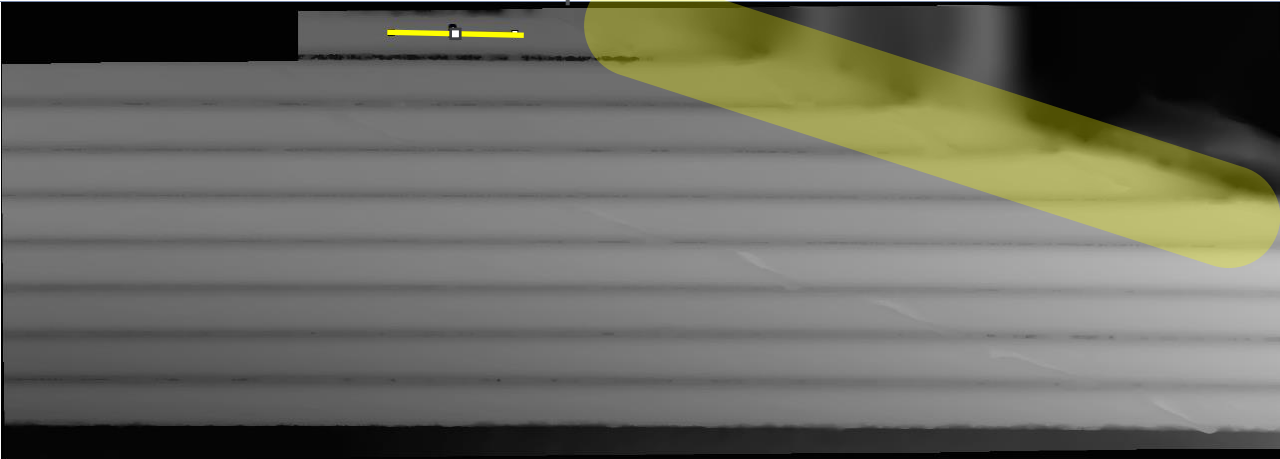
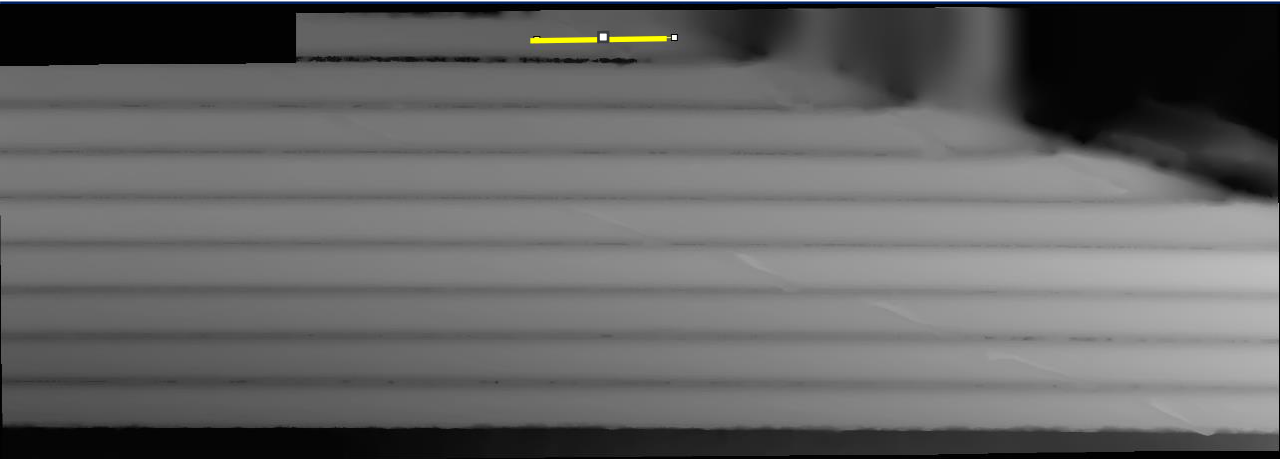
Red Region

- The calibration value for this image was : $0.03784 \mu\text{m}$
- The deepest cut measured was: $52.36 \mu\text{m}$
- The same scratch measured at $25.43 \mu\text{m}$

Blue Strands-Red Region : Scratch 1

Scratch Data

Expected Data

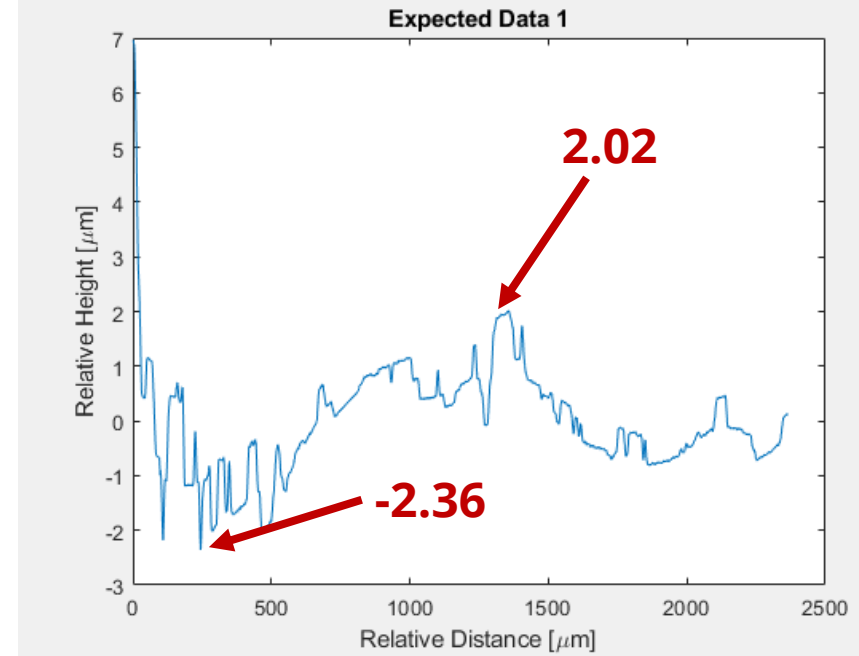


Lifted Material

Scratch 1

- Cut Depth: 37.6 μm
- Expected Standard Deviation: 1.0069 μm over 2.2 mm

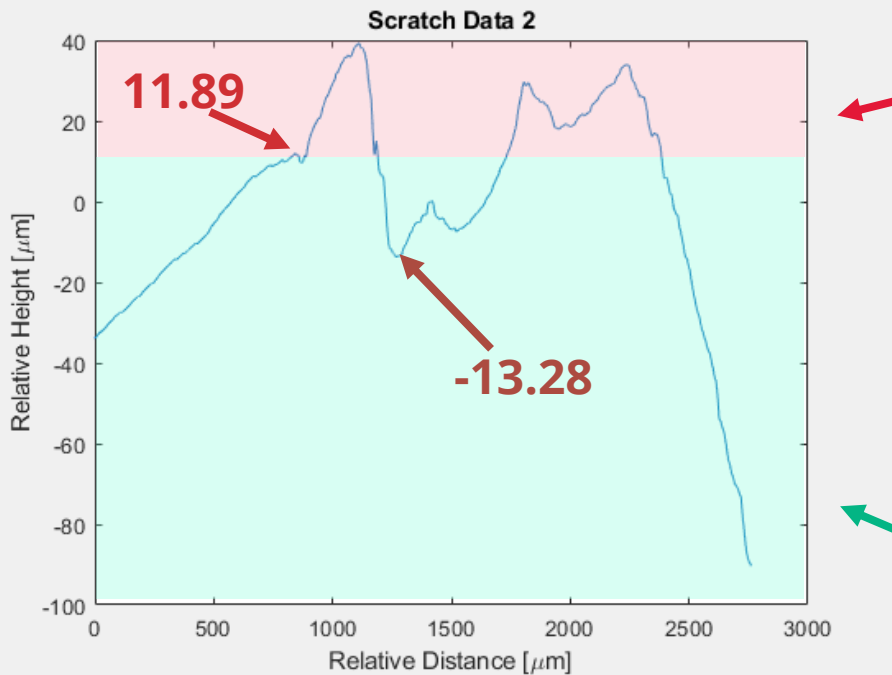
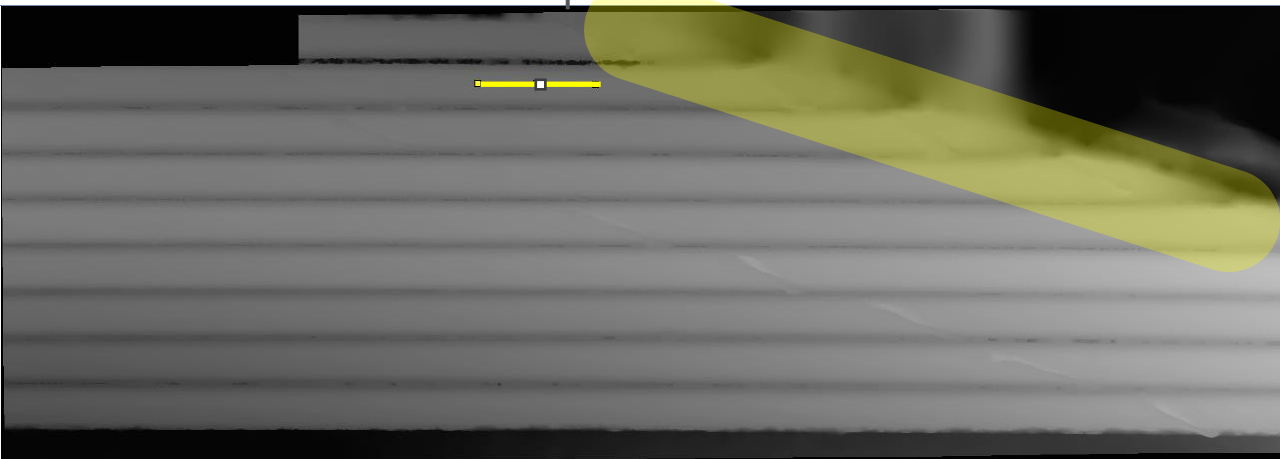
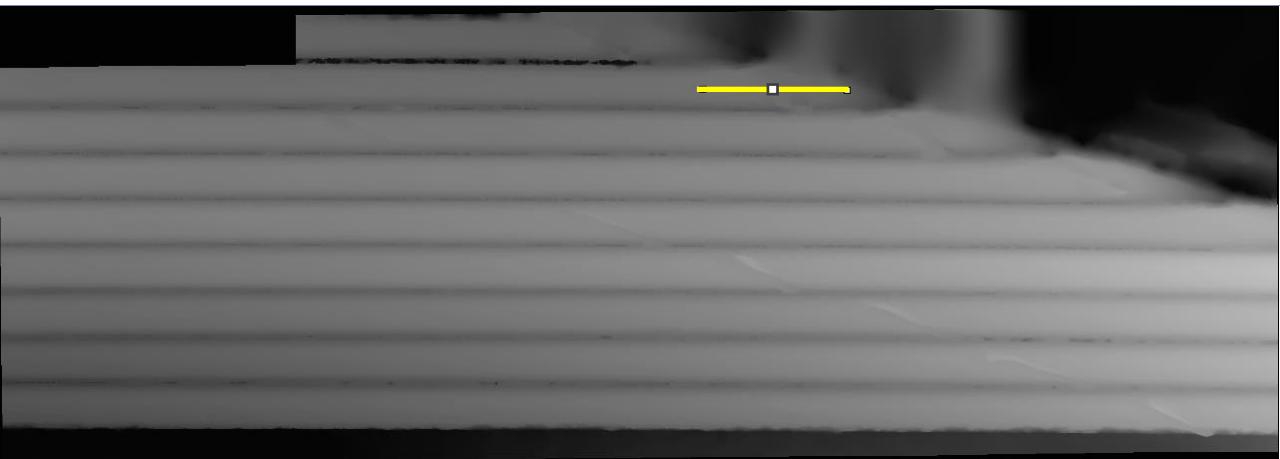
Scratch Area



Blue Strands-Red Region : Scratch 2

Scratch Data

Expected Data

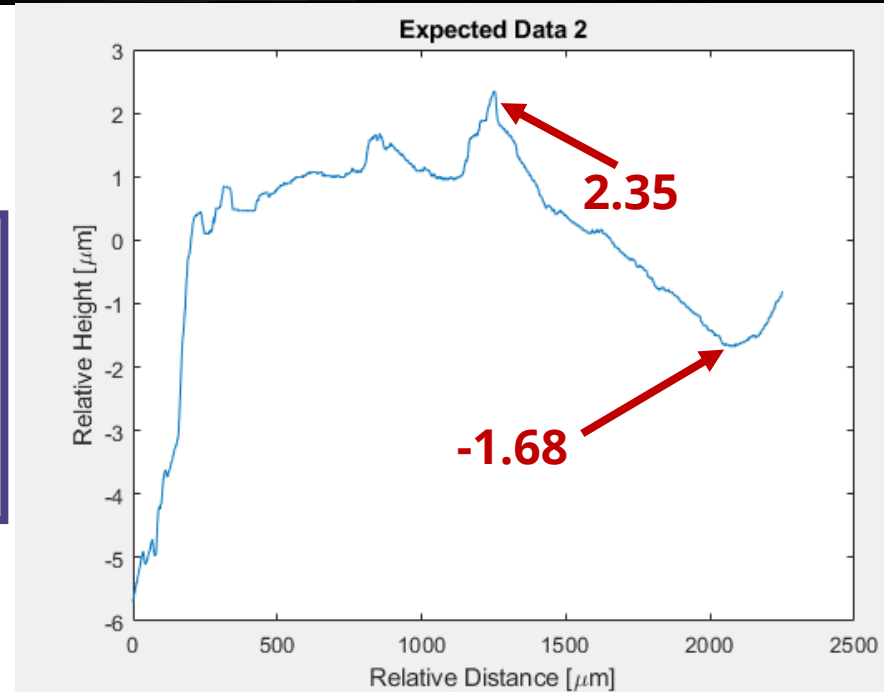


Lifted Material

Scratch 2

- Cut Depth: 25.17 μm
- Expected Standard Deviation: 1.5916 μm over 2.2 mm

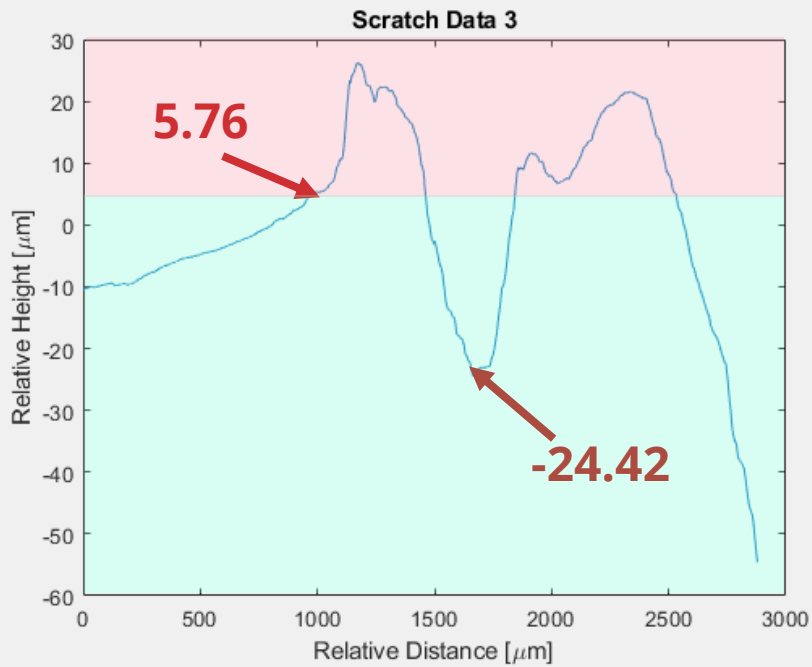
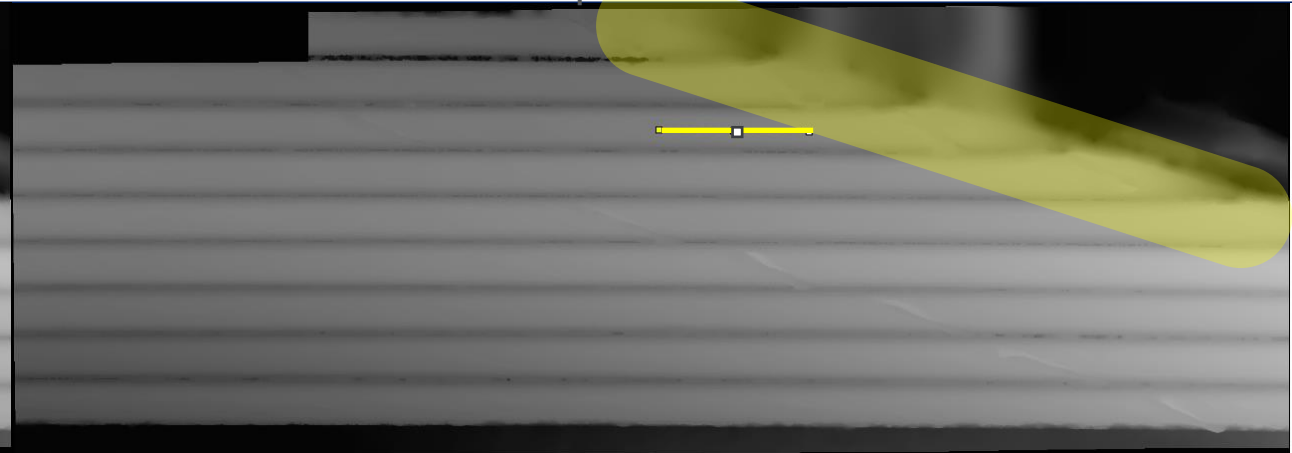
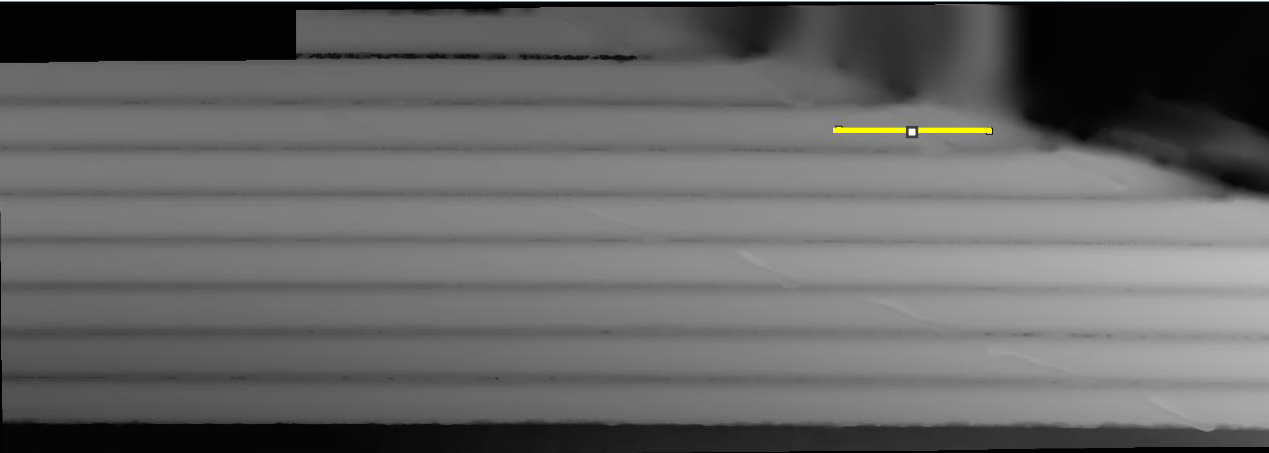
Scratch Area



