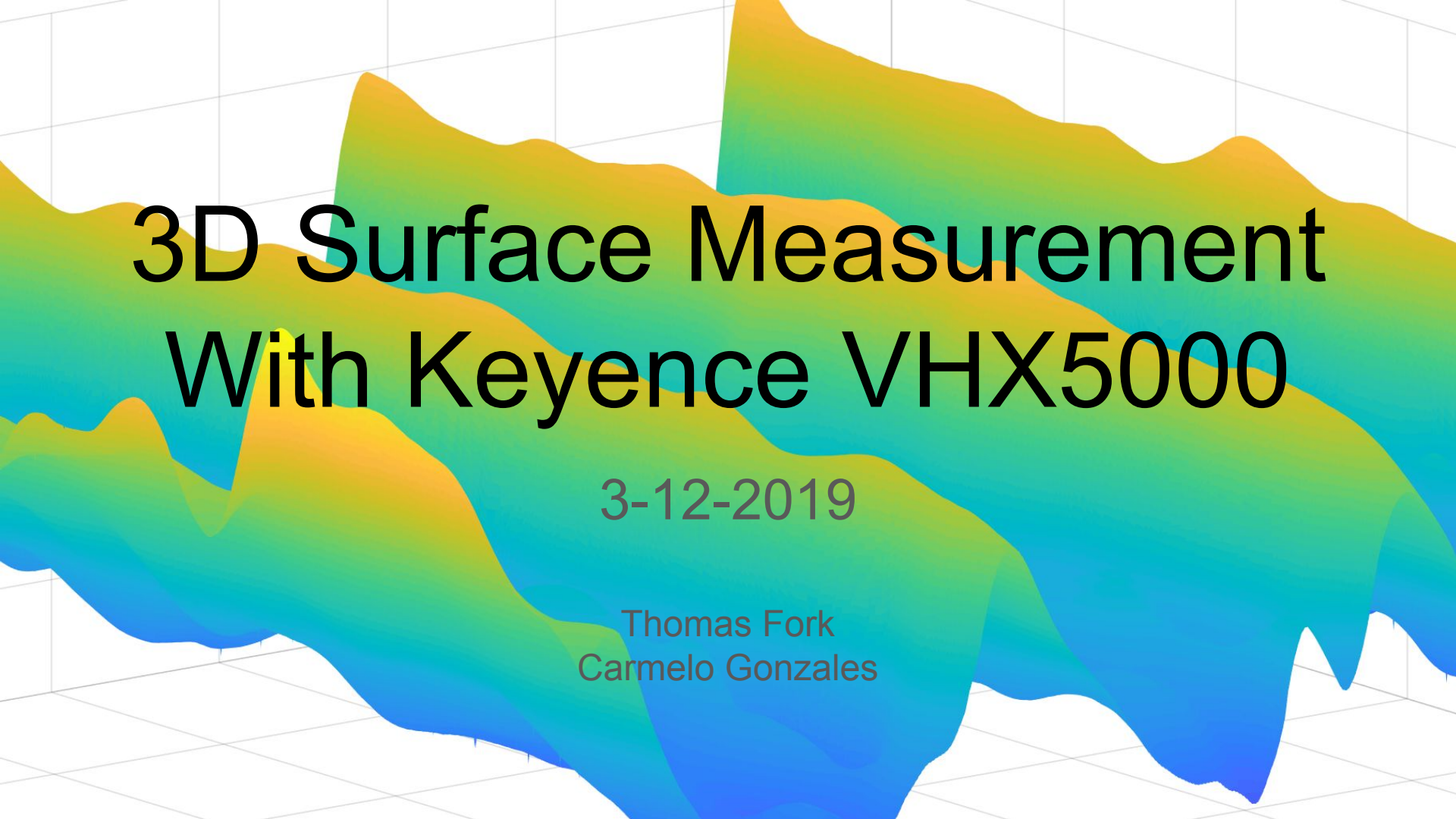


3D Surface Measurement With Keyence VHX5000

3-12-2019

Thomas Fork
Carmelo Gonzales

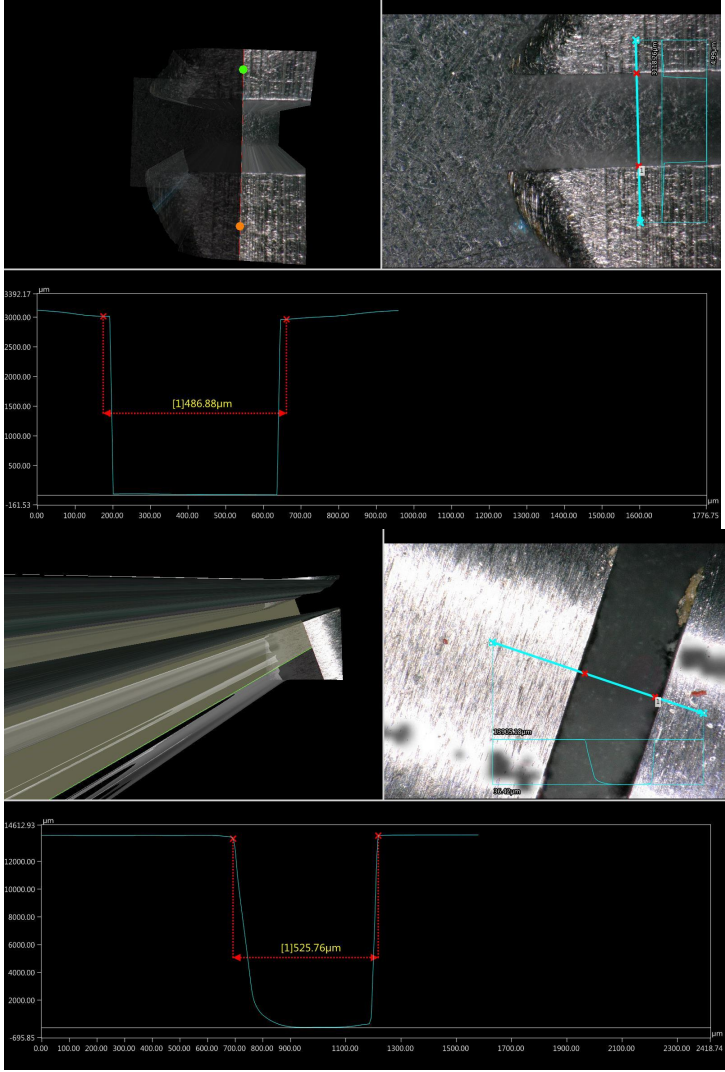
The Microscope

- Digital Scanning Confocal
- 0.2 - 1000x magnification
- Objective can be tilted

Testing Accuracy

- Calipers set to 0.5mm
- Vertical Keyence imaging
- Built in tools to measure gap

- Micrometer set to 0.5mm
- Vertical Keyence imaging
- Built in tools to measure gap
- Note position of red x’s



