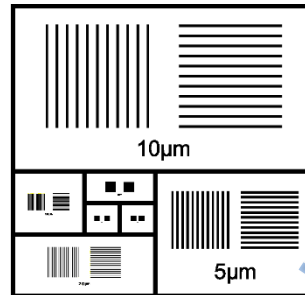
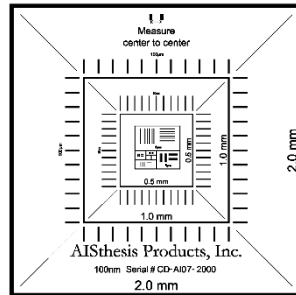


AISthesis Products

Advanced Imaging Products for Nanotechnology,
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PO Box 1950, Clyde NC 28721



Certificate of Calibration for Pelcotec™ Critical Dimension Magnification Standard



Product Number: Pelcotec™ 698-01 CDMS-XY-0.1C-ISO

Customer name and contact information:

Product Description: 2.5x2.5mm, Pelcotec™ 2mm-100nm
Critical Dimension Magnification Standard.



Product Serial Number: CD-AI07-1234

P.O. Box 492477

As Received Condition: New

Redding, CA 96049-2477

As Returned Condition: N/A

Tel: 530.243.2200

Date of Receipt: N/A

www.tedpella.com

The accuracy of this product with Serial Number CD-AI07-1234 was determined using a Field Emission Scanning Electron Microscope (FE-SEM) by reference comparison to working standards traceable to the National Institute of Standards and Technology (NIST), using methods in CP 01 FE-SEM Imaging of Critical Dimension Magnification Standards (CDMS) and CP 02 Certification of Critical Dimension Magnification Standards. The data applies only to the CDMS identified in this report. All results are "as-is". Repair and/or adjustments are not possible.

Below are the ISO 17025:2017 compliant Certified 10 µm Pitch Measurements unique to Serial Number CD-AI07-1234 and traceable to NIST Certified Standard CD-PG01-0211.

X-Direction

Line	ISO 17025:2017 Compliant Certified Pitch	Position of Measurement
0-10 µm	9.993 µm	± 7.5 µm from center
10-20 µm	9.980 µm	± 7.5 µm from center
20-30 µm	9.980 µm	± 7.5 µm from center
30-40 µm	9.999 µm	± 7.5 µm from center
40-50 µm	10.007 µm	± 7.5 µm from center
50-60 µm	10.014 µm	± 7.5 µm from center
60-70 µm	9.999 µm	± 7.5 µm from center
70-80 µm	9.999 µm	± 7.5 µm from center

80-90 μm	9.999 μm	$\pm 7.5 \mu\text{m}$ from center
90-100 μm	9.999 μm	$\pm 7.5 \mu\text{m}$ from center
<i>Sum</i>	<i>99.969 μm</i>	
Average	9.9969 μm	
2-Sigma *	0.0042 μm	

* Corrected for sample size using the appropriate Student t-factor.

Y-Direction

Line	ISO 17025:2017 Compliant Certified Pitch	Position of Measurement
0-10 μm	9.993 μm	$\pm 7.5 \mu\text{m}$ from center
10-20 μm	9.980 μm	$\pm 7.5 \mu\text{m}$ from center
20-30 μm	9.980 μm	$\pm 7.5 \mu\text{m}$ from center
30-40 μm	9.999 μm	$\pm 7.5 \mu\text{m}$ from center
40-50 μm	10.007 μm	$\pm 7.5 \mu\text{m}$ from center
50-60 μm	10.014 μm	$\pm 7.5 \mu\text{m}$ from center
60-70 μm	9.999 μm	$\pm 7.5 \mu\text{m}$ from center
70-80 μm	9.999 μm	$\pm 7.5 \mu\text{m}$ from center
80-90 μm	9.999 μm	$\pm 7.5 \mu\text{m}$ from center
90-100 μm	9.999 μm	$\pm 7.5 \mu\text{m}$ from center
<i>Sum</i>	<i>99.969 μm</i>	
Average	9.9969 μm	
2-Sigma *	0.0042 μm	

* Corrected for sample size using the appropriate Student t-factor.