Blue Strands-Red Region : Scratch 3

Scratch Data

Expected Data

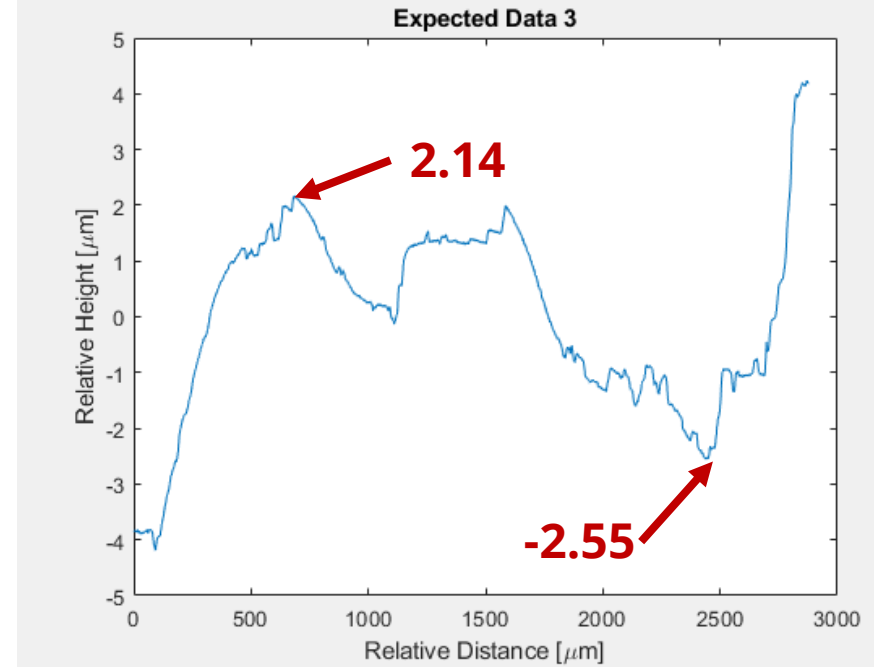


Lifted Material

Scratch 4

- Cut Depth: 30.18 μm
- Expected Standard Deviation: 1.6663 μm over 2.9 mm

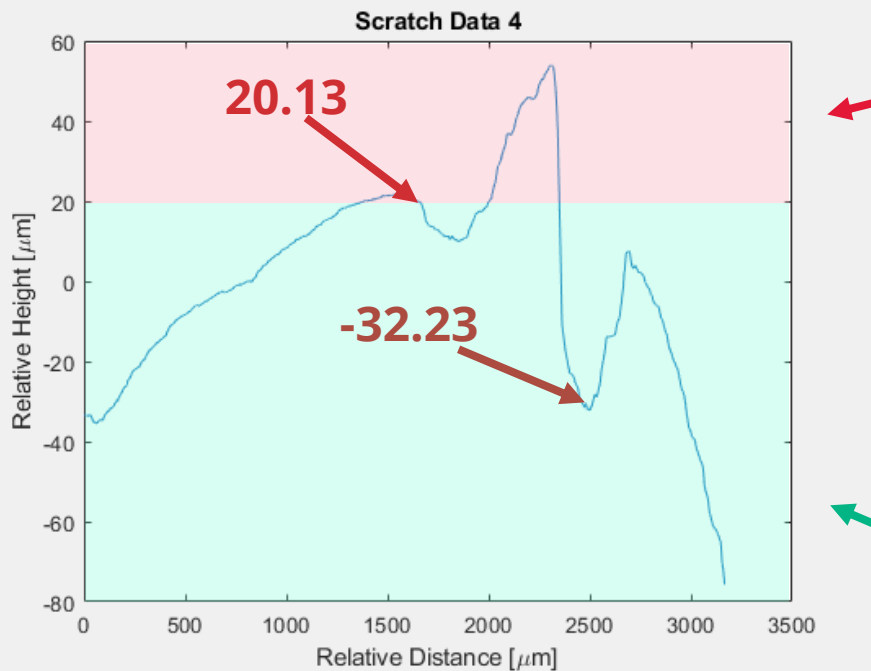
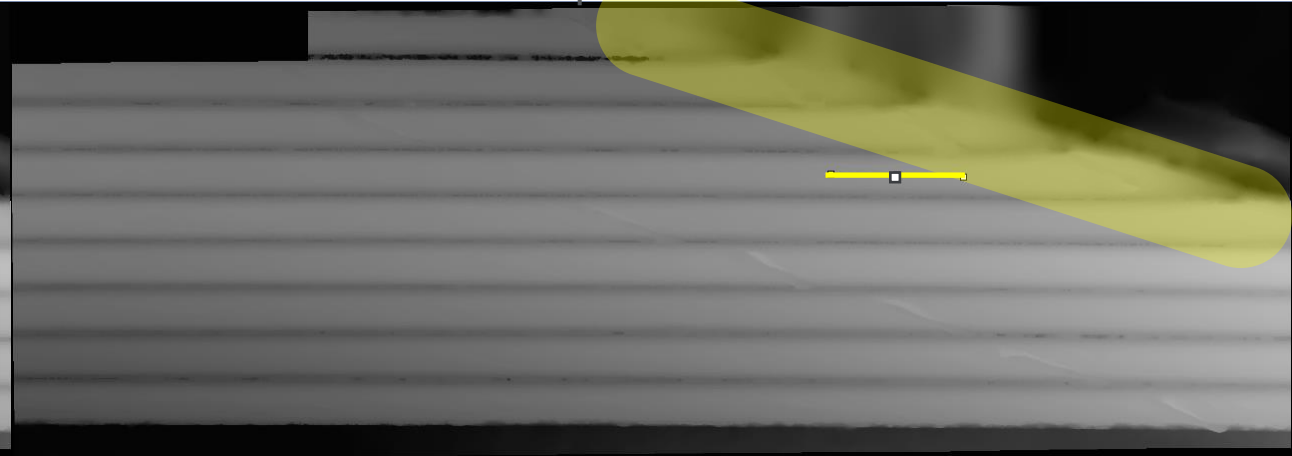
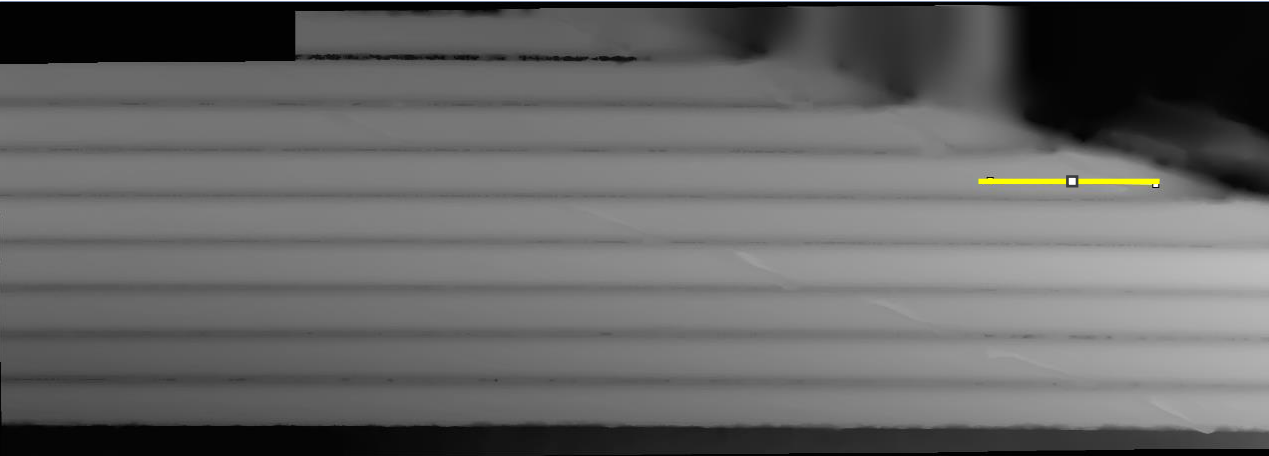
Scratch Area



Blue Strands-Red Region : Scratch 4

Scratch Data

Expected Data

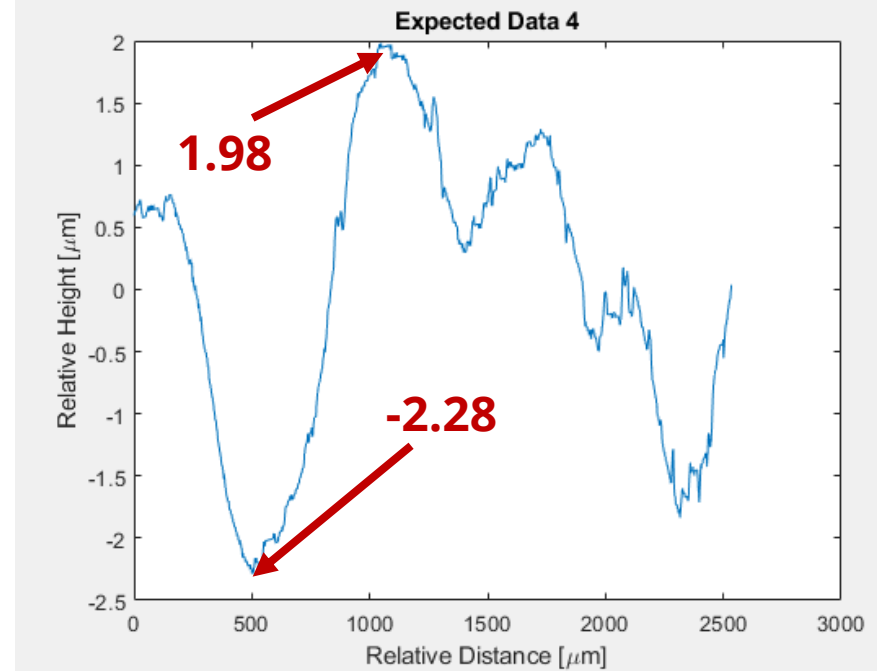


Lifted Material

Scratch 4

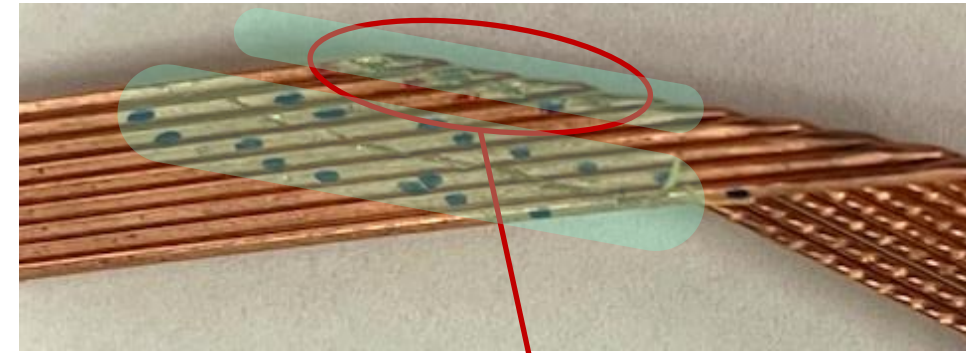
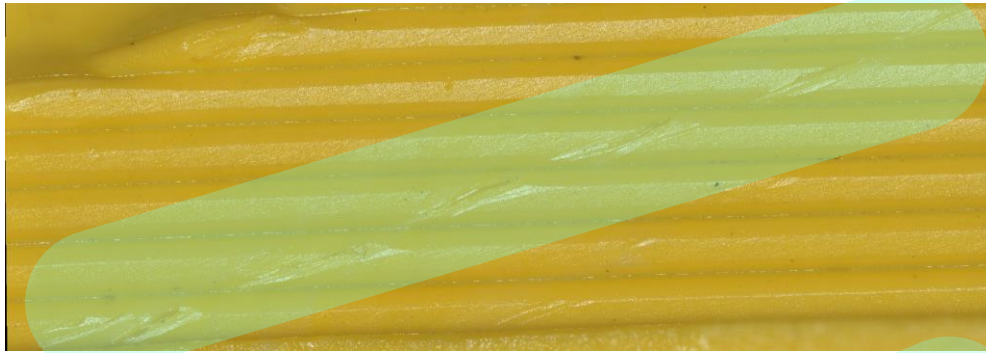
- Cut Depth: 52.36 μm
- Expected Standard Deviation: 1.19614 μm over 2.5 mm

Scratch Area

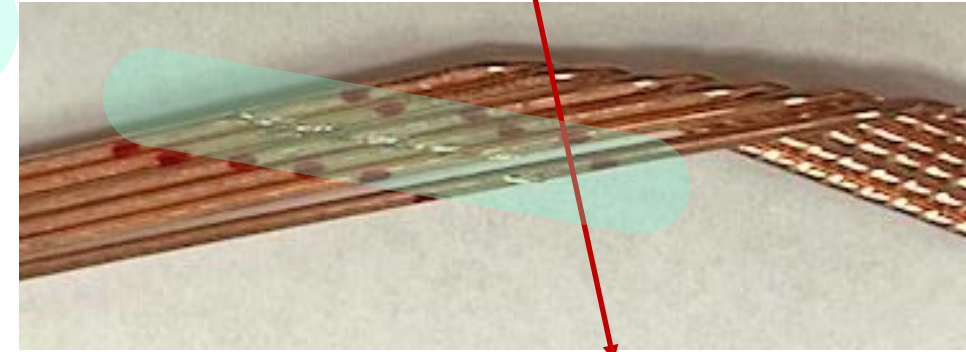
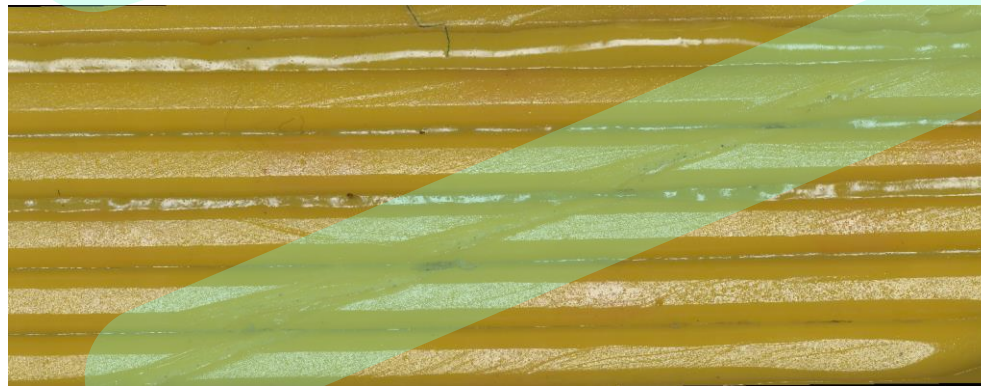