Testing Accuracy

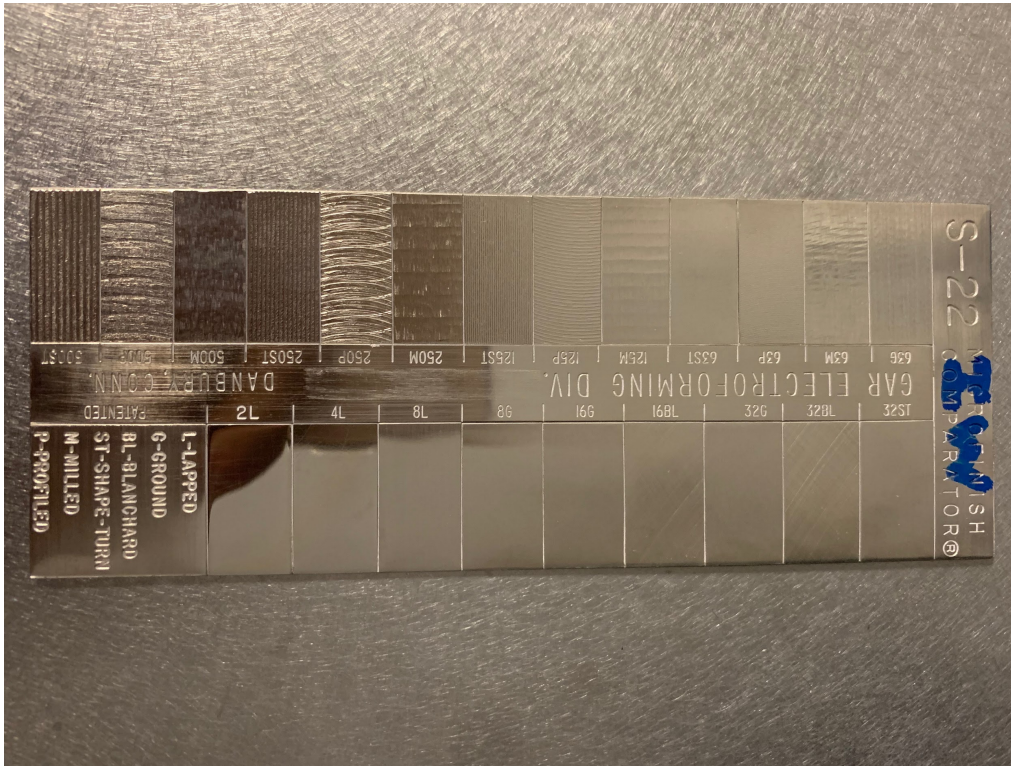
- Within 5-10% of true distance each time
- Build in Keyence tools didn’t always work perfect
- Field of view larger than datasheet says

VH-Z20R/Z20T or VH-Z20UR/Z20UT							
Magnification		20x	30x	50x	100x	150x	200x
Field of View	Horizontal (mm)	15.24	10.16	6.10	3.05	2.03	1.52
	Vertical (mm)	11.40	7.60	4.56	2.28	1.52	1.14
Pixelsize (um)		9.525	6.35	3.825	1.906	1.269	0.95

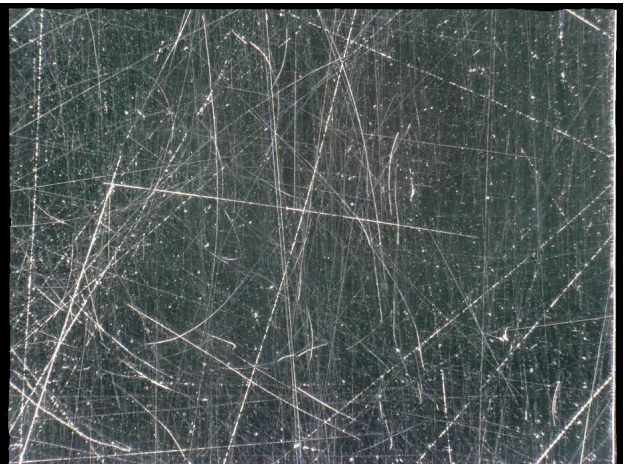
VH-Z100R/Z100T or VH-Z100UR/Z100UT							
Magnification		100x	200x	300x	500x	700x	1000x
Field of View	Horizontal (mm)	3.05	1.52	1.02	0.61	0.44	0.30
	Vertical (mm)	2.28	1.14	0.76	0.46	0.33	0.23
Pixel size (um)		1.906	0.95	0.638	0.381	0.275	0.188

Surface Roughness Comparator

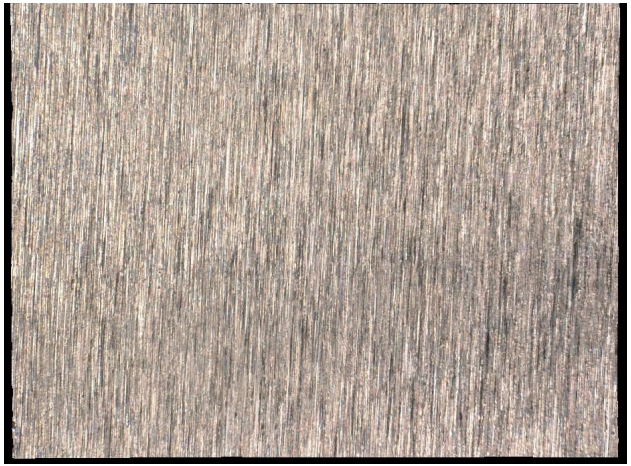
- 6 different finishes
- 2-500 microinches
- Average deviation from mean
- Not calibrated