Measurements are reported with an uncertainty (k=2)** of $\pm 0.012 \mu\text{m}$. Statements of Conformity are not provided in this report. Review the results and verify that they meet the requirements for the intended use. Physical damage to or contamination of the CDMS occurring after calibration may invalidate the reported measurements. Use this product at $25^\circ\text{C} \pm 5^\circ\text{C}$ and at less than 80% RH.

** Reported uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of $k = 2$. The reported expanded measurement uncertainty is stated as the standard measurement uncertainty multiplied by the coverage factor K such that the coverage probability corresponds to approximately 95%.

X-Direction

Line	Number of Lines	Position of Measurement	Non-ISO 17025:2017 Compliant Measured Distance (first to last line)	Average Pitch
2.0mm	2	$\pm 1.00\text{mm}$ from center	2.000 mm	2.000 mm
1.0mm	2	$\pm 0.5\text{mm}$ from center	1.000 mm	1.000 mm
0.5mm	2	$\pm 0.25\text{mm}$ from center	0.500 mm	0.500 mm
0.1mm	11	$\pm 50 \mu\text{m}$ from center	1.000mm	100.038 μm
50 μm	11	$\pm 50 \mu\text{m}$ from center	0.500 mm	50.031 μm
5 μm	12	$\pm 20 \mu\text{m}$ from center	55.057 μm	5.005 μm
2 μm	16	$\pm 10 \mu\text{m}$ from center	30.051 μm	2.003 μm
1 μm	17	$\pm 5 \mu\text{m}$ from center	16.033 μm	1.002 μm
500nm	20	$\pm 4 \mu\text{m}$ from center	9.519 μm	501.0 nm
250nm	21	$\pm 2.5 \mu\text{m}$ from center	5.018 μm	250.9 nm
100nm	52	$\pm 2.5 \mu\text{m}$ from center	5.119 μm	100.4 nm

Y-Direction

Line	Number of Lines	Position of Measurement	Non-ISO 17025:2017 Compliant Measured Distance (first to last line)	Average Pitch
2.0mm	2	± 1.00mm from center	2.000 mm	2.000 mm
1.0mm	2	± 0.5mm from center	1.000 mm	1.000 mm
0.5mm	2	± 0.25mm from center	0.500 mm	0.500 mm
0.1mm	11	± 50 µm from center	1.000mm	100.038 µm
50µm	11	± 50 µm from center	0.500 mm	50.031 µm
5µm	12	± 20 µm from center	55.057 µm	5.005 µm
2µm	16	± 10 µm from center	30.051 µm	2.003 µm
1µm	17	± 5 µm from center	16.033 µm	1.002 µm
500nm	20	± 4 µm from center	9.519 µm	501.0 nm
250nm	21	± 2.5 µm from center	5.018 µm	250.9 nm
100nm	52	± 2.5 µm from center	5.119 µm	100.4 nm

The average pitch is derived from the stated length that was determined using measurements (taken center-to-center) over the stated number of lines (i.e., length divided by the number of lines minus one).

Date of Analysis: January 29th, 2023

Equipment used:

Instrument	Model	Serial #	Resolution	Repeatability	Temperature	Humidity	Ref.
FE-SEM	FEI Verios 460L	9922551	0.9nm	0.030%	23.3 ± 0.3 °C	42.5 ± 1.5%	CD-PG01-0211

Location: Analytical Instrumentation Facility, NC State University, Raleigh NC 27695-7531.

Notes:

D.S. Finch
Certified by _____ Signature

H. Haehlen
Authorized by _____ Signature

January 29th, 2023
Date report issued. _____

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P.O. Box 1950, Clyde, North Carolina 28721 Tel: 828.627.6555 E-mail: CDMS@aistthesisproducts.com