Strands Extracted from LBNL Rutherford Cable

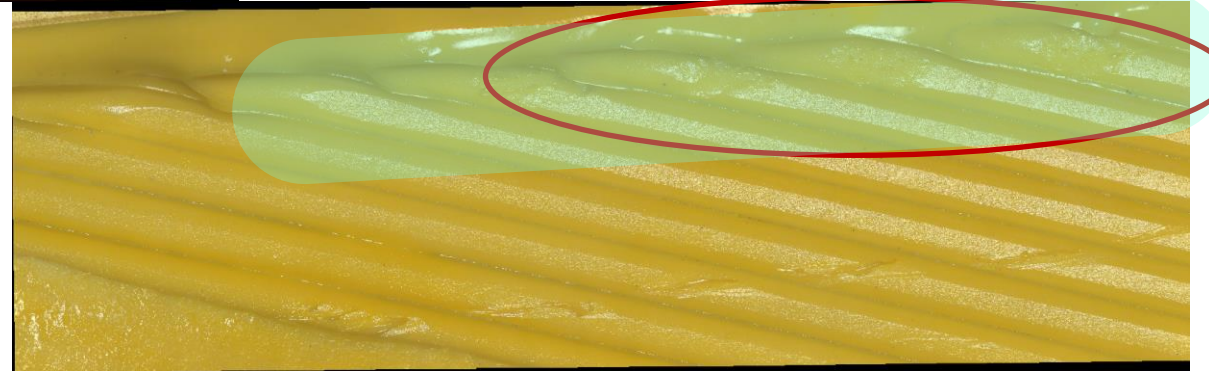
Blue Strands



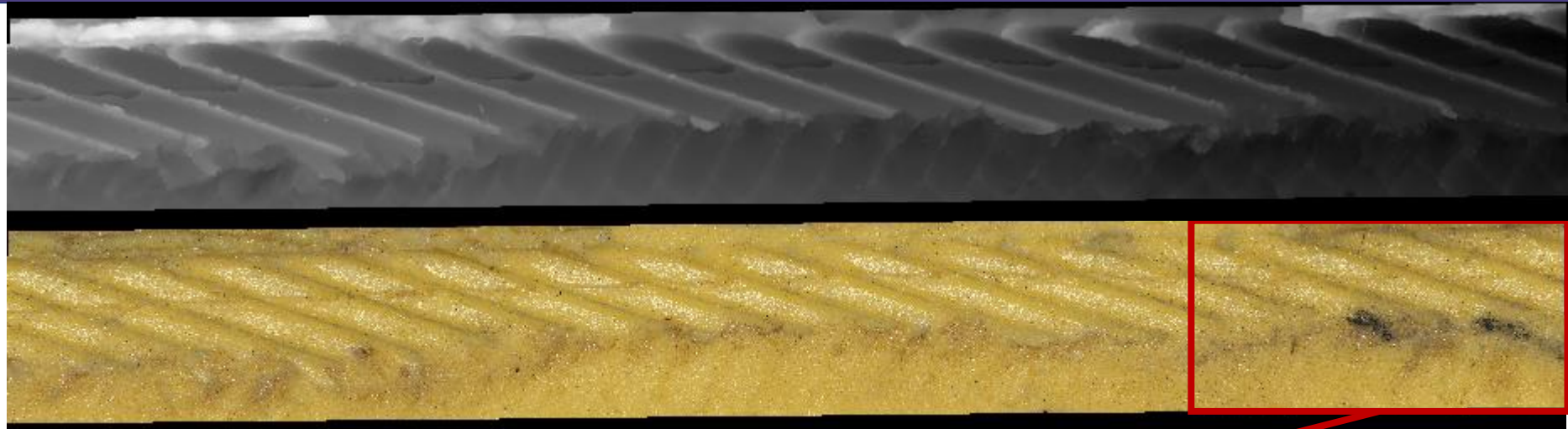
Red Strands



Blue Strands: Red Region



Polymer Imprint of BNL Rutherford Cable



BNL Cable:

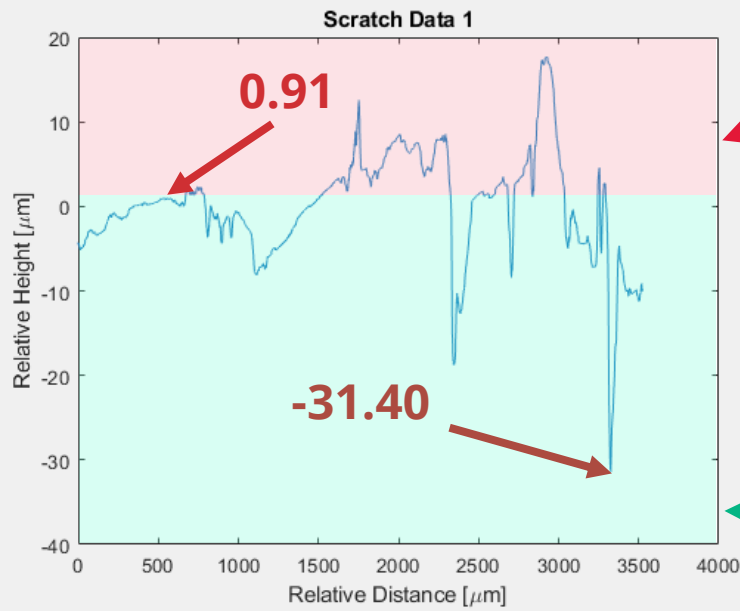
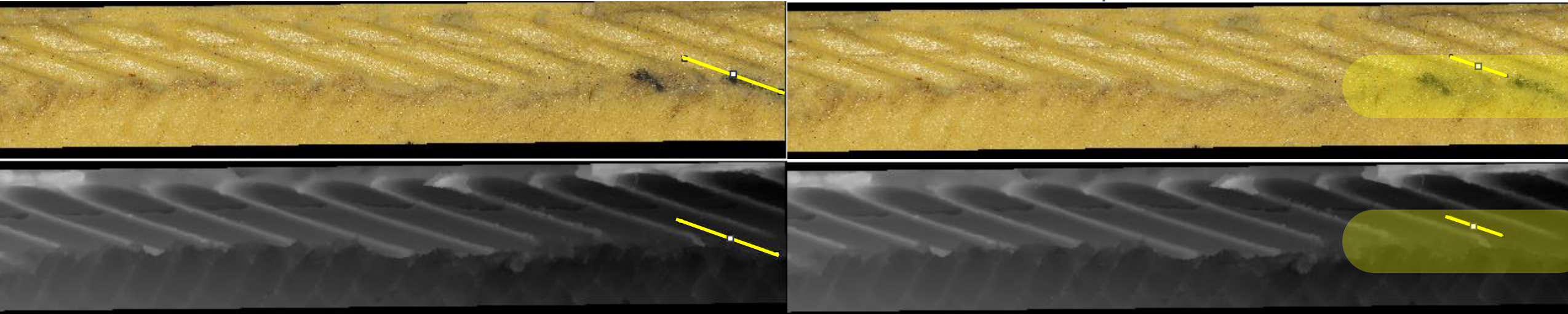
- The following data will reflect only the damaged edge indicated
- The calibration value for this image was : $0.0255 \mu\text{m}$
- Deepest scratch: $82.18 \mu\text{m}$



BNL: Scratch 1

Scratch Data

Expected Data

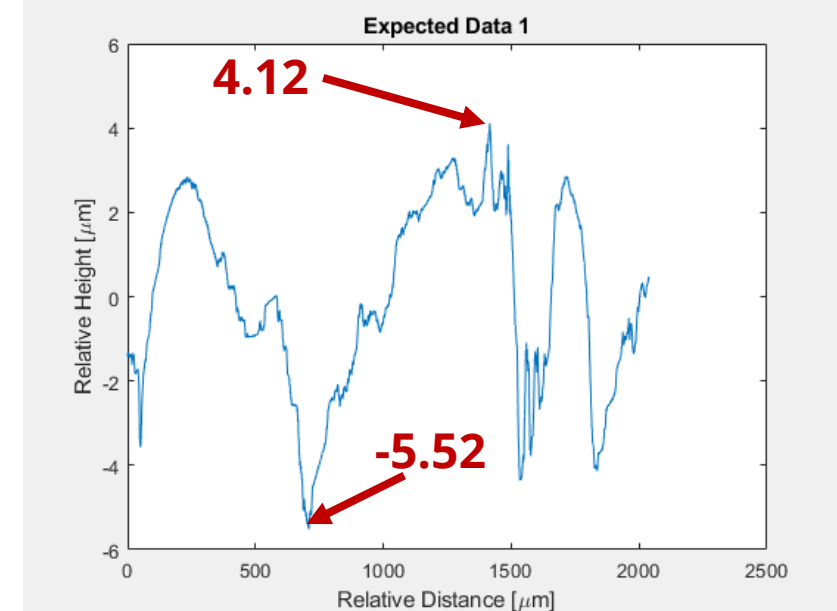


Lifted Material

Scratch 1

- Cut Depth: 32.31 μm
- Expected Standard Deviation: 2.2119 μm over 2 mm

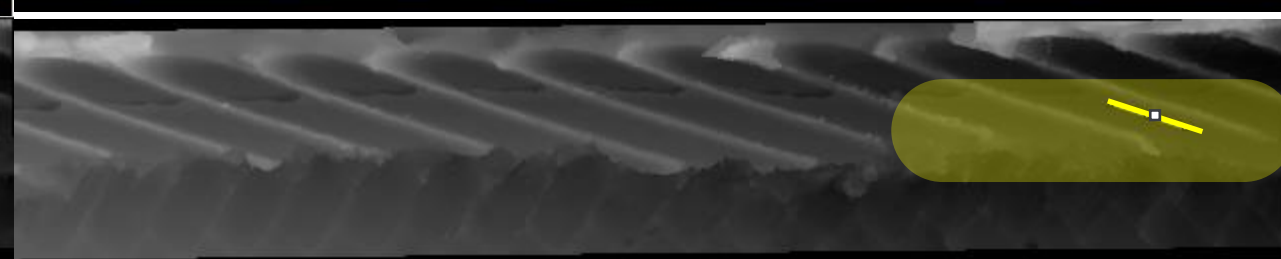
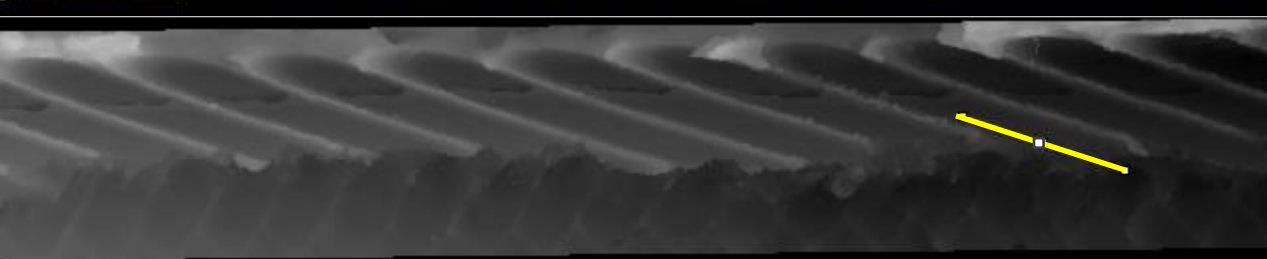
Scratched Area



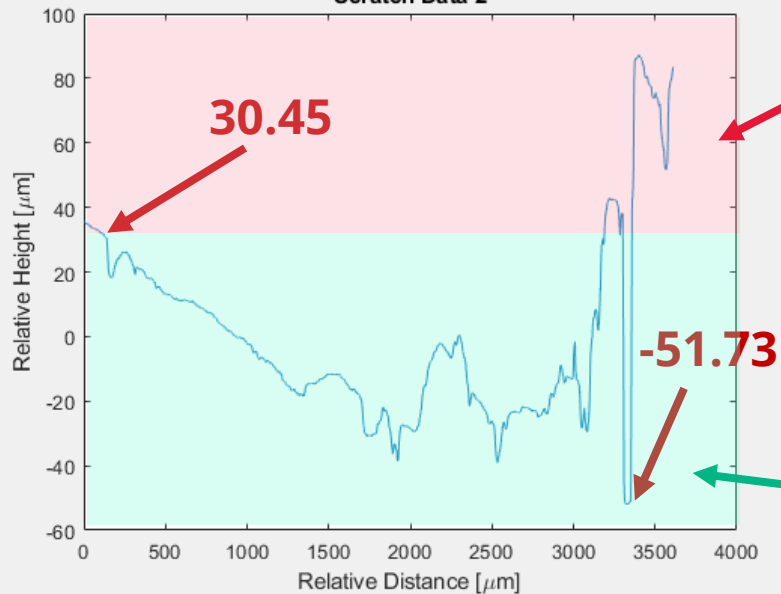
BNL: Scratch 2

Scratch Data

Expected Data



Scratch Data 2



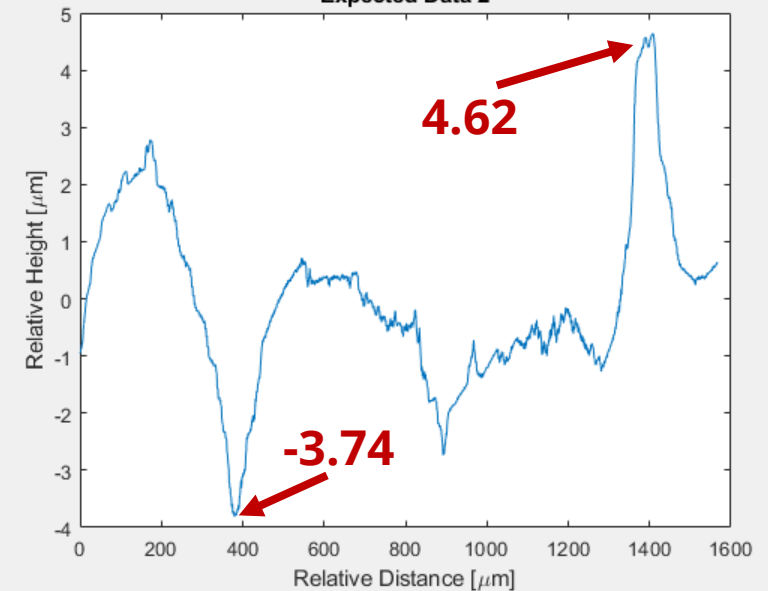
Lifted Material

Scratch 2

- Cut Depth: 82.18 μm
- Expected Standard Deviation: 1.53 μm over 1.6 mm

Scratched Area

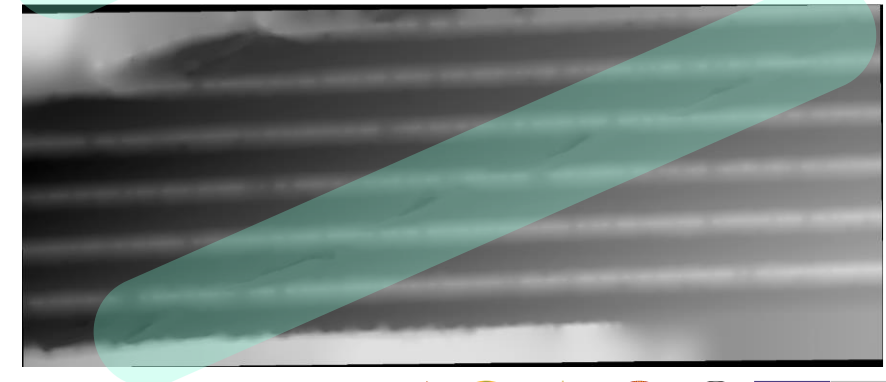
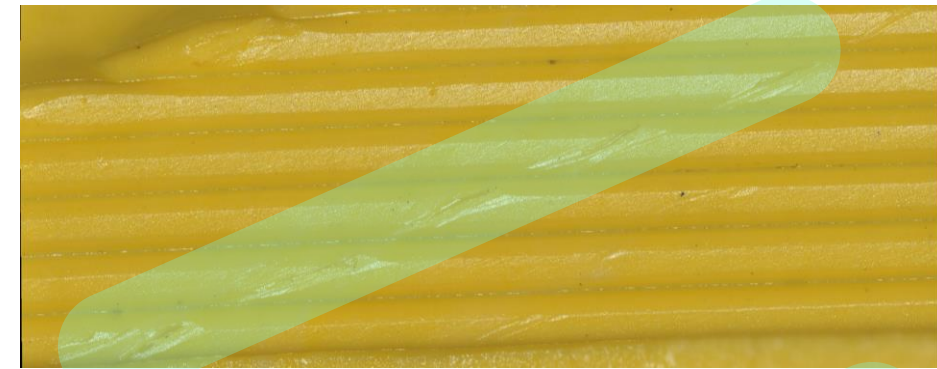
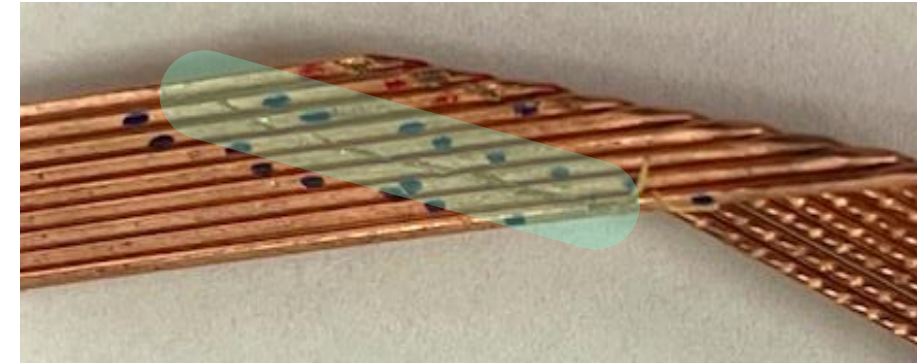
Expected Data 2



Polymer Imprint: "Blue Strands"

Blue Strands:

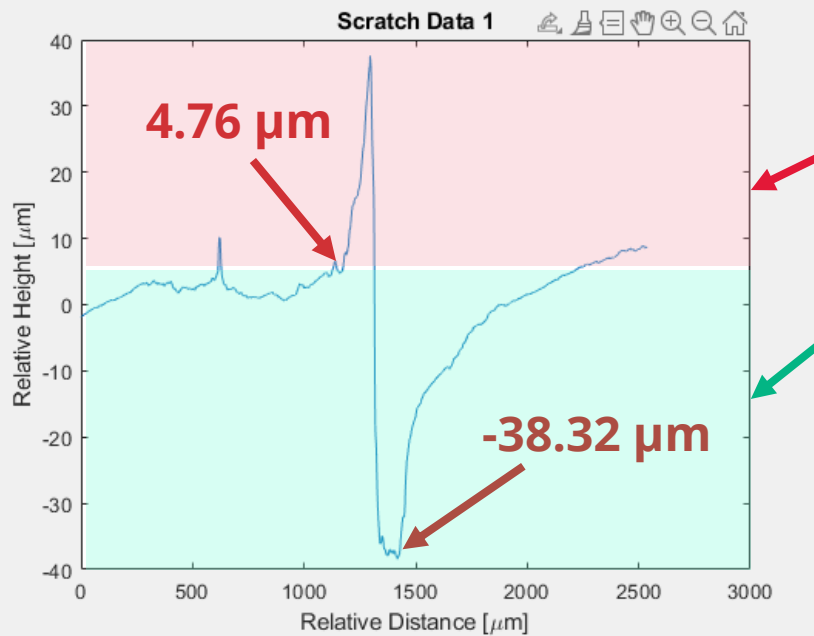
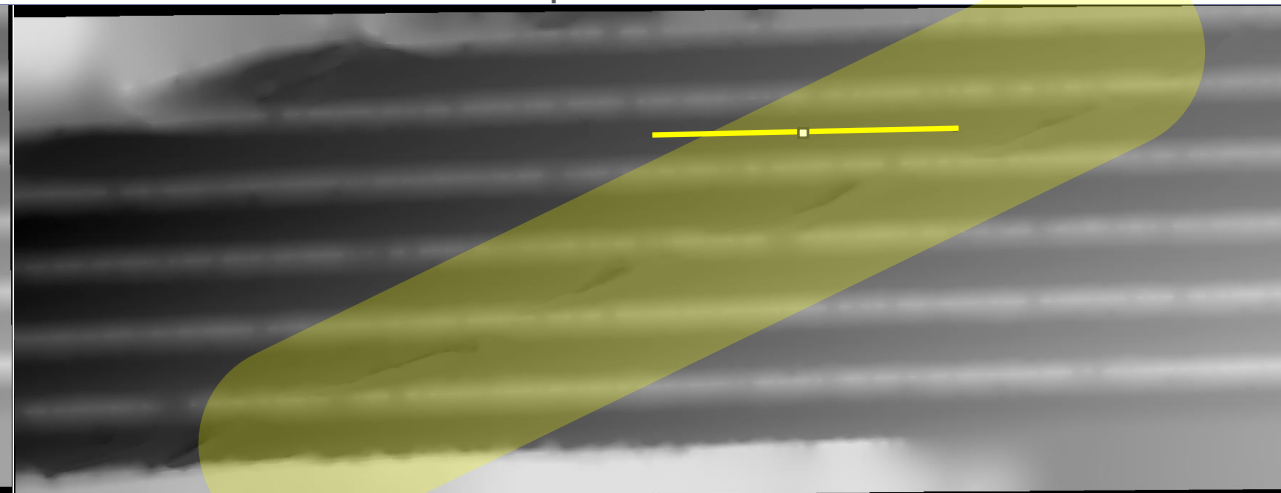
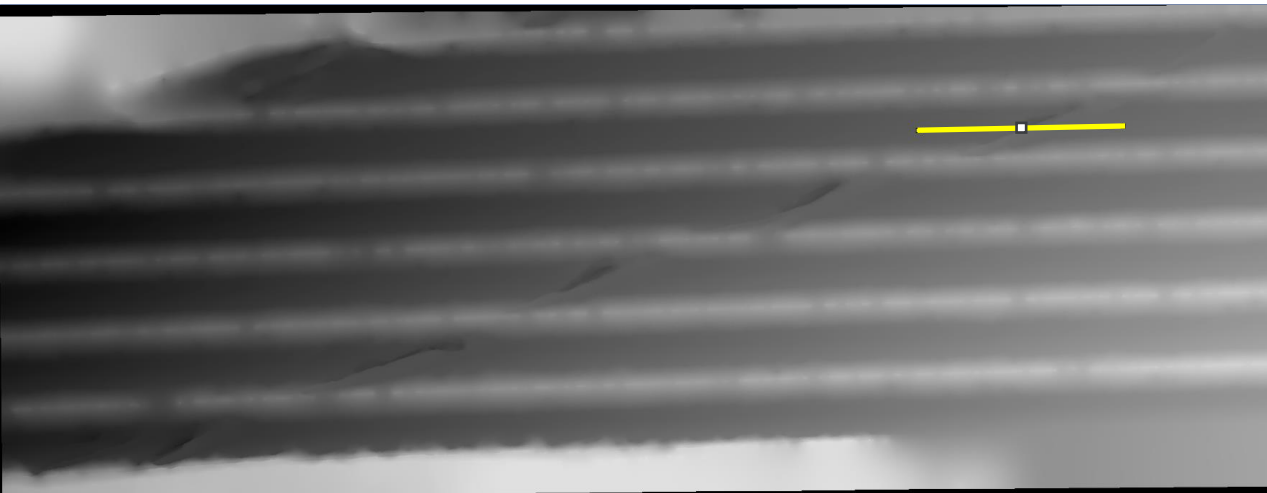
- The calibration value for this image was : 0.02363 μm
- The deepest cut measured was: 46.35 μm



Blue Strands: Scratch 1

Scratch Data

Expected Data

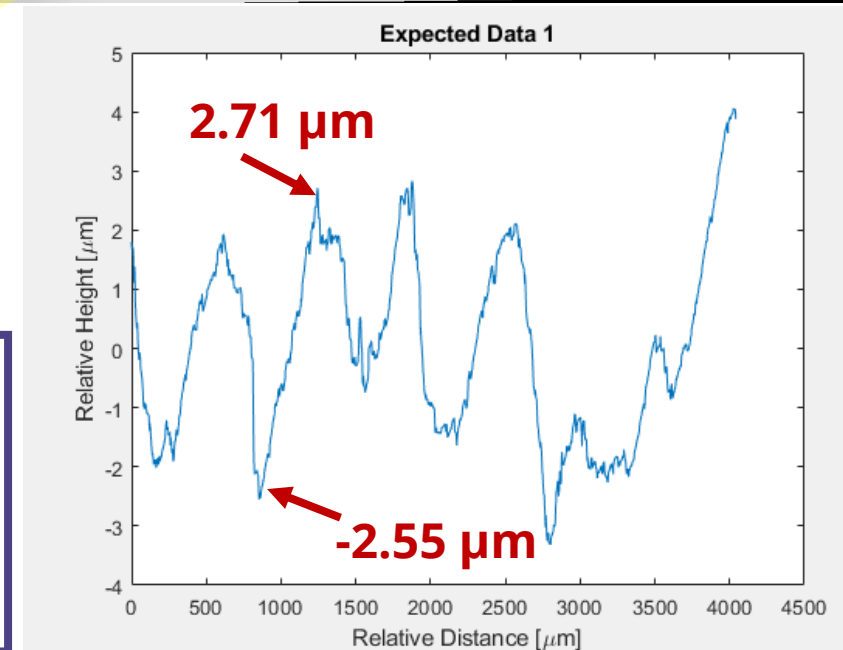


Lifted Material

Scratched Area

Scratch 1

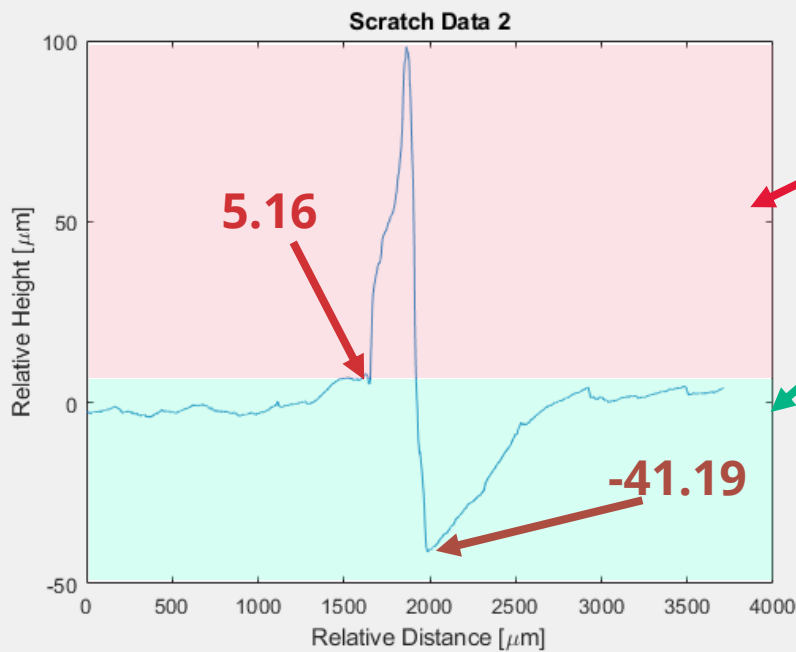
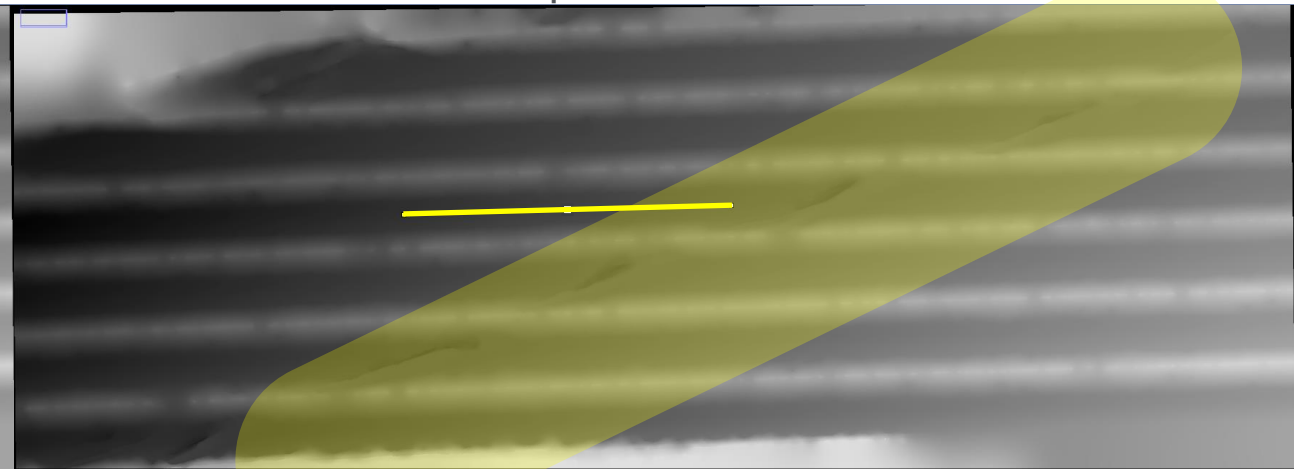
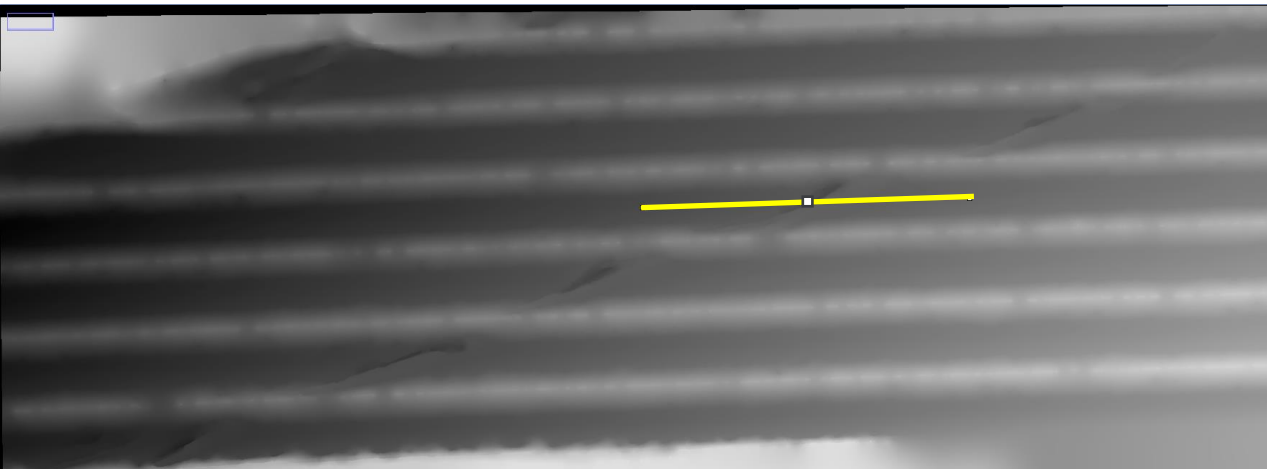
- Cut Depth: 43.08 μm
- Expected Standard Deviation: 1.5712 μm over 4 mm



Blue Strands: Scratch 2

Scratch Data

Expected Data

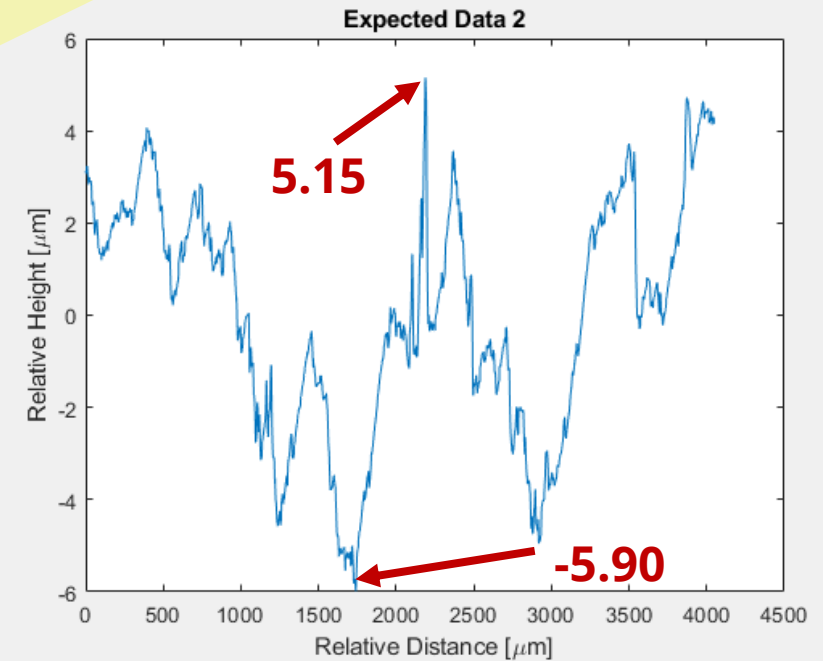


Lifted Material

Scratched Area

Scratch 2

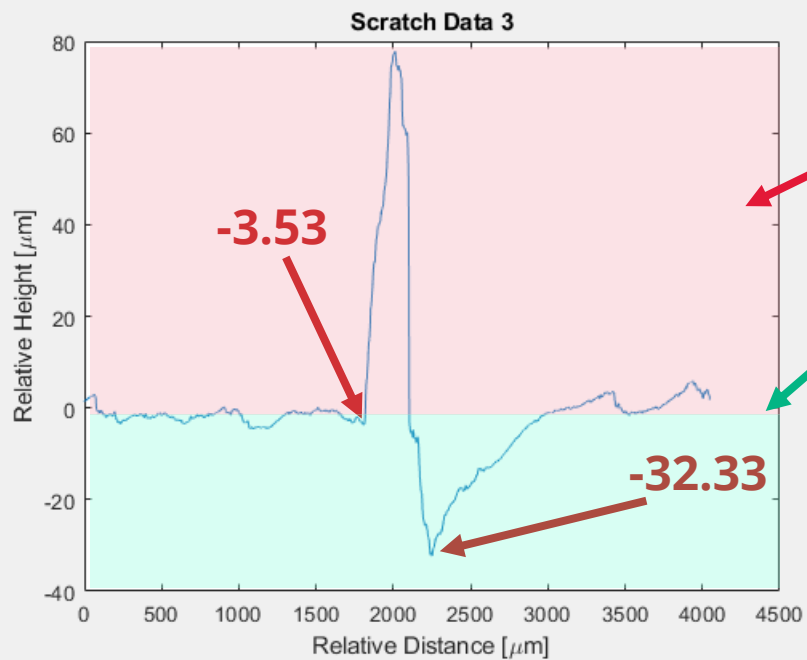
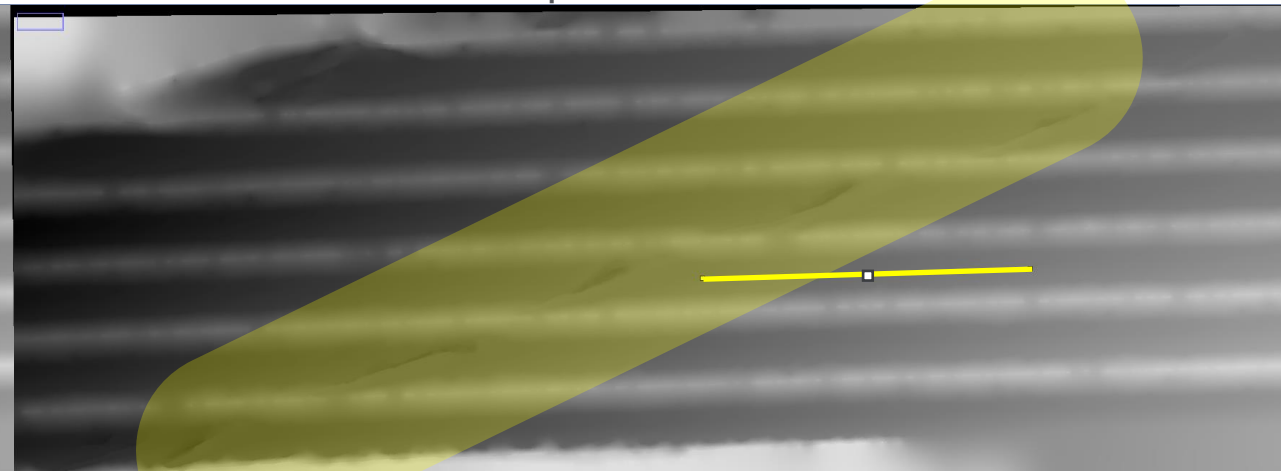
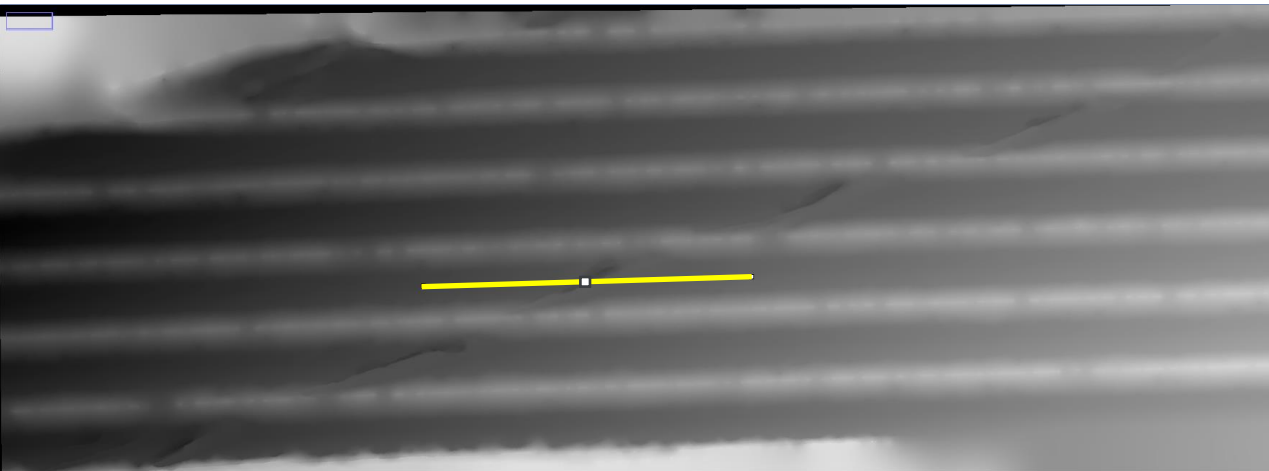
- Cut Depth: 46.35 μm
- Expected Standard Deviation: 2.5208 μm over 4046 μm