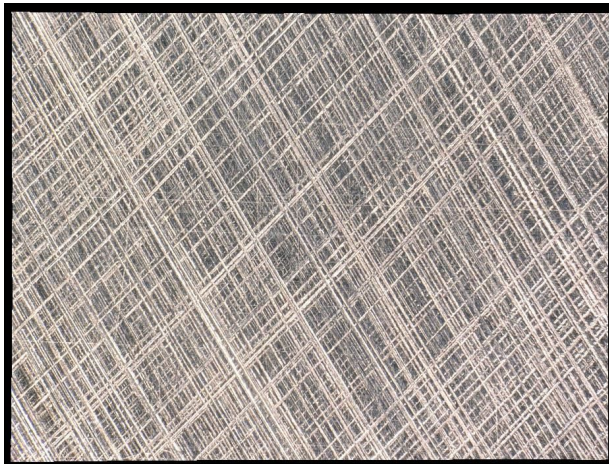
Surface Roughness Categories



4L - Lapped



8G - Ground

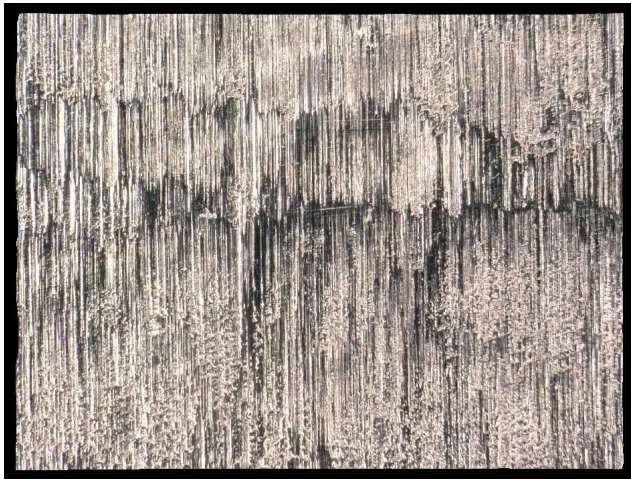


16BL - Blanchard Ground

Surface Roughness Categories

250P - Profiled

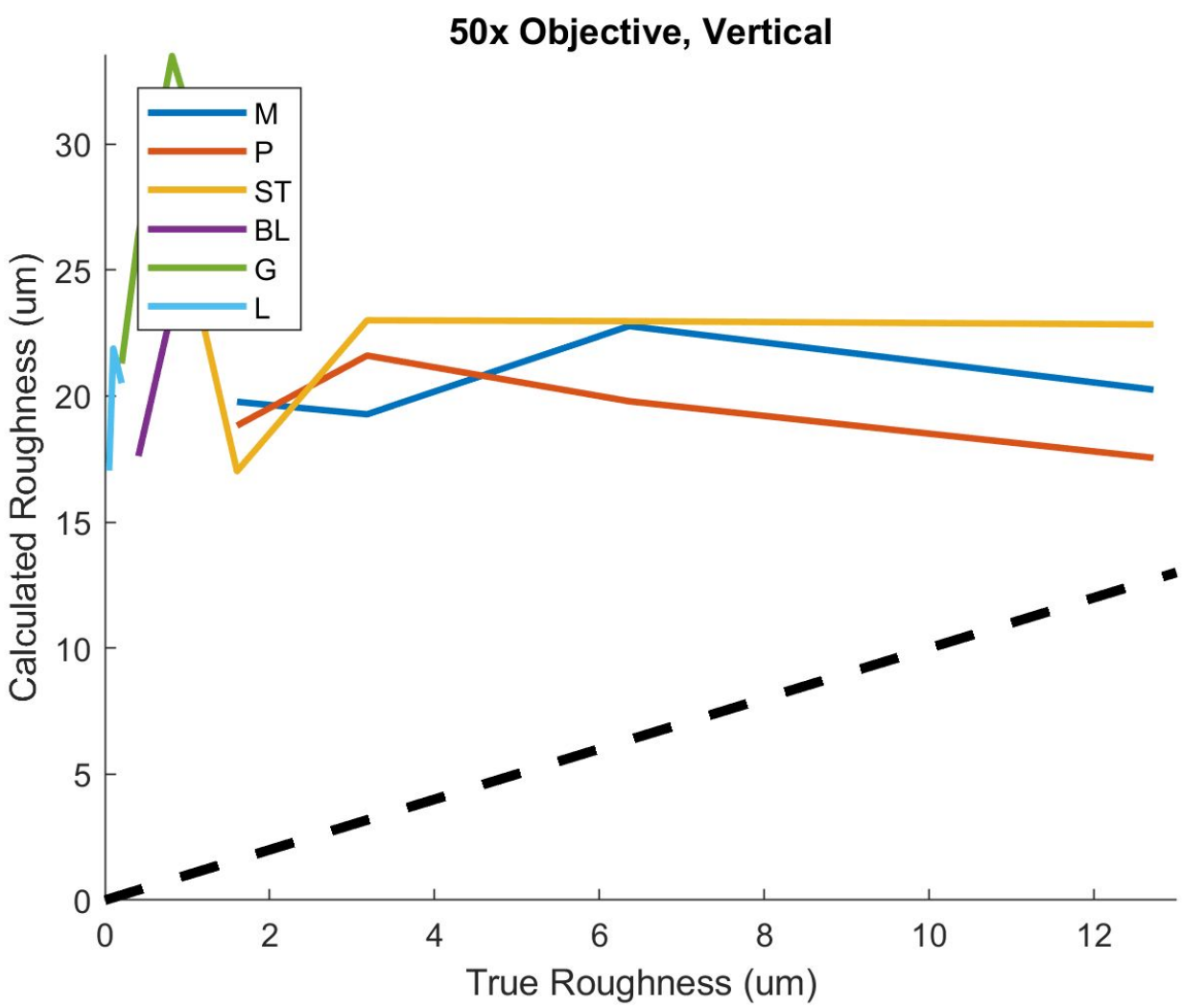
500ST - Shape Turned

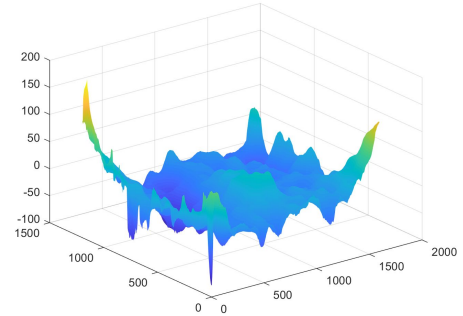


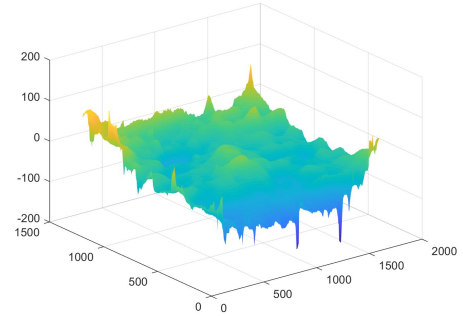
500M - Milled

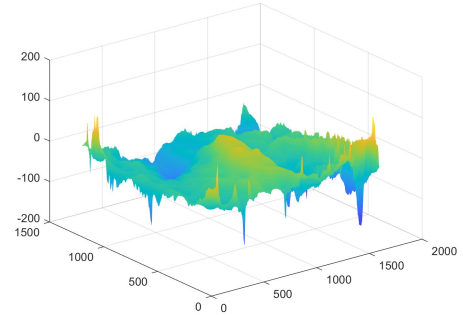
Data Analysis