AI07 1234

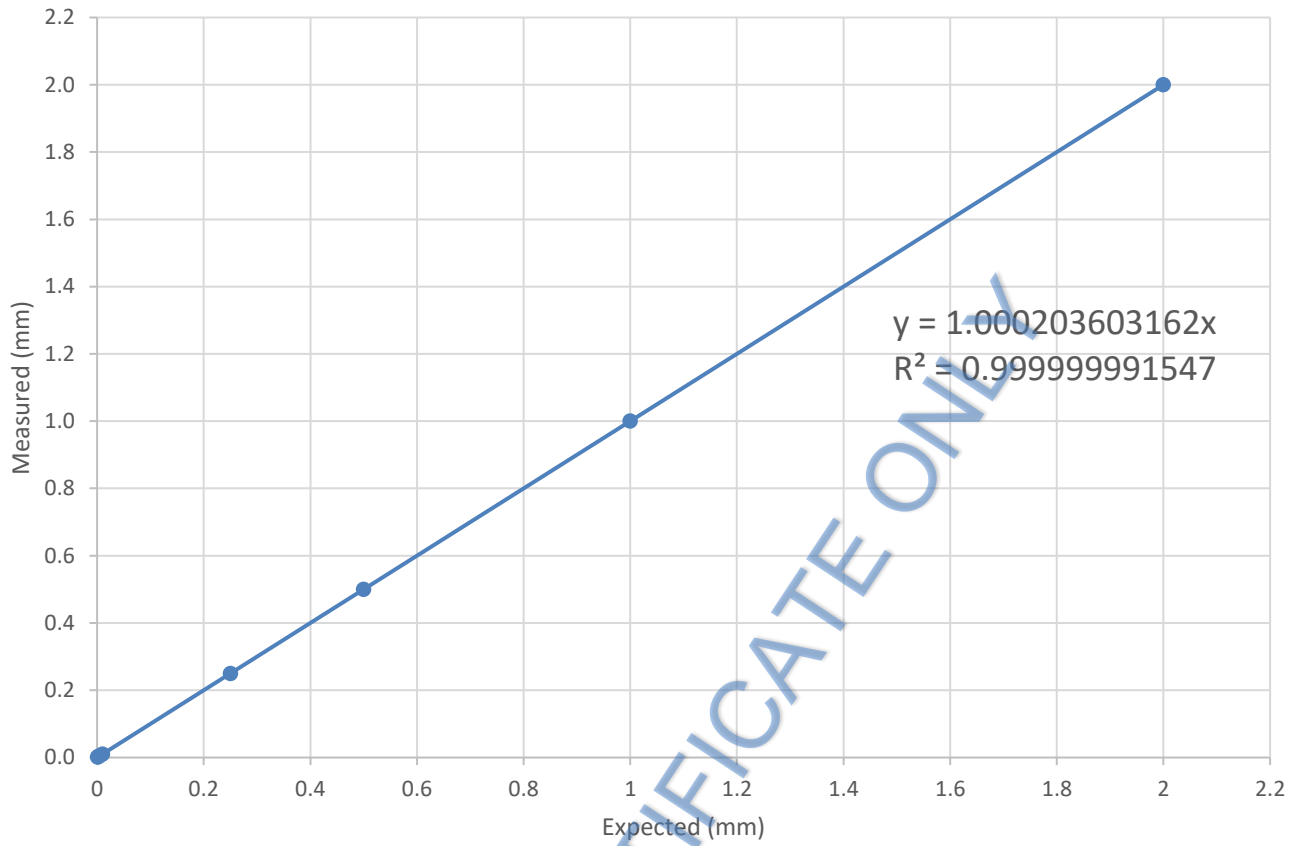


Figure 1. Expected versus actual measurements in the X direction including all lines with linear regression and R^2 values reported.