Blue Strands: Scratch 3

Scratch Data

Expected Data

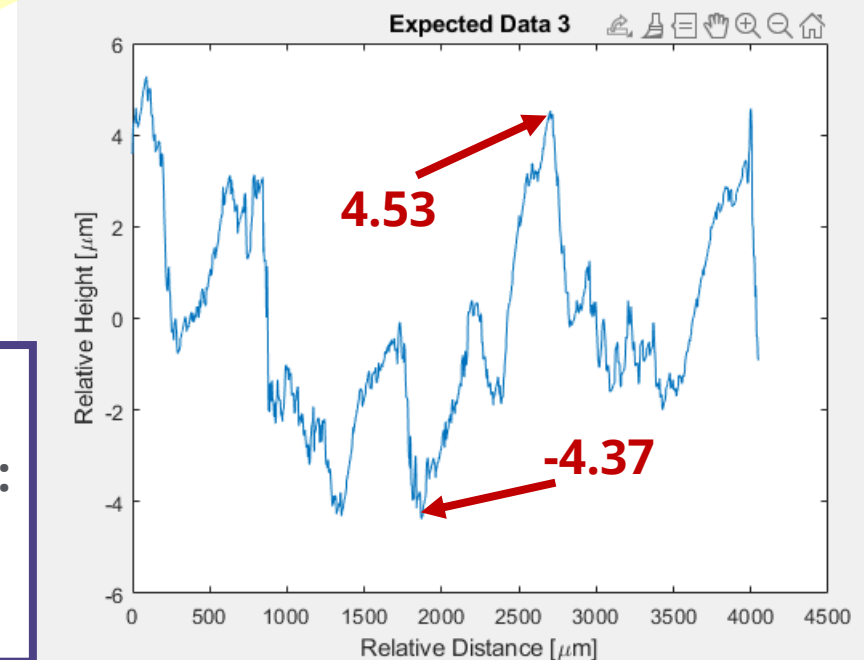


Lifted Material

Scratched Area

Scratch 3

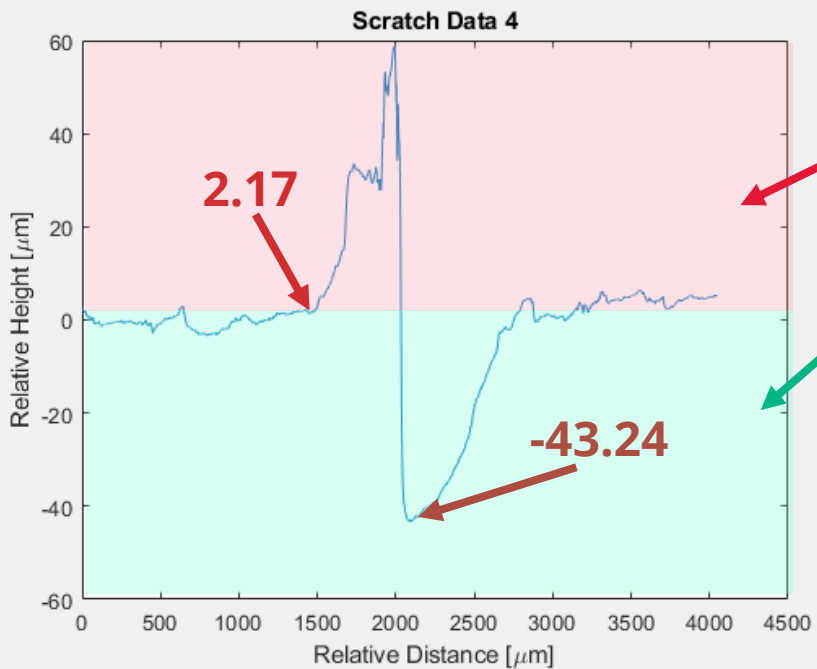
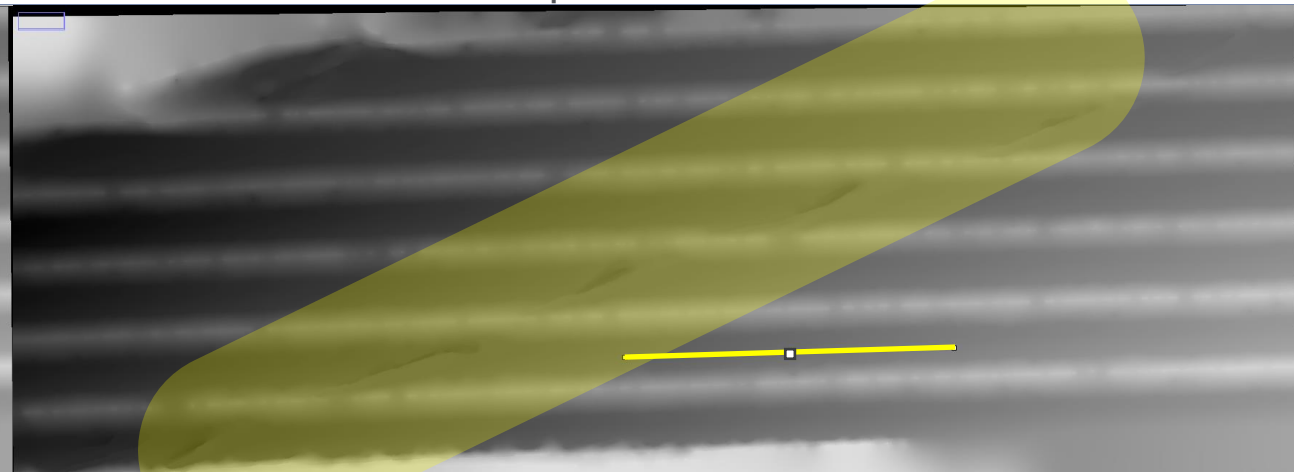
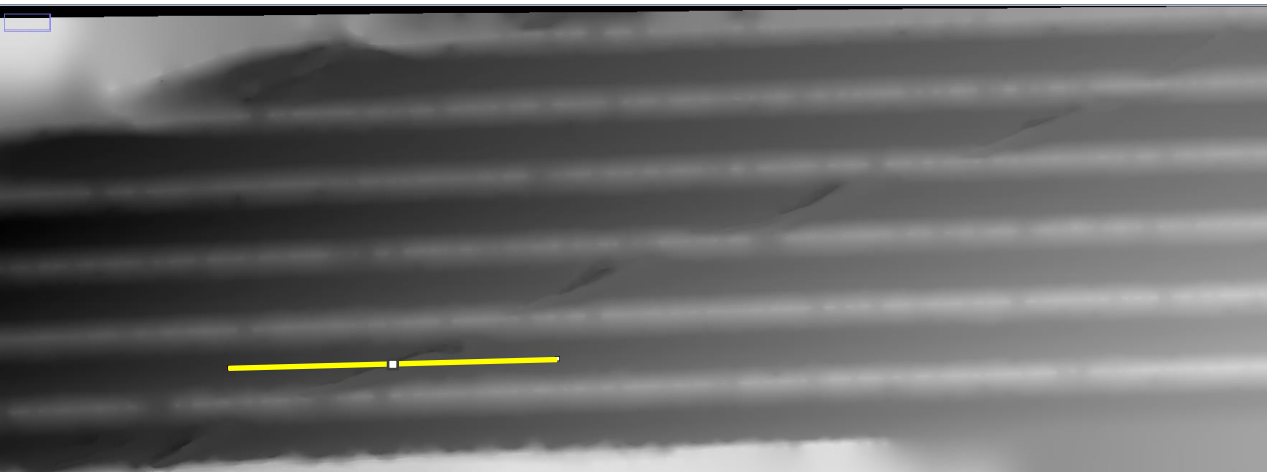
- Cut Depth: 28.8 μm
- Expected Standard Deviation: 2.2455 μm over 4048 μm



Blue Strands: Scratch 4

Scratch Data

Expected Data

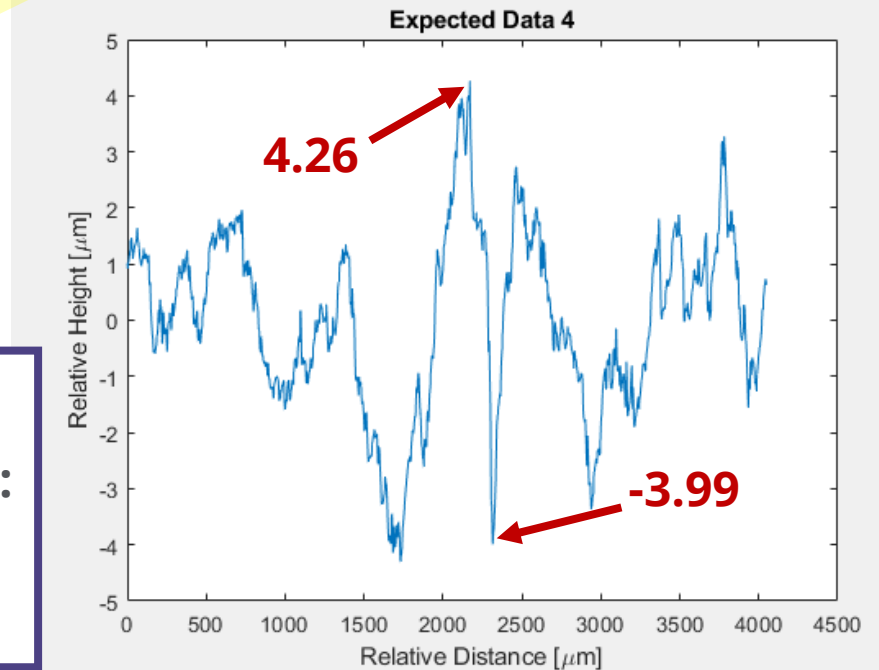


Lifted Material

Scratched Area

Scratch 4

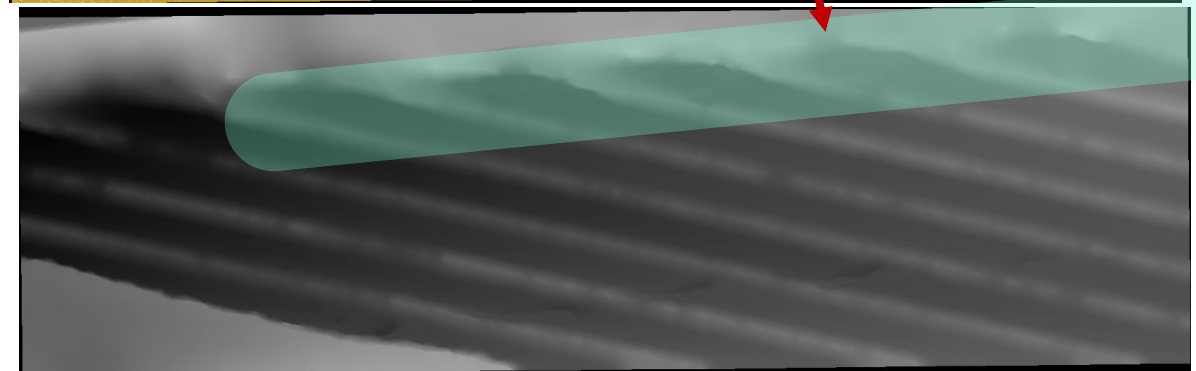
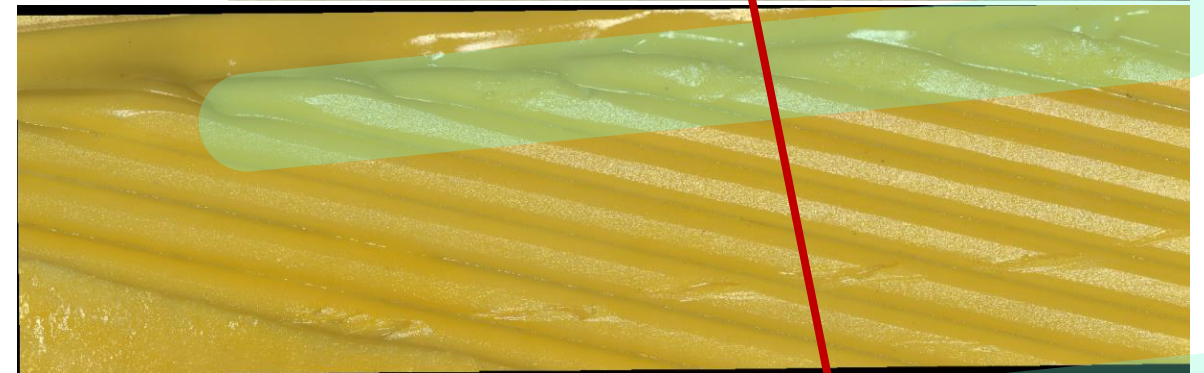
- Cut Depth: 45.41 μm
- Expected Standard Deviation: 1.5772 μm over 4048 μm



Polymer Imprint: "Blue Strands: Red Region"

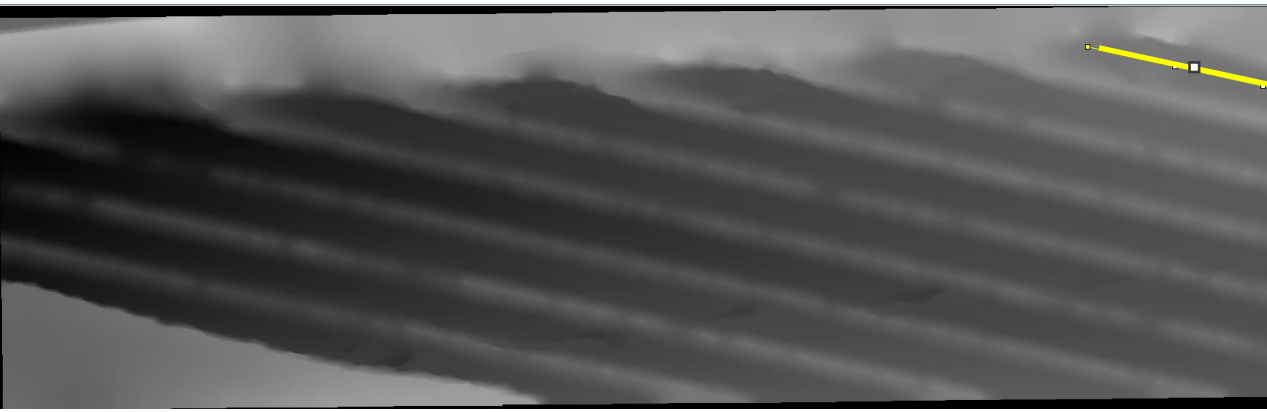
Blue Strands: Red Region

- The calibration value for this image was : $0.04179 \mu\text{m}$
- The deepest cut measured was: $28.8 \mu\text{m}$