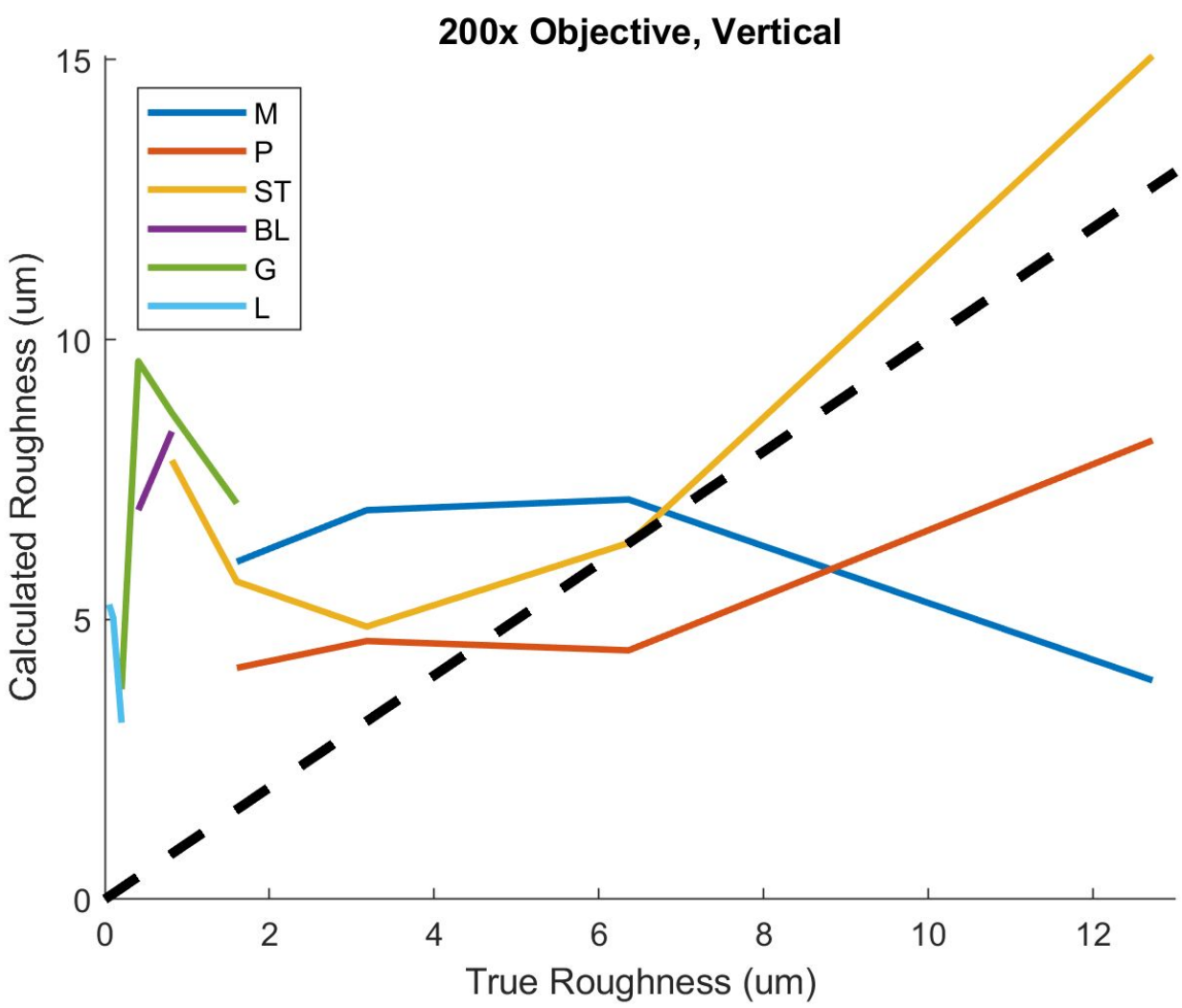
- Matlab reads .csv file generated by VHX software
- Unfilled data entries are removed (3 rows and 3 columns of “-1”)
- A plane is fit to data and subtracted (tilt correction)
- Average difference from mean is calculated

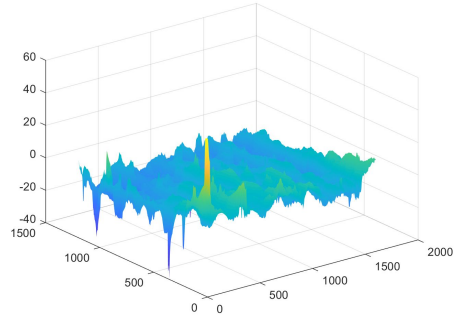

50x Objective, Vertical
M
P
ST
BL
G
L
Calculated Roughness (um)
True Roughness (um)
0
5
10
15
20
25
30
0
2
4
6
8
10
12