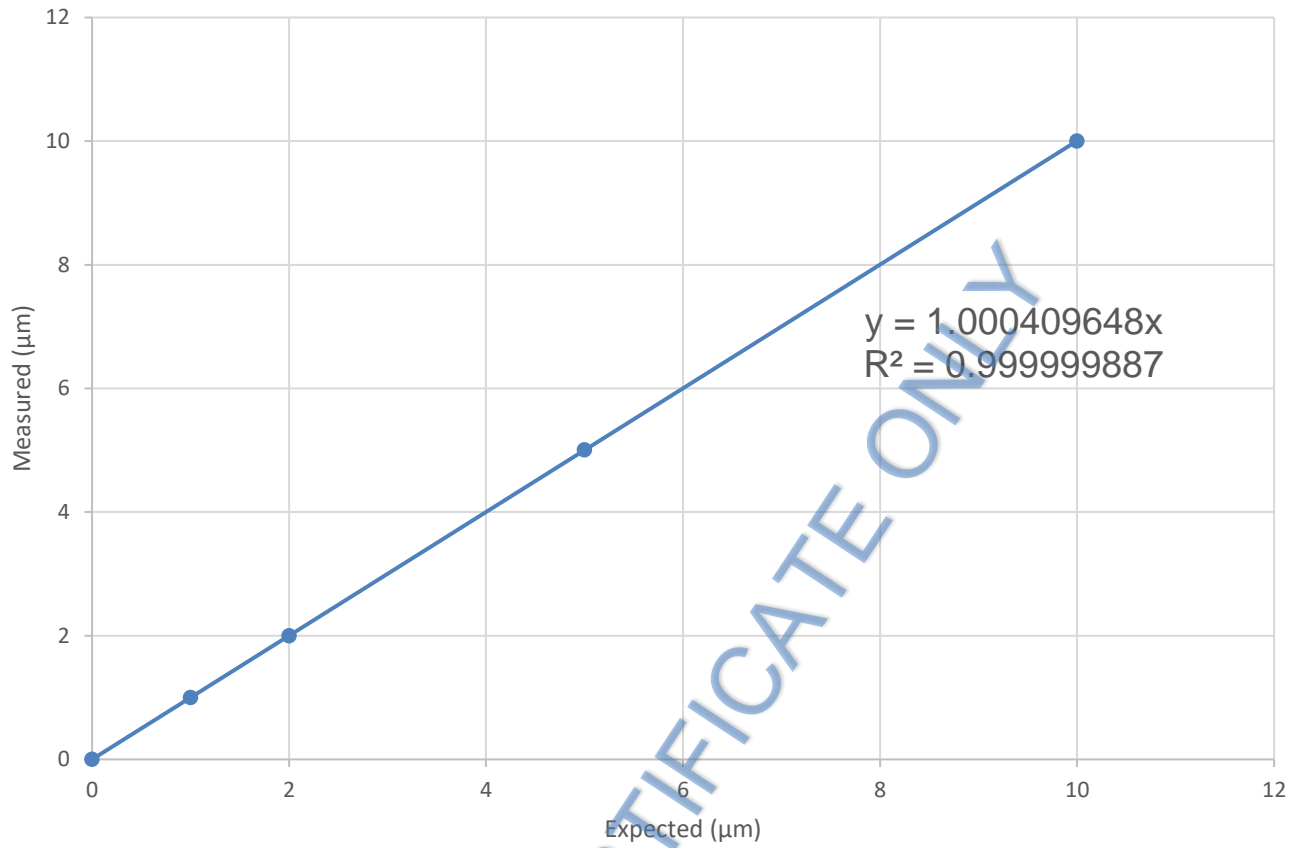


Figure 2. Expected versus actual measurements for the X-direction 10µm, 5µm, 2µm, and 1µm pitch lines with linear regression and R² values reported.