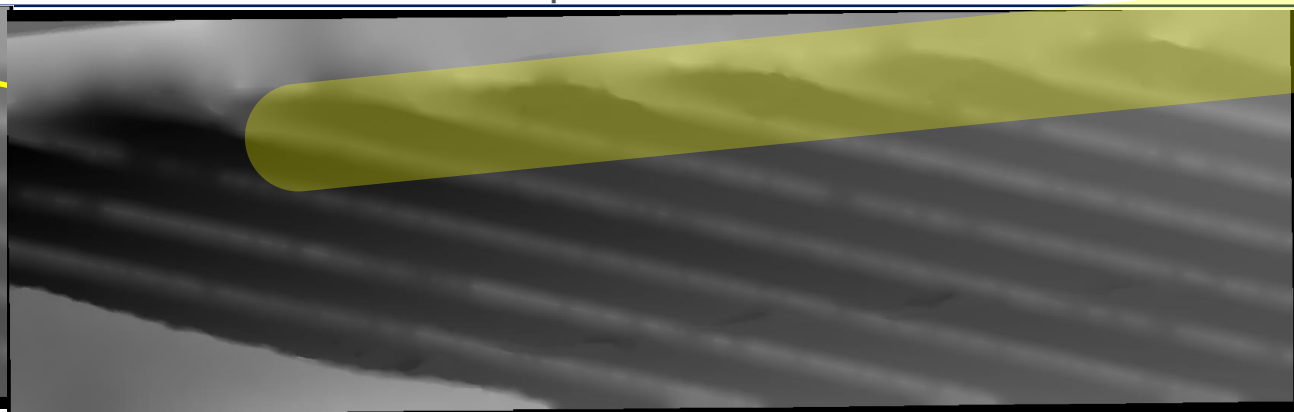


Red Region: Scratch 1

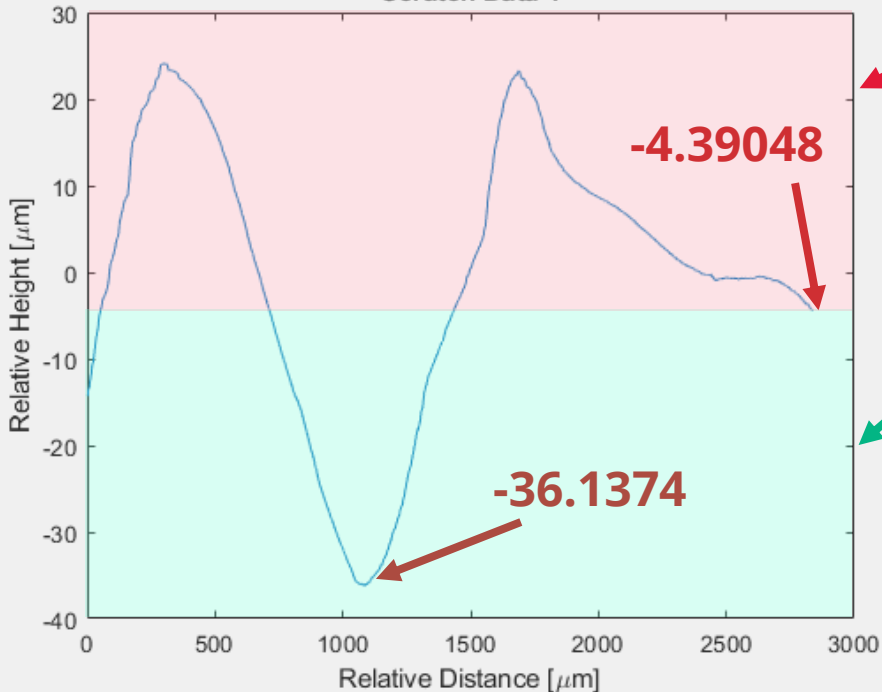
Scratch Data



Expected Data



Scratch Data 1



Lifted Material

Scatched Area

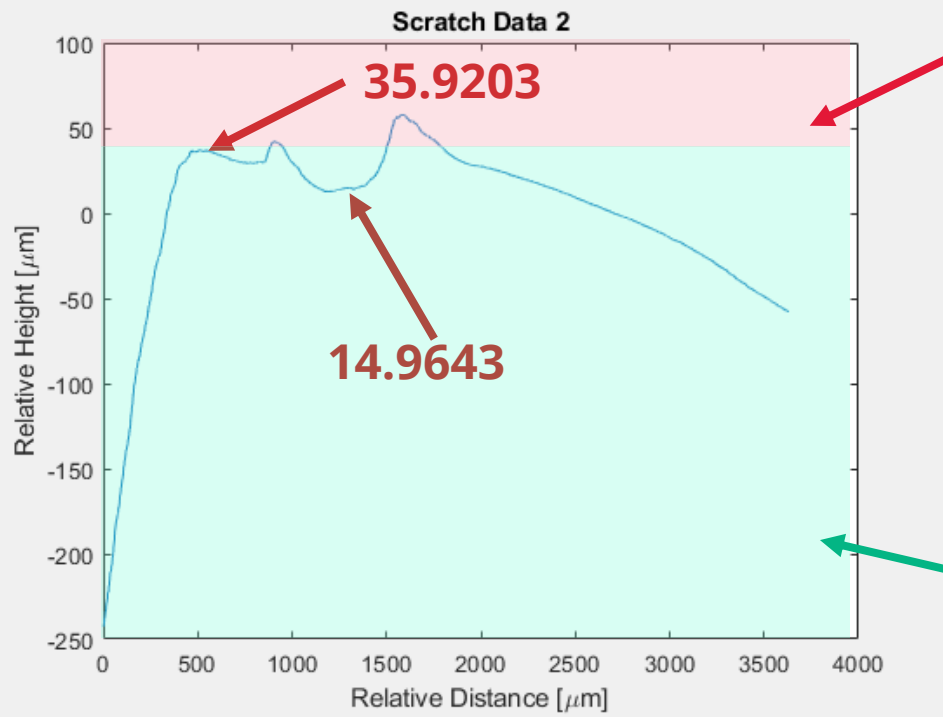
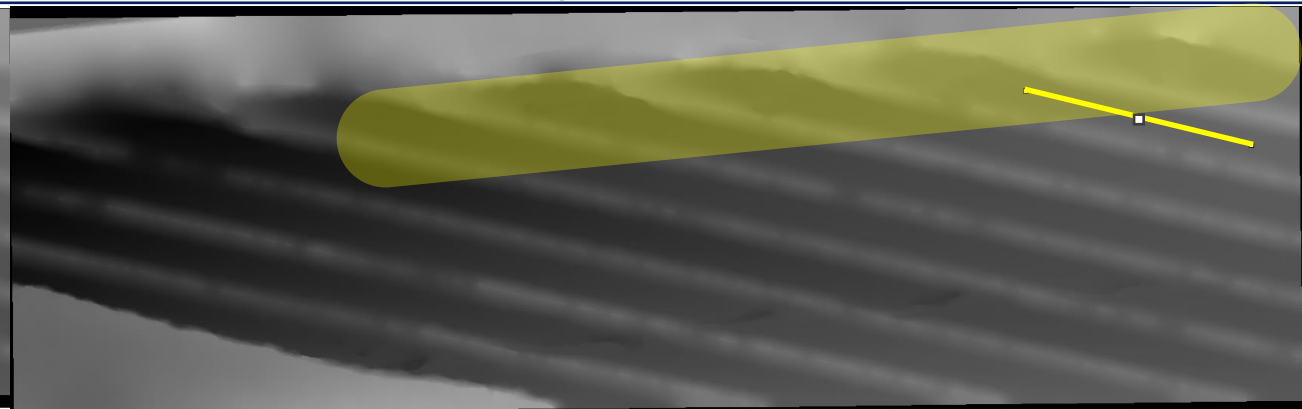
Scratch 1

- Cut Depth: 28.8 μm
- No expected data was collected due to lack of viable surface area

Red Region: Scratch 2

Scratch Data

Expected Data

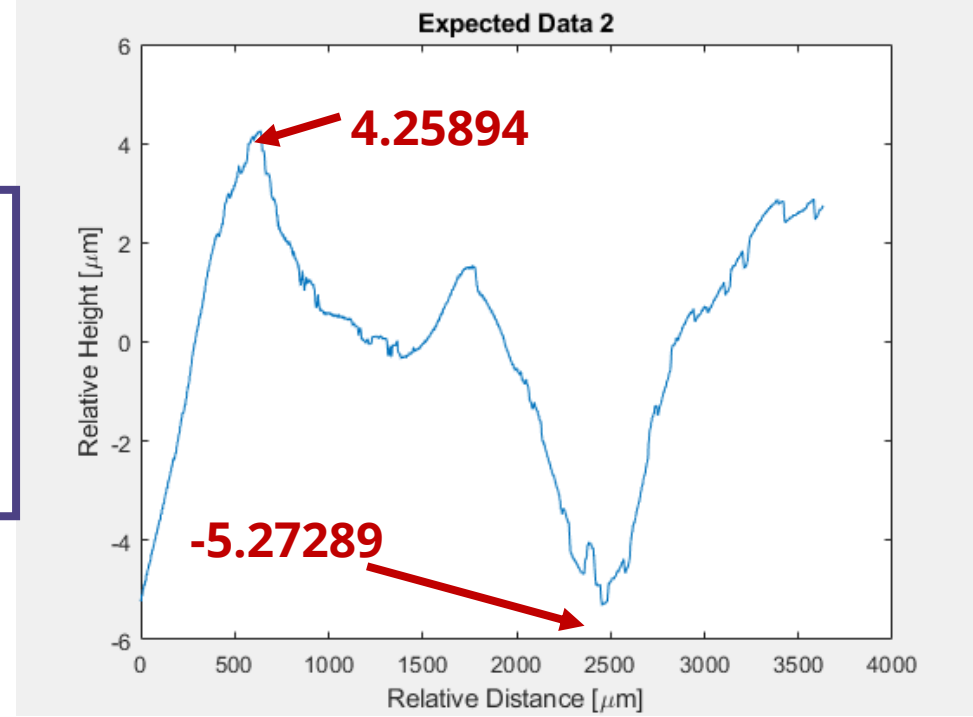


Lifted Material

Scratch 2

- Cut Depth: 20.96 μm
- Expected Standard Deviation: 2.3715 μm over 3.6 mm

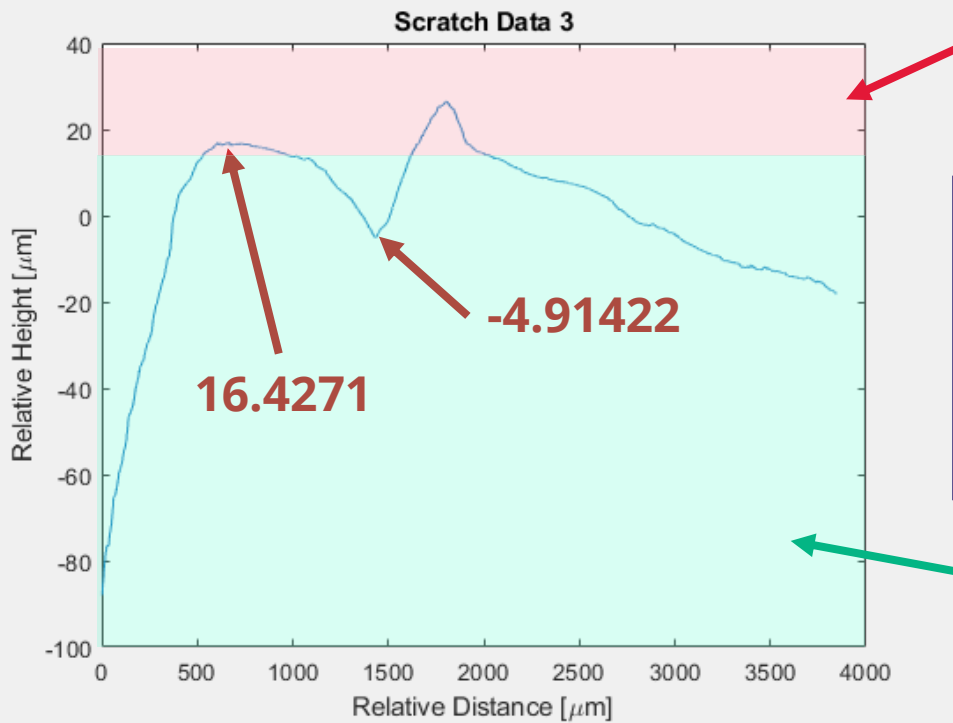
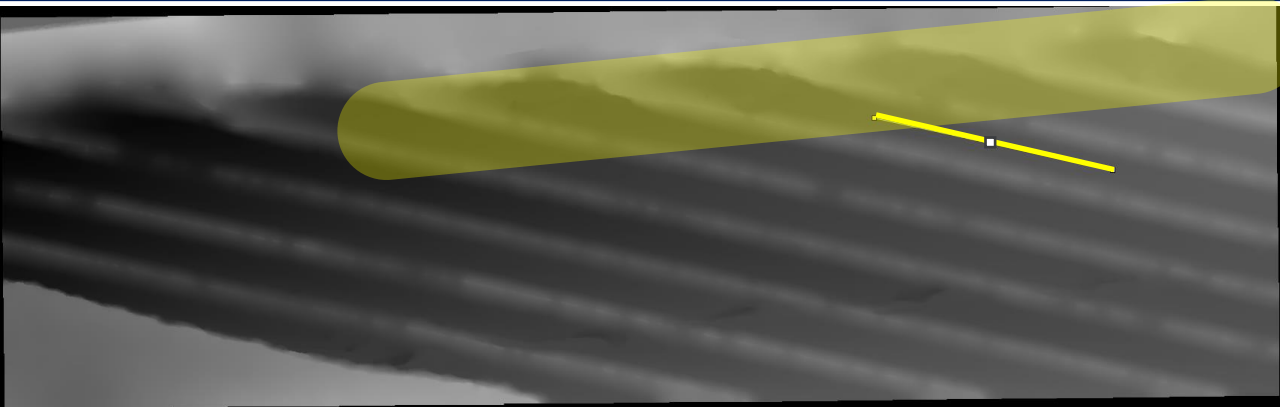
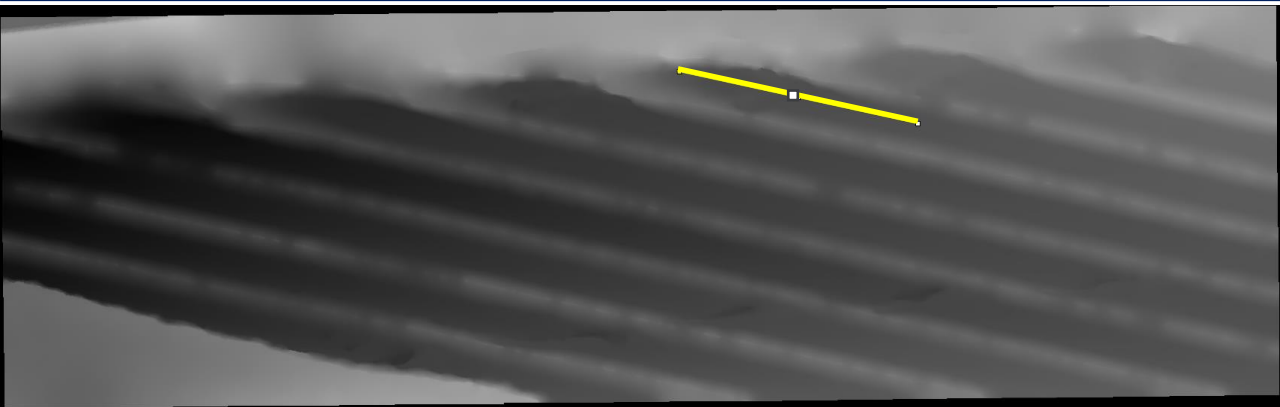
Scratched Area



Red Region: Scratch 3

Scratch Data

Expected Data

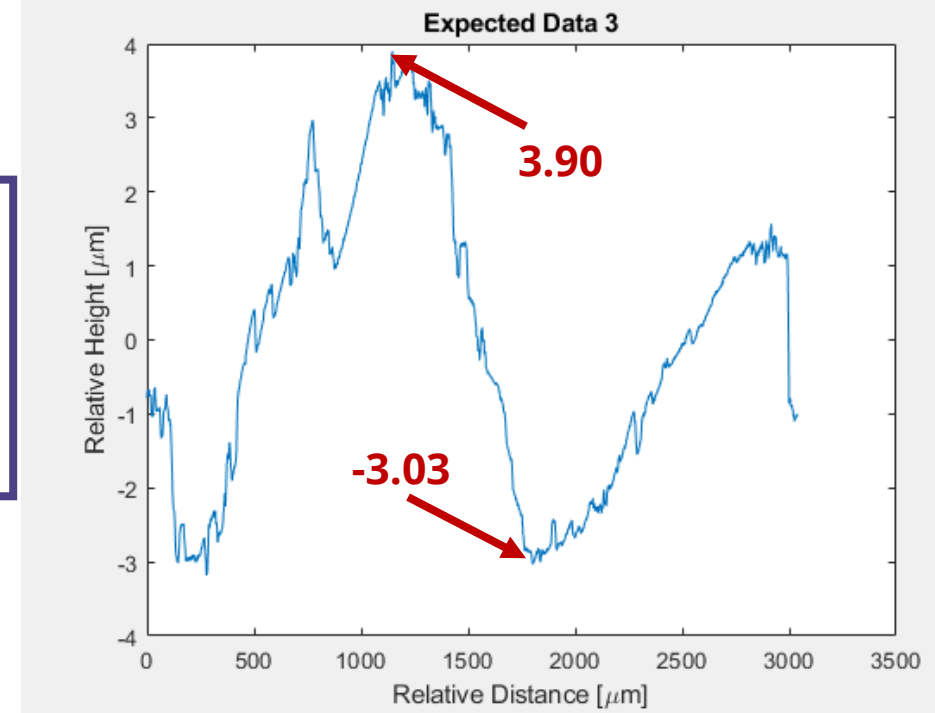


Lifted Material

Scratch 3

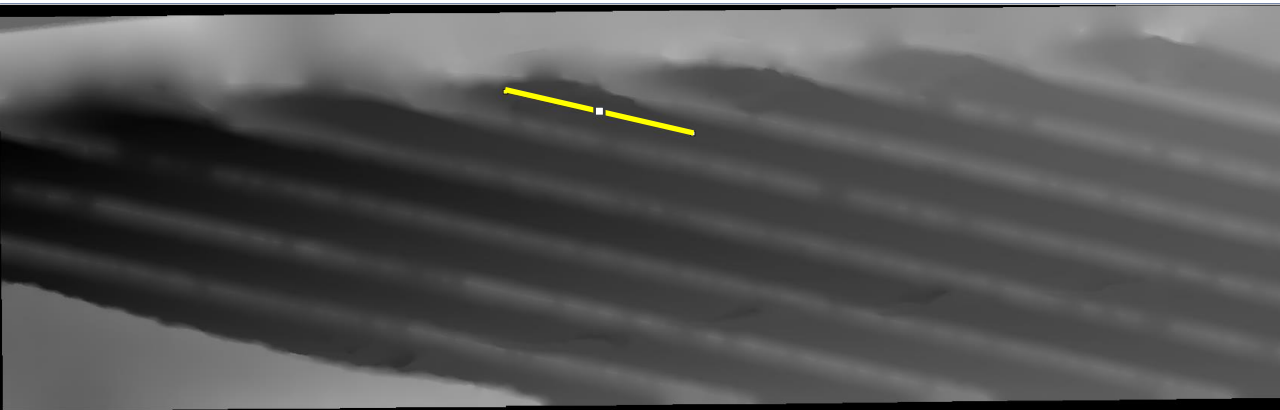
- Cut Depth: 21.34 μm
- Expected Standard Deviation: 1.97 μm over 3 mm