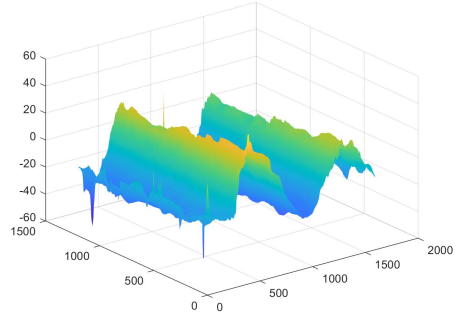

200
150
100
50
0
-50
-100
1500
1000
500
0
0
500
1000
1500
2000

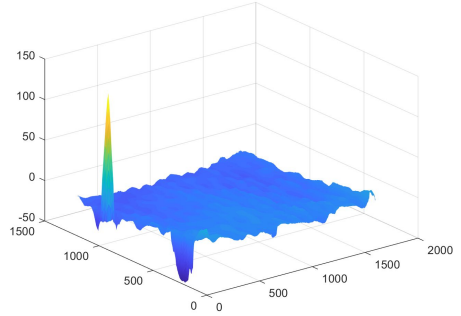

200
100
0
-100
-200
1500
1000
500
0
0
500
1000
1500
2000

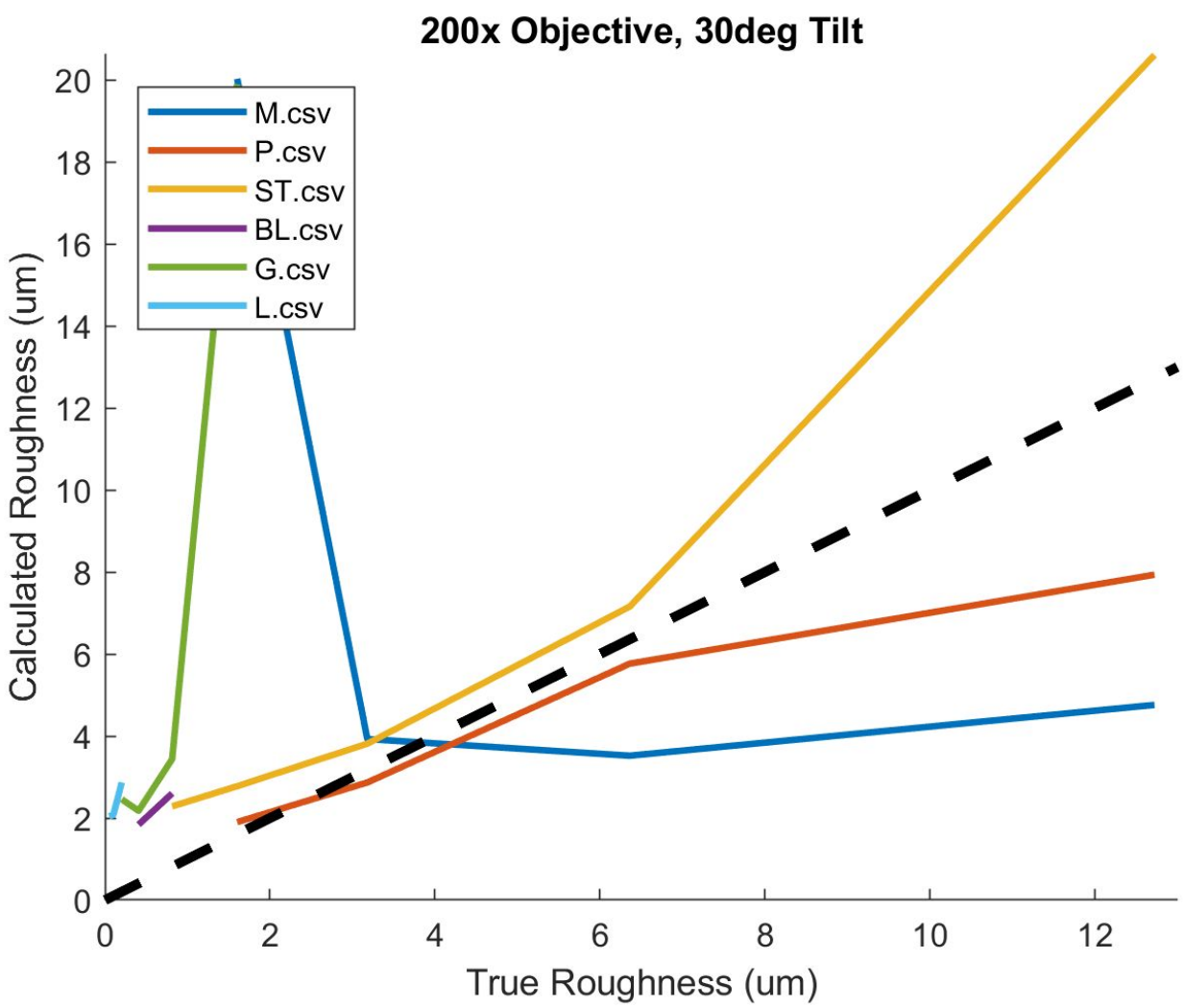

200
100
0
-100
-200
1500
1000
500
0
0
500
1000
1500
2000

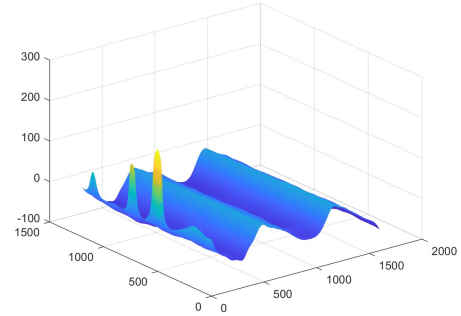

200x Objective, Vertical
M
P
ST
BL
G
L
Calculated Roughness (um)
True Roughness (um)
0
5
10
15
0
2
4
6
8
10
12

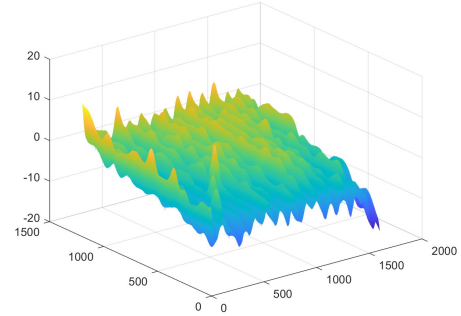

60
40
20
0
-20
-40
1500
1000
500
0
0
500
1000
1500
2000

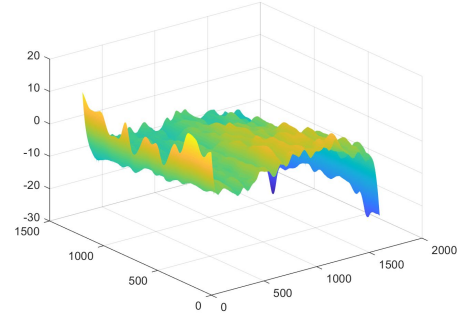

60
40
20
0
-20
-40
-60
1500
1000
500
0
0
500
1000
1500
2000


150
100
50
0
-50
1500
1000
500
0
0
500
1000
1500
2000

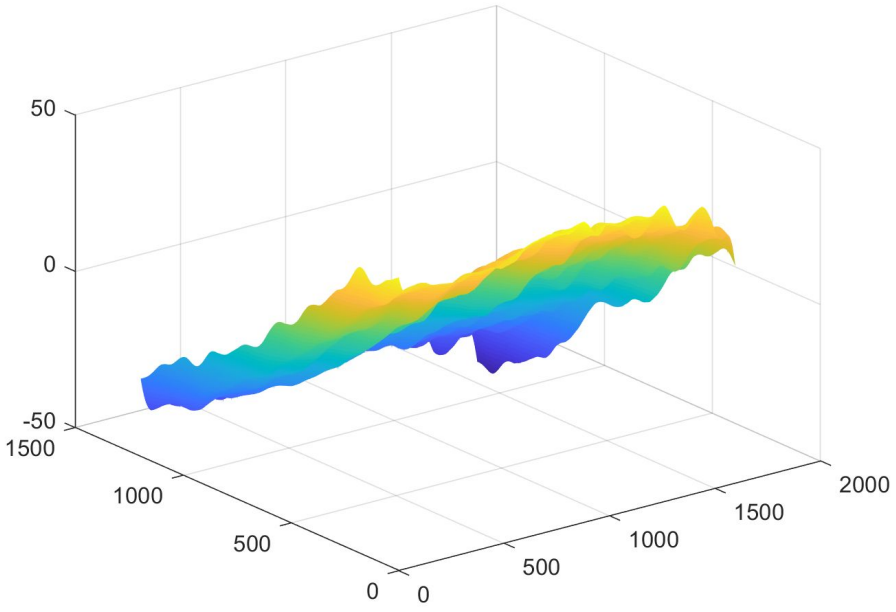

200x Objective, 30deg Tilt
M.csv
P.csv
ST.csv
BL.csv
G.csv
L.csv
Calculated Roughness (um)
True Roughness (um)
0
2
4
6
8
10
12
14
16
18
20