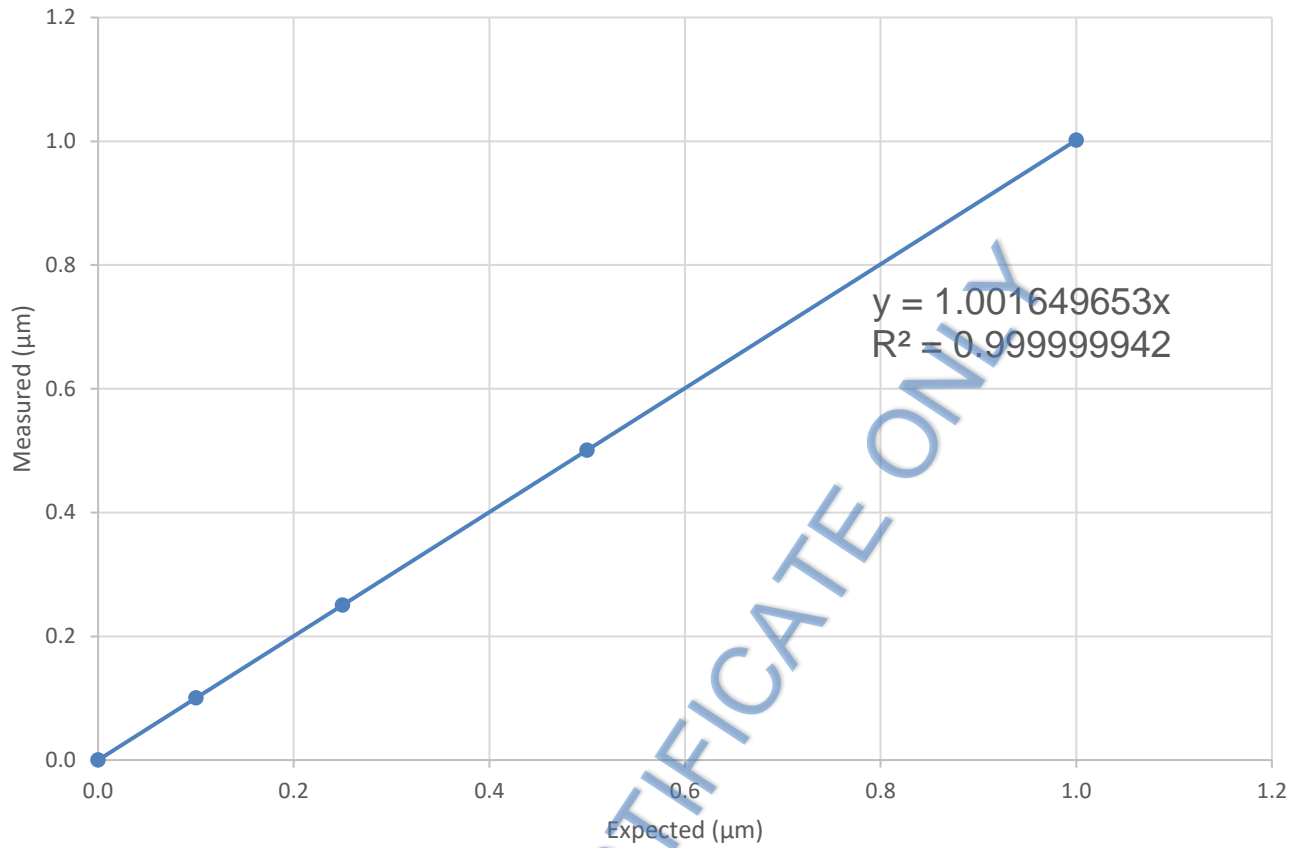


Figure 3. Expected versus actual measurements for the X-direction 1µm, 0.5µm, 0.25µm and 0.1µm pitch lines with linear regression and R² values reported.