Scratched Area

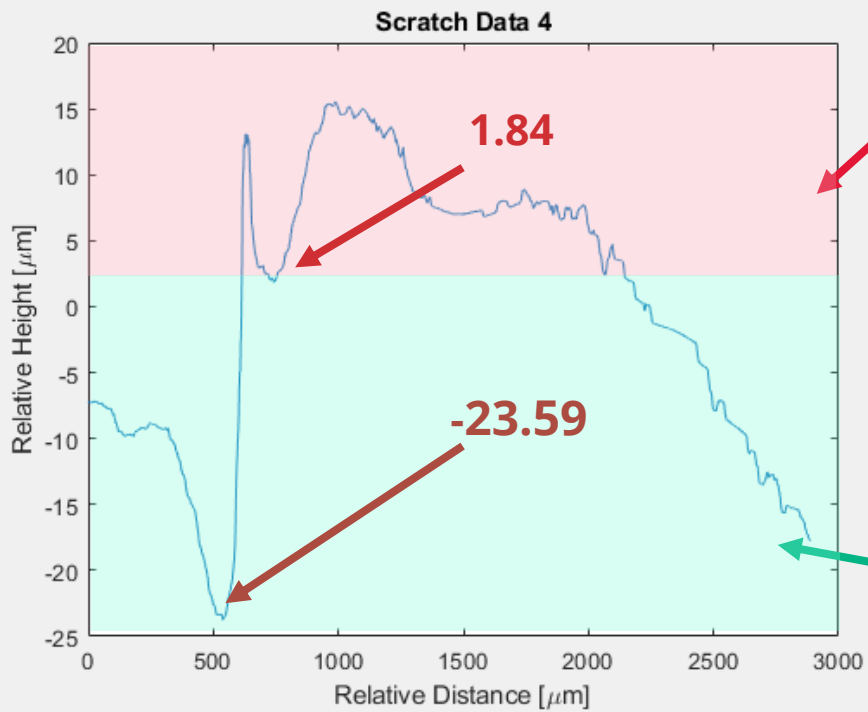
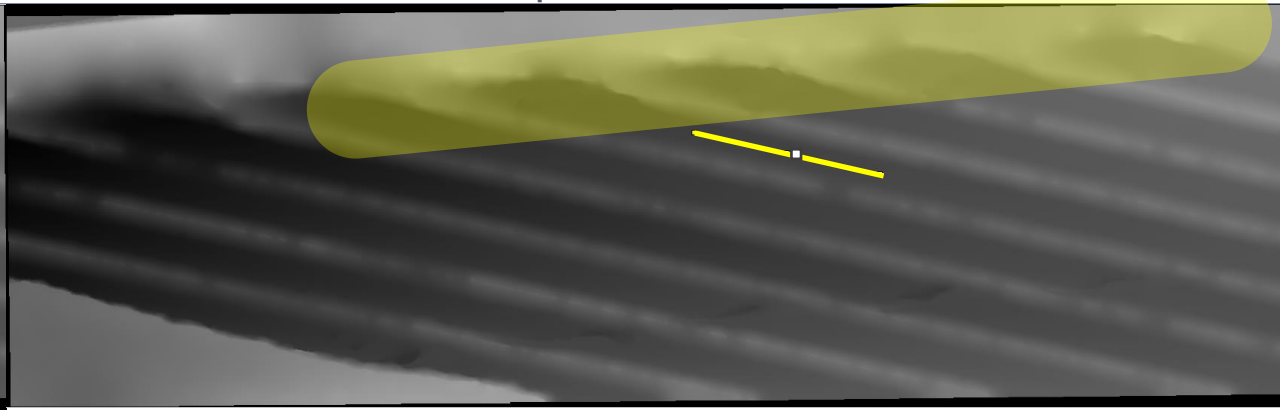


Red Region: Scratch 4

Scratch Data



Expected Data

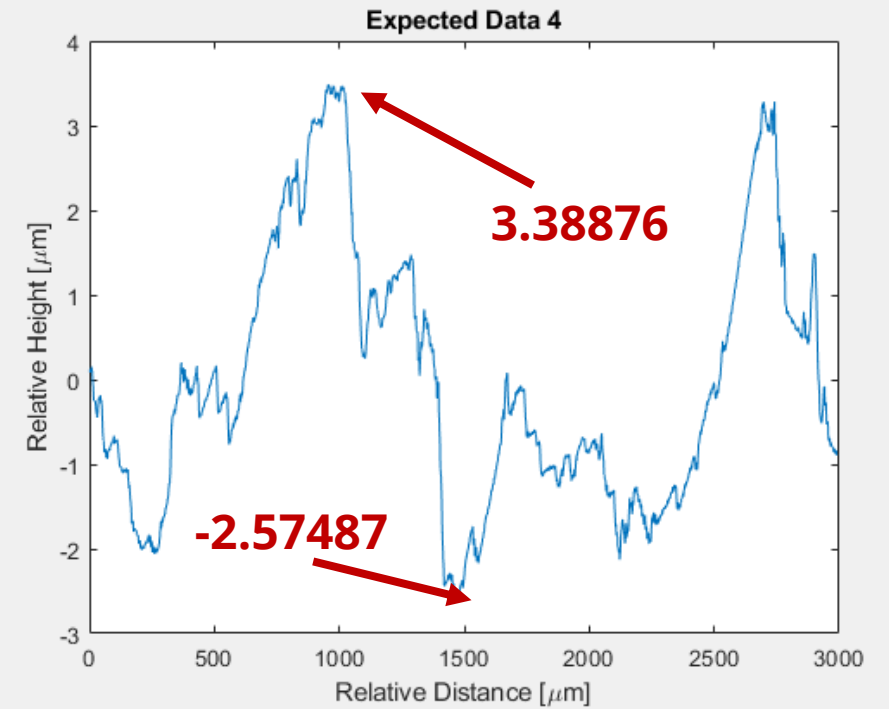


Lifted Material

Scratch 4

- Cut Depth: 25.43 μm
- Expected Standard Deviation: 1.52 μm over 3 mm

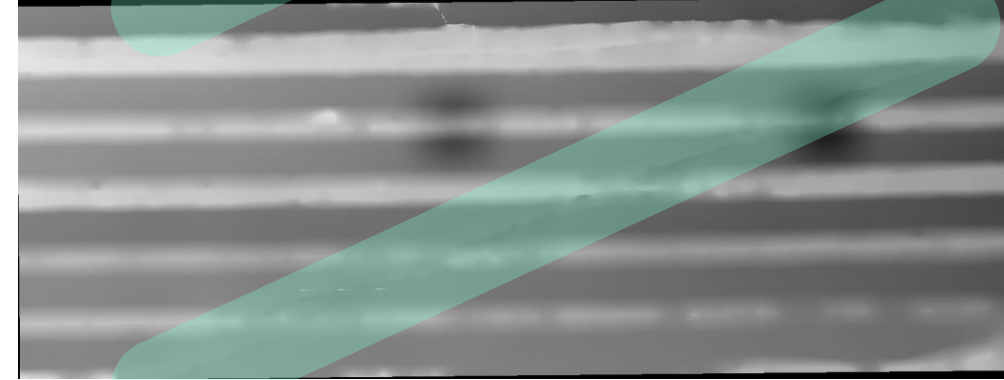
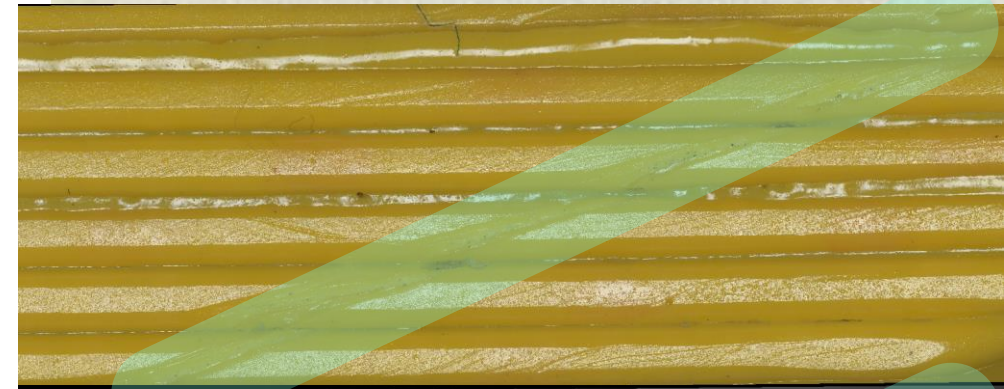
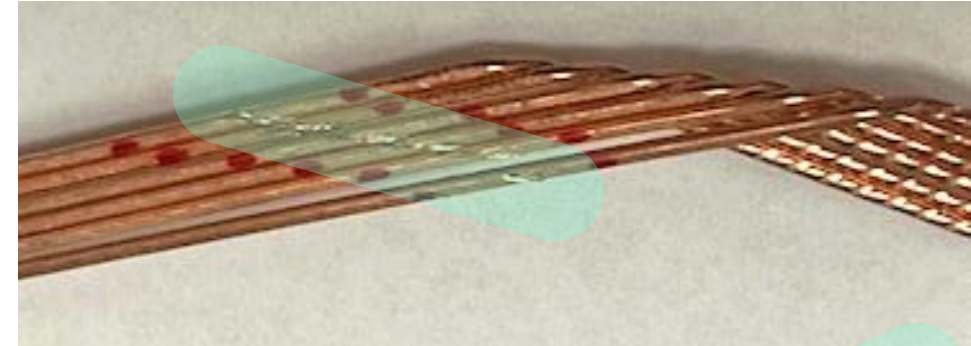
Scratched Area



Polymer Imprint: "Red Strands"

Red Strands:

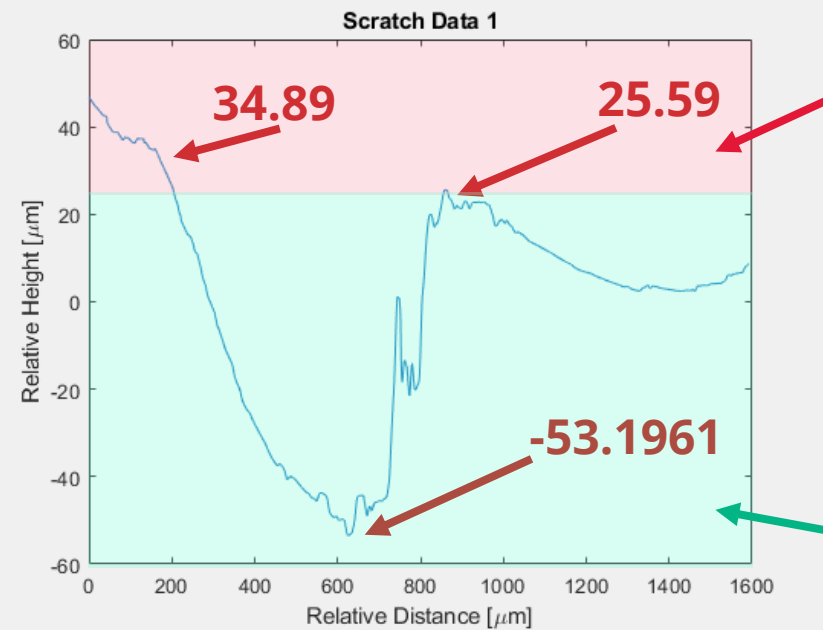
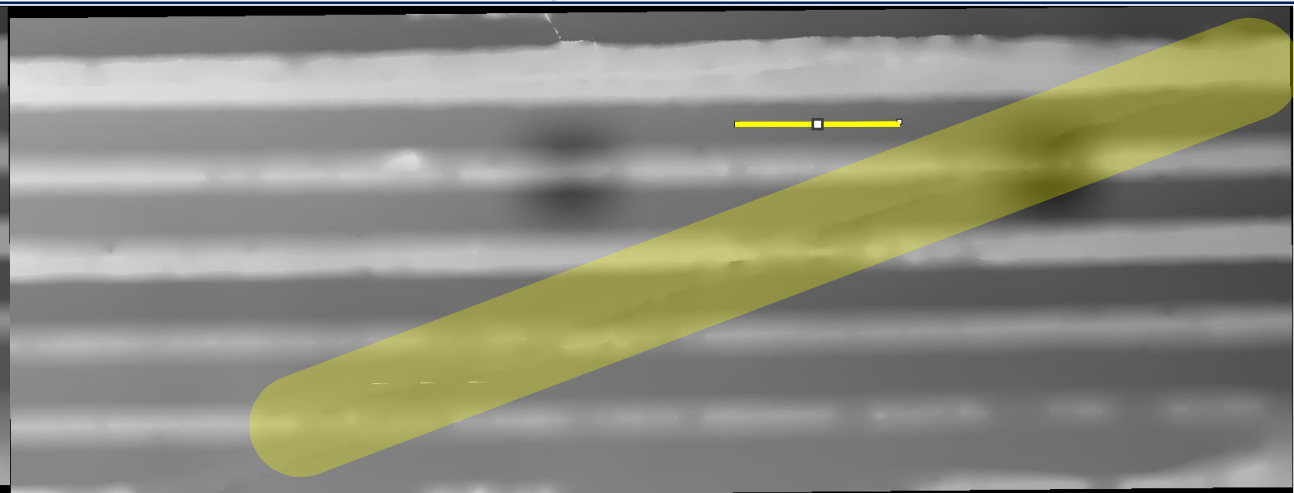
- The calibration value for this image was : $0.03449 \mu\text{m}$
- The deepest cut measured was: $78.79 \mu\text{m}$



"Red Strands: Scratch 1"

Scratch Data

Expected Data

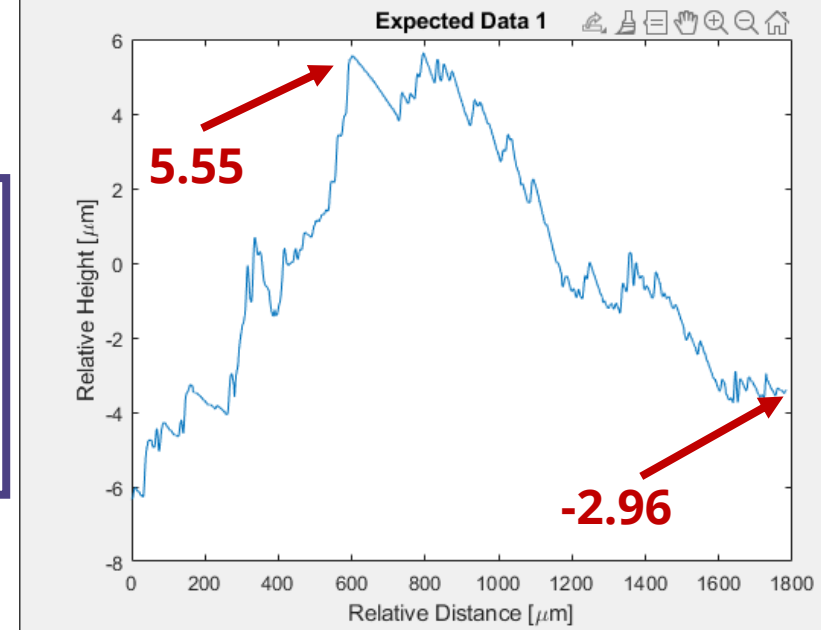


Lifted Material

Scratch 1

- Cut Depth: 78.79 μm
- Expected Standard Deviation: 3.26 μm over 1.78 mm

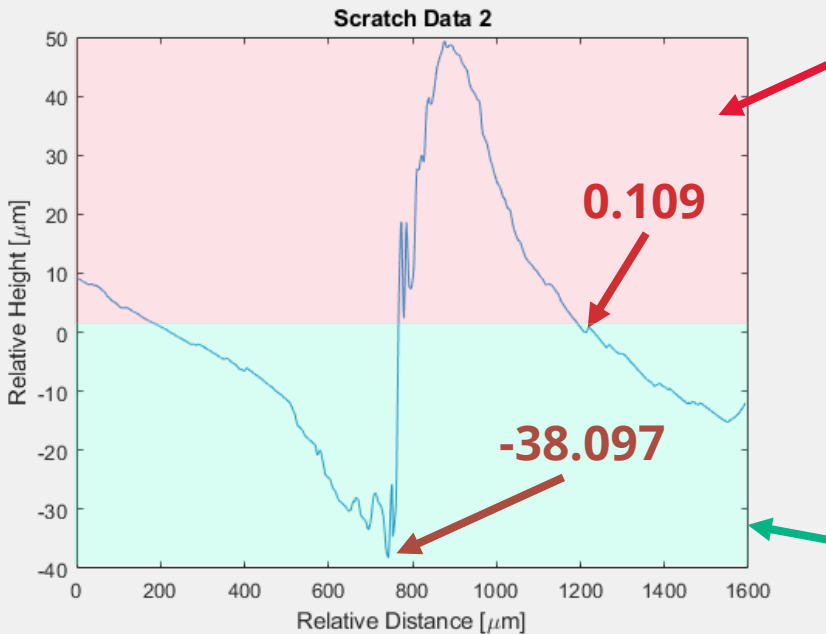
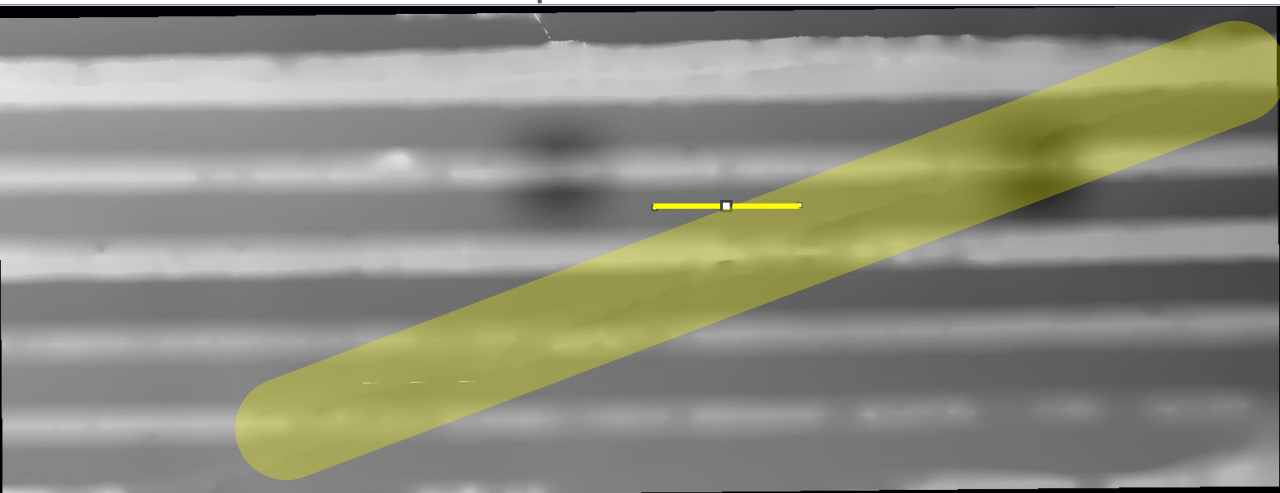
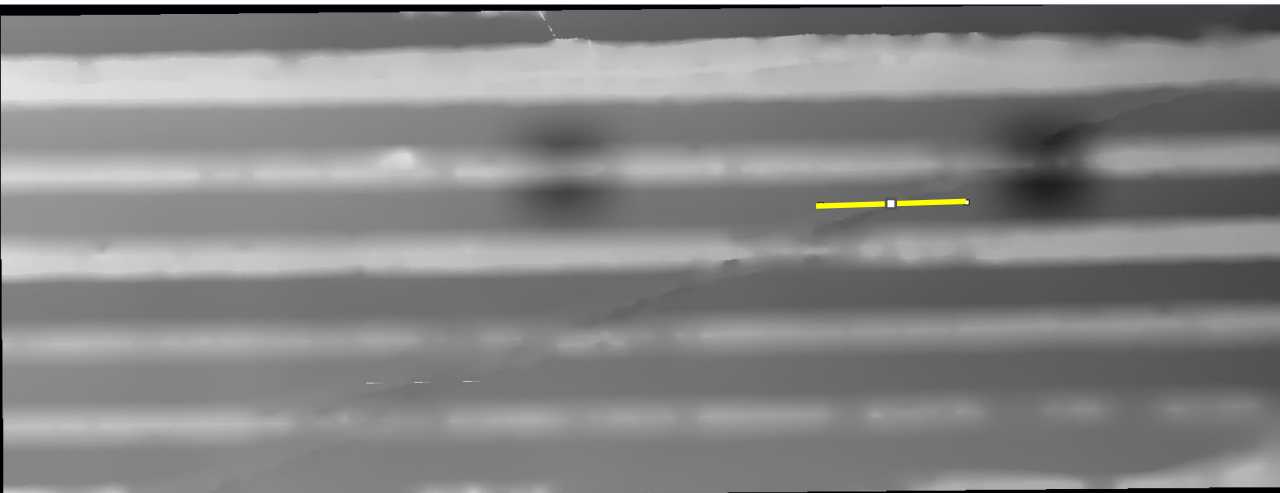
Scratched Area