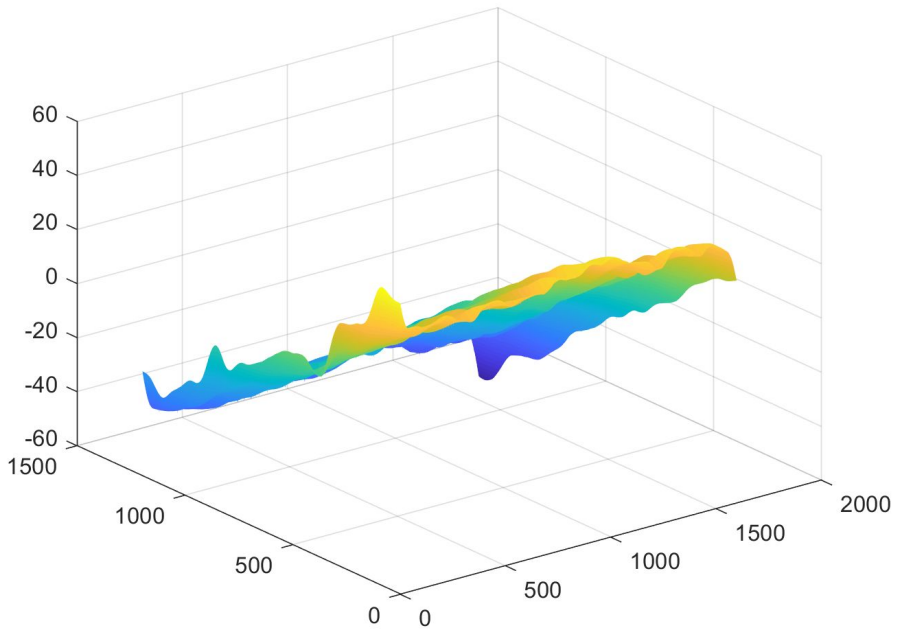

300
200
100
0
-100
1500
1000
500
0
0
500
1000
1500
2000

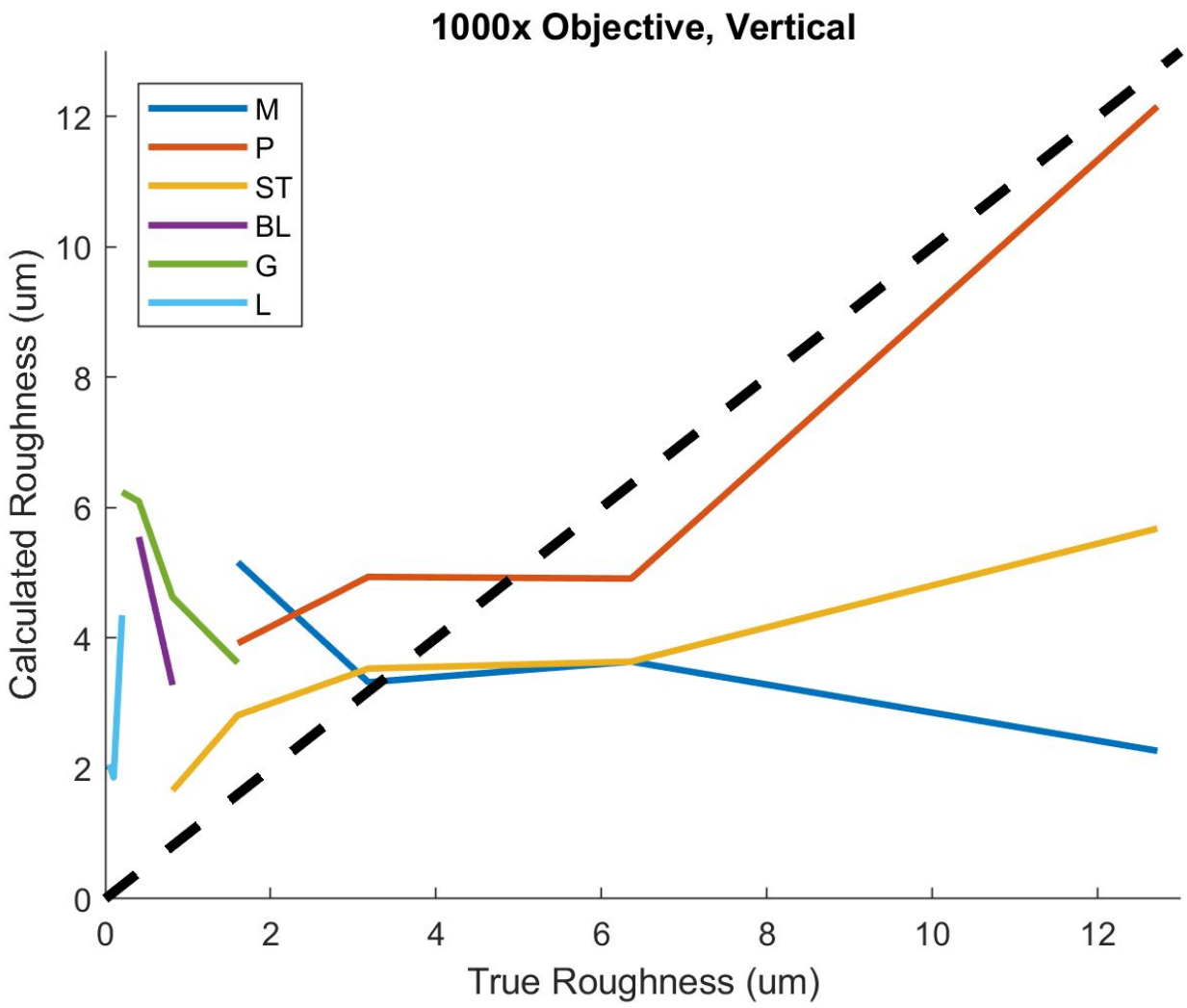

20
10
0
-10
-20
1500
1000
500
0
0
500
1000
1500
2000

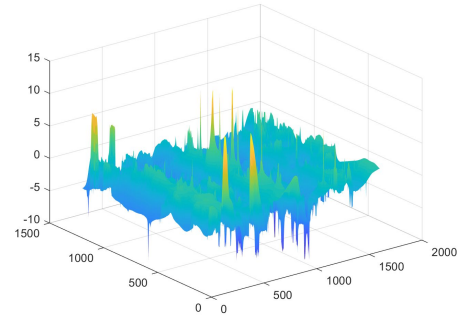

20
10
0
-10
-20
-30
1500
1000
500
0
0
500
1000
1500
2000

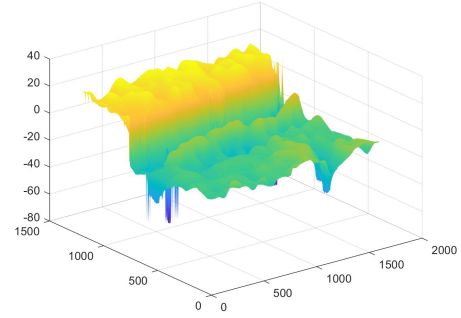
200x, 30deg Tilt Outliers

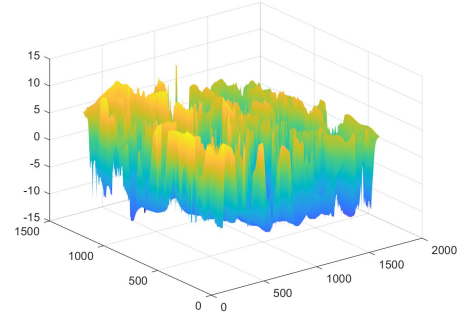





1000x Objective, Vertical
M
P
ST
BL
G
L
Calculated Roughness (um)
True Roughness (um)
0
2
4
6
8
10
12