EXAMPLE CERTIFICATE ONLY

AI07 1234

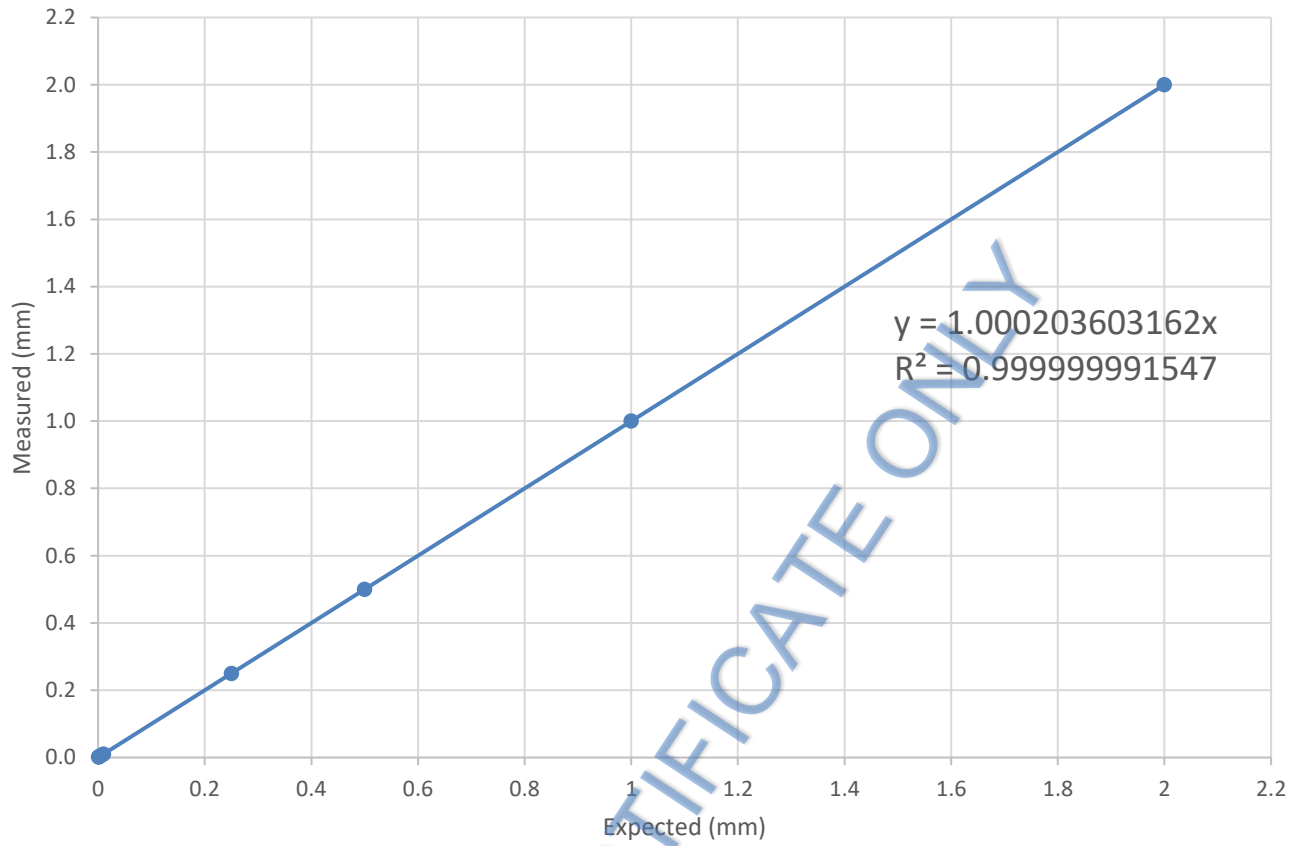


Figure 4. Expected versus actual measurements in the Y-direction including all lines with linear regression and R^2 values reported.