"Red Strands: Scratch 2"

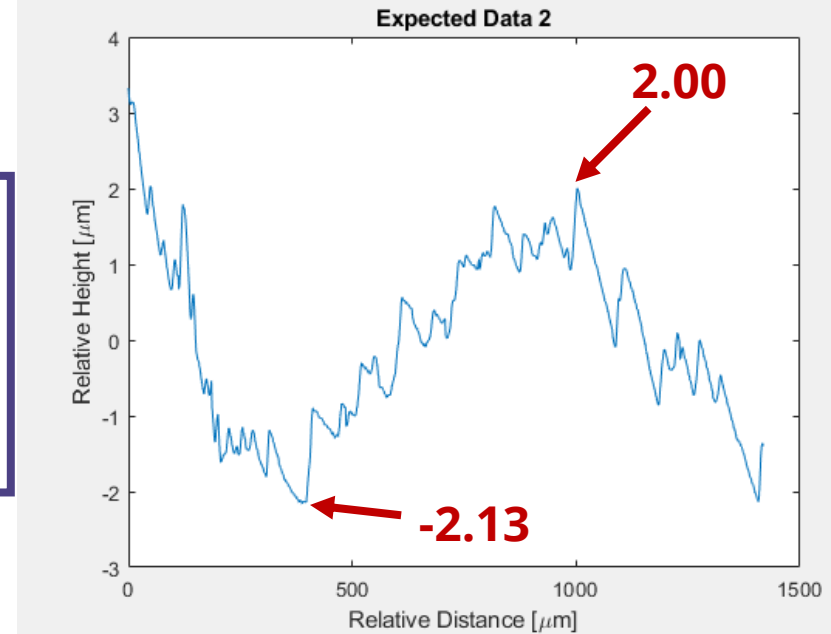
Scratch Data

Expected Data



Scratch 2

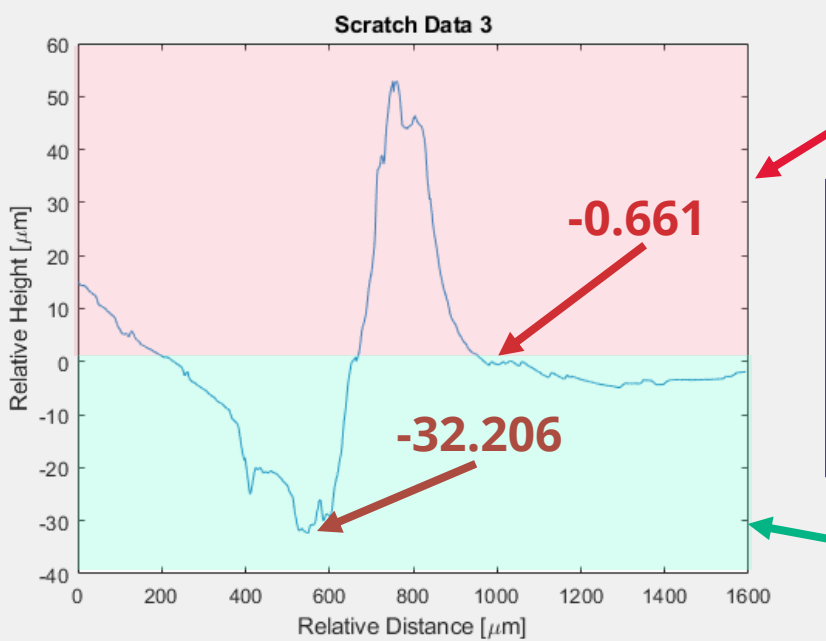
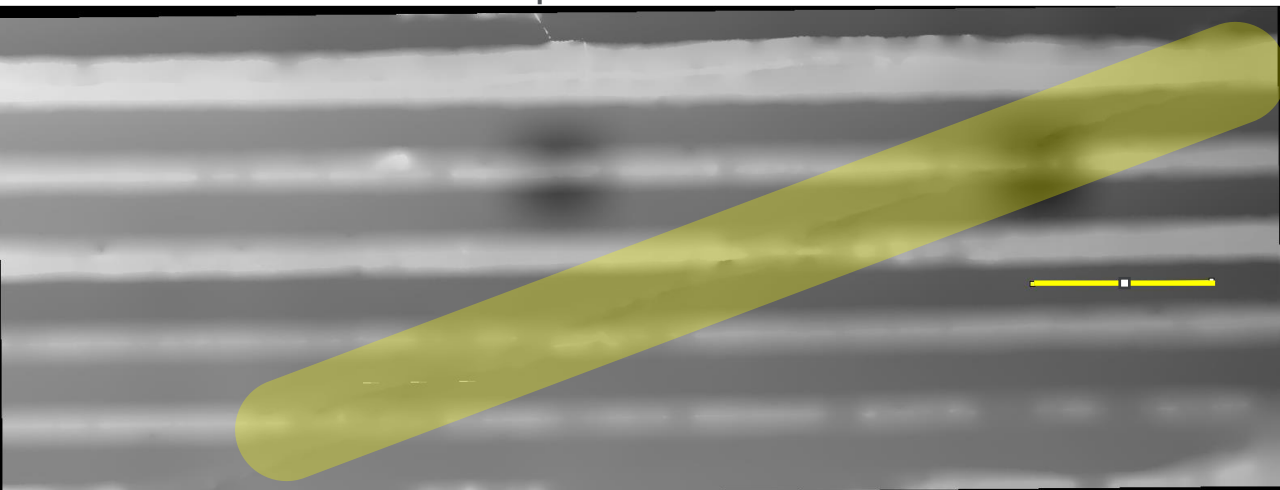
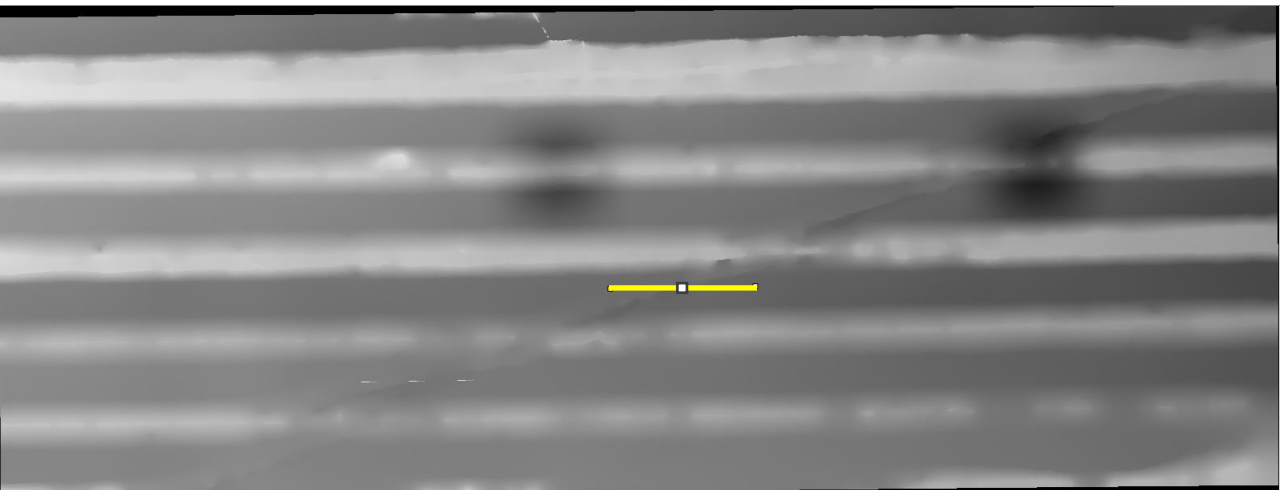
- Cut Depth: 38.206 μm
- Expected Standard Deviation: 1.19 μm over 1.4 mm



"Red Strands: Scratch 3"

Scratch Data

Expected Data

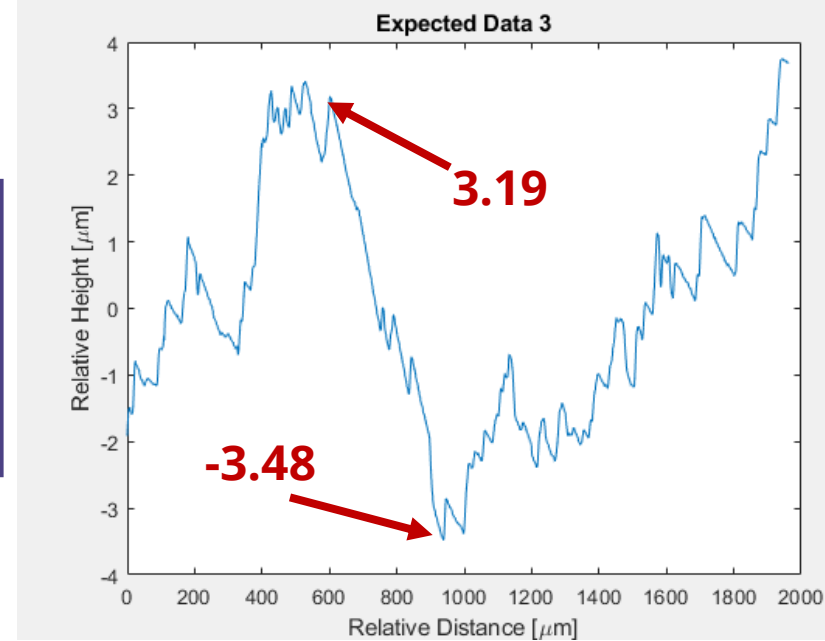


Lifted Material

Scratch 3

- Cut Depth: $31.545 \mu\text{m}$
- Expected Standard Deviation: $1.77 \mu\text{m}$ over 1.96 mm

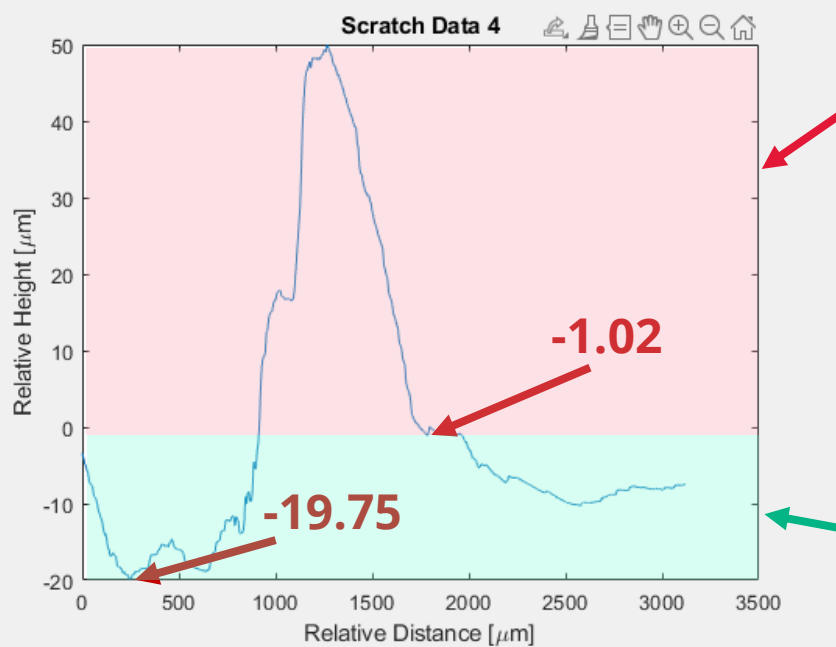
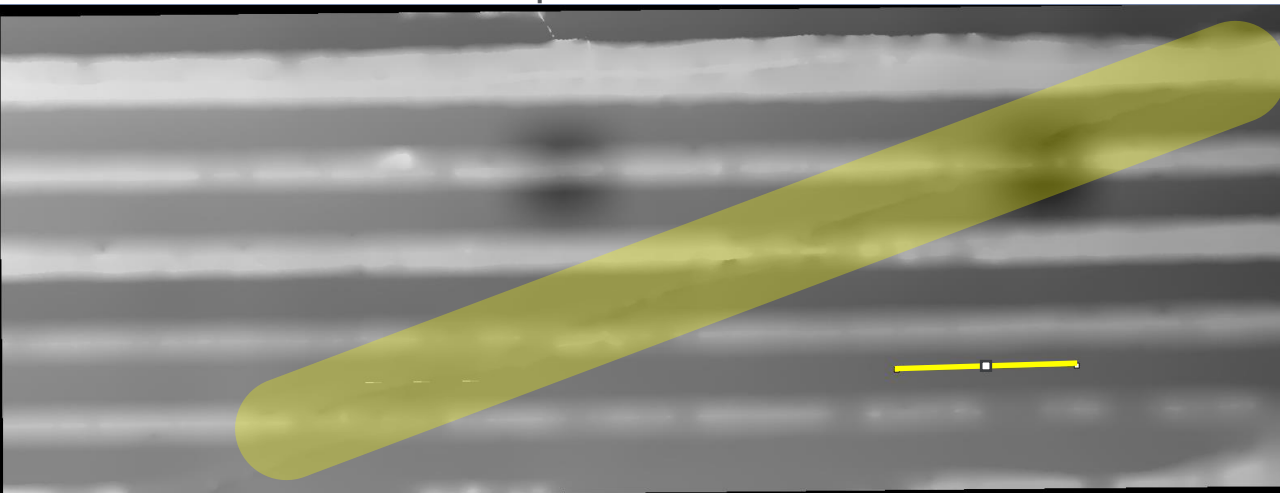
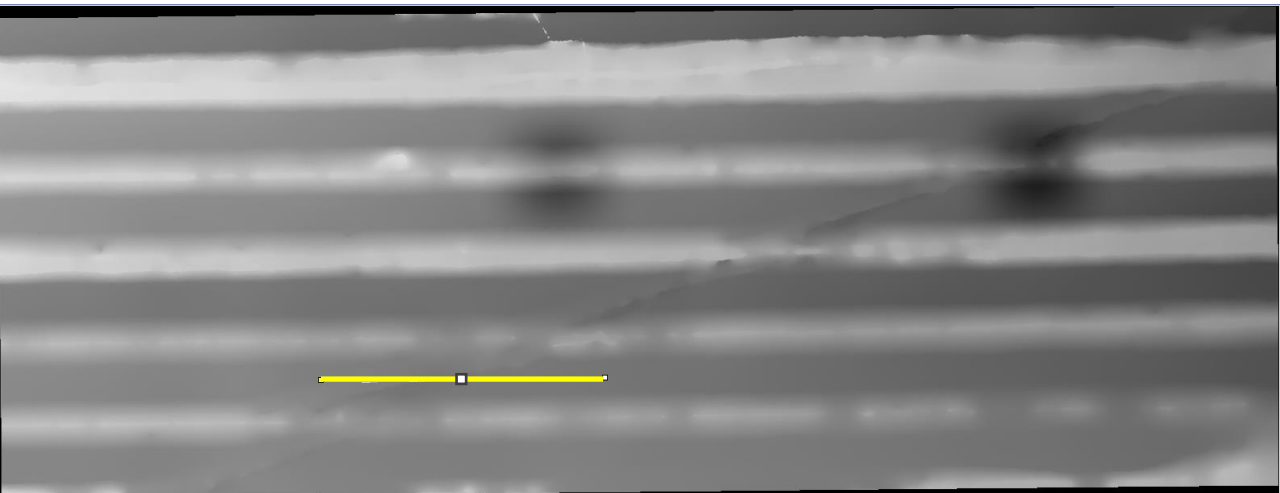
Scratched Area



"Red Strands: Scratch 4"

Scratch Data

Expected Data



Lifted Material

Scratch 4

- Cut Depth: 18.73 μm
- Expected Standard Deviation: 2.53 μm over 2.4 mm

Scratched Area