15
10
5
0
-5
-10
1500
1000
500
0
0
500
1000
1500
2000


40
20
0
-20
-40
-60
-80
1500
1000
500
0
0
500
1000
1500
2000

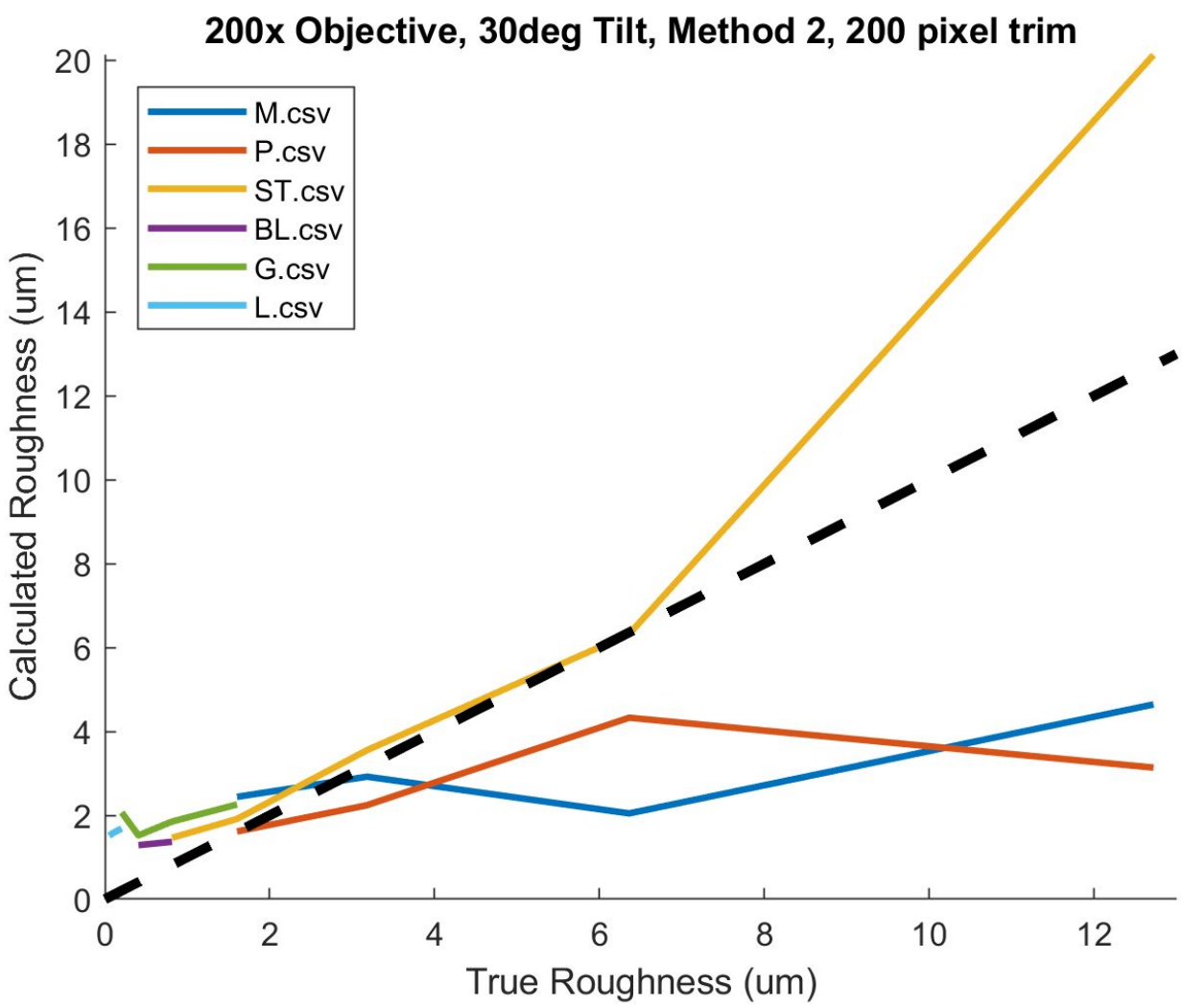

15
10
5
0
-5
-10
-15
1500
1000
500
0
0
500
1000
1500
2000

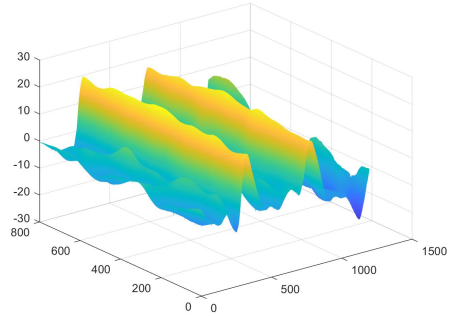
Findings and Notes

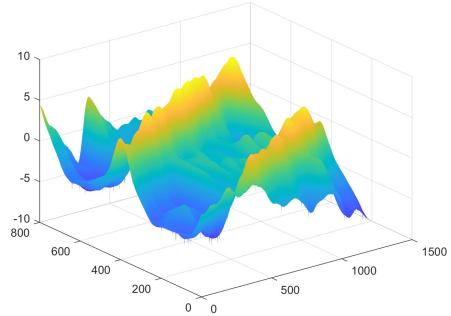
- 1000x and 200x have noise floor of 3-5um
- 1000x Objective noticeably vibrates back and forth during depth scanning (not noticeable for 200x)
- Vertical imaging causes spikey noise with all objectives
- Tilted imaging produces artifacts at edges
- Least square regression routine doesn’t always work!