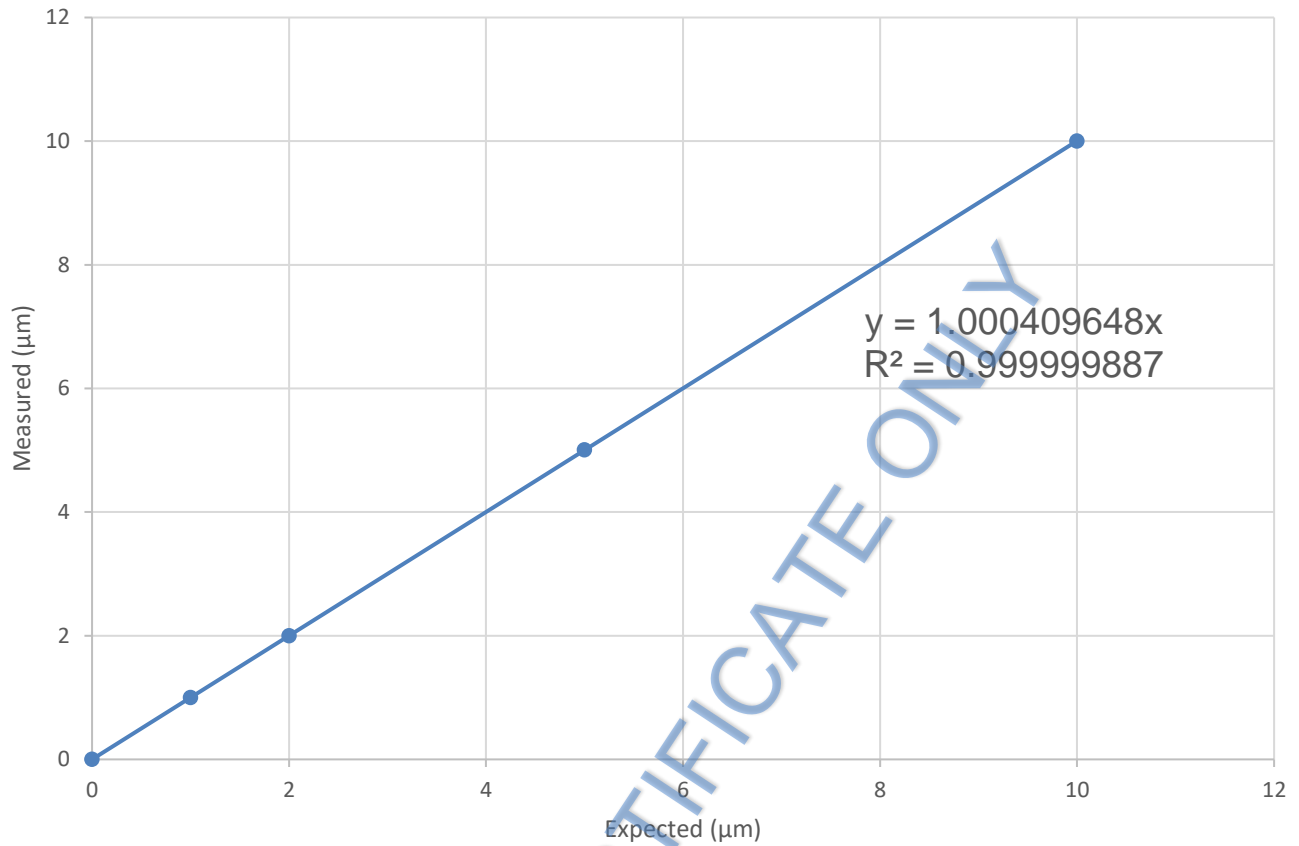


Figure 5. Expected versus actual measurements for the Y-direction 10μm, 5μm, 2μm, and 1μm pitch lines with linear regression and R² values reported.