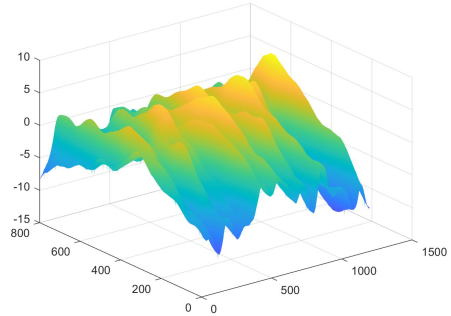
Modified Fitting Routine

- Set mean of x derivative to 0
- Set mean of y derivative to 0
- Set mean to 0
- Note: Only done with borders of data removed to avoid bias from artifacts


200x Objective, 30deg Tilt, Method 2, 200 pixel trim
M.csv
P.csv
ST.csv
BL.csv
G.csv
L.csv
Calculated Roughness (um)
True Roughness (um)
0
2
4
6
8
10
12
14
16
18
20







Surface Roughness Conclusion

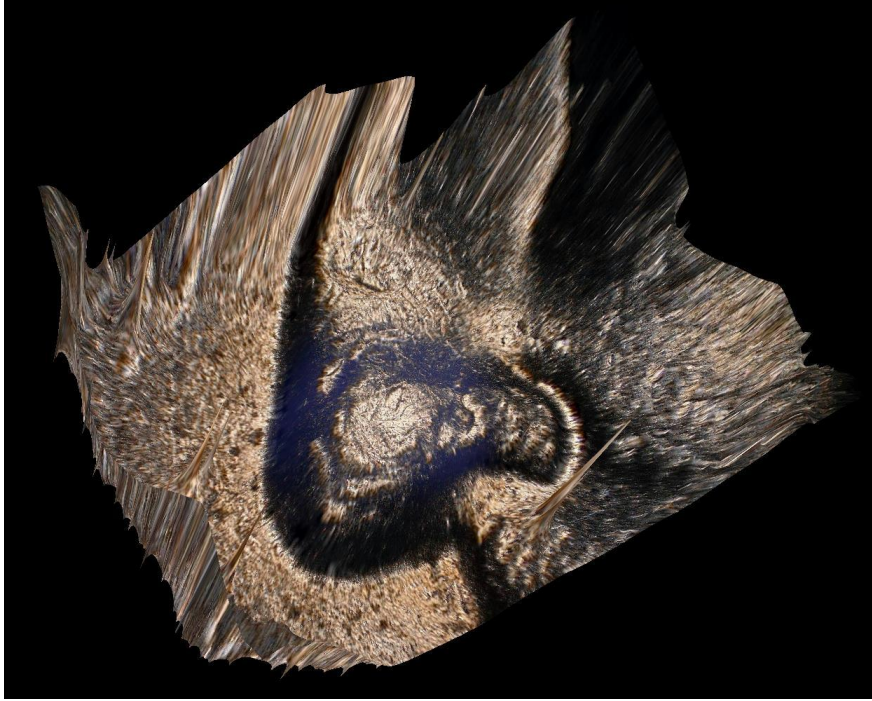
- Lack of calibration and sample size for quantitative results
- Milled surface roughness always underpredicted (feels extra smooth too)
- Field of view may be an issue for large surface roughness
- Promising data between lower resolution limit and upper samping limit.

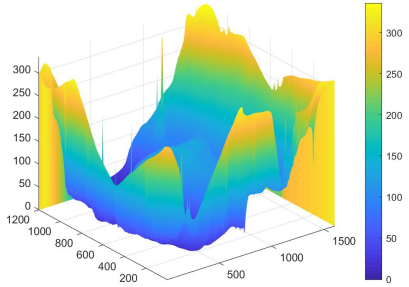
STL Generation and 3D Printing

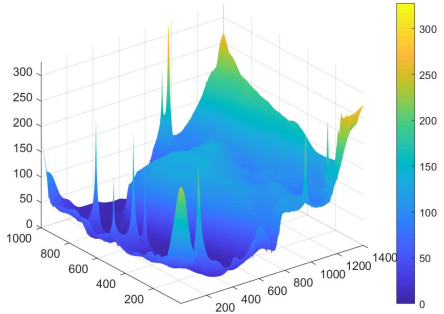
- Use Keyence to capture 3D image of specimen
- Extract 3D data to a csv file using VHX software
- Load csv into matlab
- Modify and clean data as needed
- Send data to STL Generator
  - Mathworks file exchange, surf2stl. Author: Bill McDonald, 02-20-04
- Import STL to slicing program
- Generate GCode
- Print

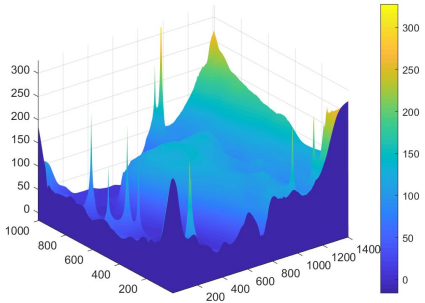
Data Extraction and Preparation

- CSV file containing height data extracted from keyence output
- Data loaded into matlab
- Edges cleaned
- Padded to provide extra bottom and side layers



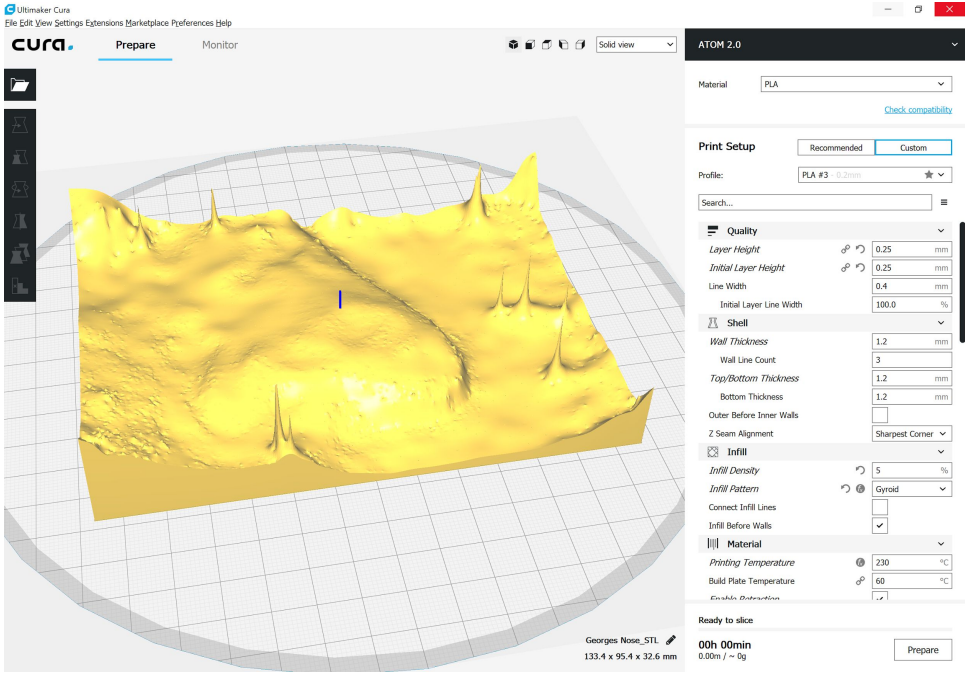






STL/GCode Generation

- Data fed into surf2stl with pixel size data
- Output is real sized STL file
- File loaded into slicer (cura)
- Desired scaling applied
- GCode Generated
- Ready to Print



Conclusions

- Lack of calibration and sample size for quantitative results
- Field of view may be an issue for large surface roughness
- Good for qualitative measurements
- Extracting 3D Data and printing can be useful for interpreting models