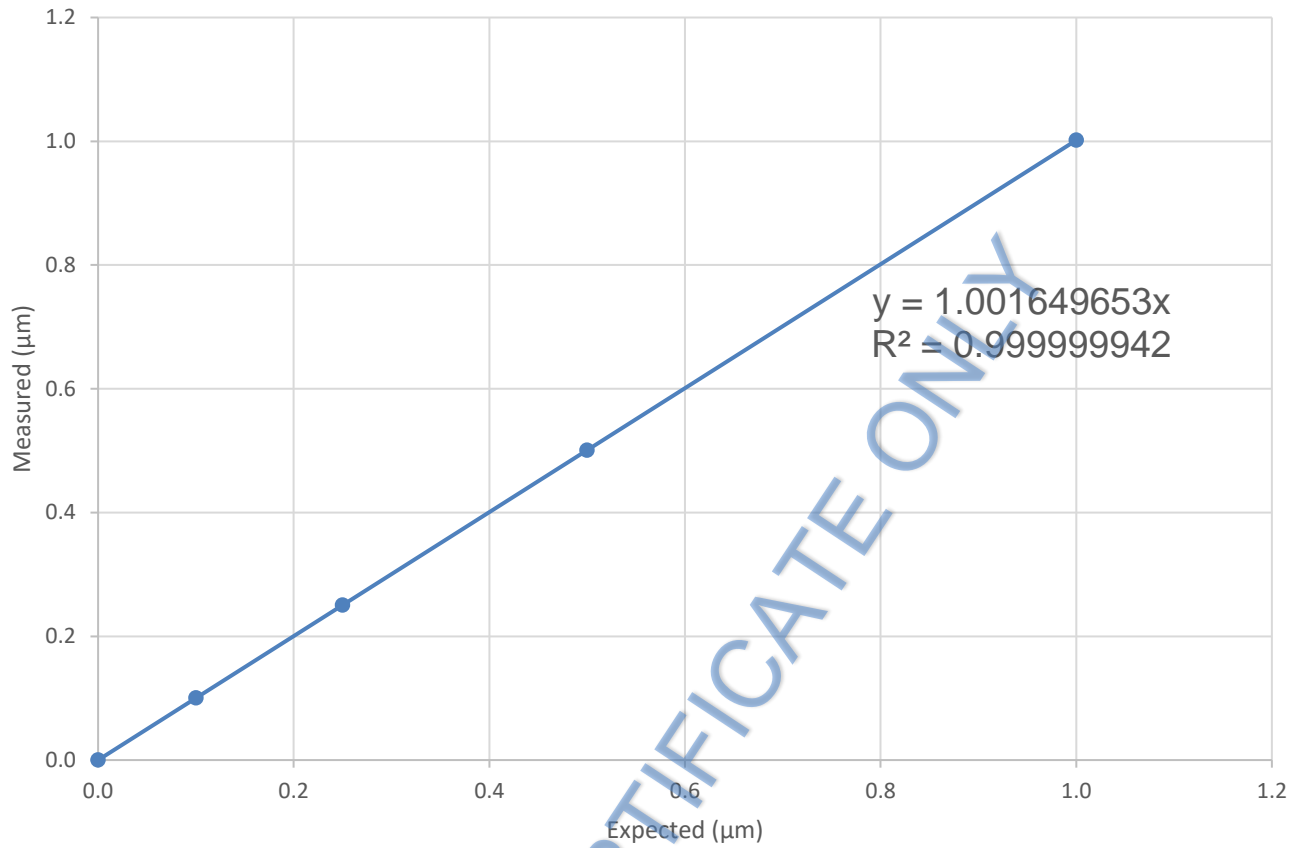


Figure 6. Expected versus actual measurements for the Y-direction 1µm, 0.5µm, 0.25µm and 0.1µm pitch lines with linear regression and R^2 values reported.

5 μm Line X-direction	Pitch
0-5 μm	5.005 μm
5-10 μm	5.005 μm
10-15 μm	5.005 μm
15-20 μm	5.010 μm
20-25 μm	5.010 μm
25-30 μm	5.005 μm
30-35 μm	5.005 μm
35-40 μm	5.003 μm
40-45 μm	5.000 μm
45-50 μm	5.008 μm
50-55 μm	5.000 μm
<i>Sum</i>	<i>55.057 μm</i>
Average	5.0051 μm
2-Sigma *	0.0079 μm

2 μm Line X-direction	Pitch
0-2 μm	2.031 μm
2-4 μm	2.003 μm
4-6 μm	2.001 μm
6-8 μm	2.003 μm
8-10 μm	2.001 μm
10-12 μm	2.001 μm
12-14 μm	2.003 μm
14-16 μm	1.998 μm
16-18 μm	2.003 μm
18-20 μm	2.001 μm
20-22 μm	2.001 μm
22-24 μm	2.001 μm
24-26 μm	2.003 μm
26-28 μm	2.001 μm
28-30 μm	2.003 μm
<i>Sum</i>	<i>30.051 μm</i>
Average	2.0034 μm
2-Sigma *	0.0173 μm

Excluding 1 st and last lines	
Average	2.0013 μm
2-Sigma *	0.0036 μm

1 μm Line X-direction	Pitch
0-1 μm	1.005 μm
1-2 μm	1.001 μm
2-3 μm	1.002 μm
3-4 μm	1.002 μm
4-5 μm	1.001 μm
5-6 μm	1.002 μm

6-7 μm	1.001 μm
7-8 μm	1.001 μm
8-9 μm	1.004 μm
9-10 μm	1.001 μm
10-11 μm	1.000 μm
11-12 μm	1.002 μm
12-13 μm	1.001 μm
13-14 μm	1.001 μm
14-15 μm	1.004 μm
15-16 μm	1.004 μm
<i>Sum</i>	<i>16.033 μm</i>
Average	1.0021 μm
2-Sigma *	0.0032 μm

Excluding 1 st and last lines	
Average	1.0017 μm
2-Sigma *	0.0026 μm

0.5 μm Line X-direction	Pitch
0-0.5 μm	0.5046 μm
0.5-1 μm	0.5015 μm
1-1.5 μm	0.4995 μm
1.5-2 μm	0.5015 μm
2-2.5 μm	0.5005 μm
2.5-3 μm	0.5005 μm
3-3.5 μm	0.5005 μm
3.5-4 μm	0.5015 μm
4-4.5 μm	0.4995 μm
4.5-5 μm	0.5026 μm
5-5.5 μm	0.4985 μm
5.5-6 μm	0.5005 μm
6-6.5 μm	0.5026 μm
6.5-7 μm	0.4985 μm
7-7.5 μm	0.5005 μm
7.5-8 μm	0.5015 μm
8-8.5 μm	0.4995 μm
8.5-9 μm	0.5026 μm
9-9.5 μm	0.5026 μm
<i>Sum</i>	<i>9.519 μm</i>
Average	0.50100 μm
2-Sigma *	0.00341 μm

Excluding 1 st and last lines	
Average	0.50070 μm
2-Sigma *	0.00285 μm

0.25 μm Line X-direction	Pitch
0-0.25 μm	0.2575 μm
0.25-0.5 μm	0.2503 μm
0.5-0.75 μm	0.2503 μm
0.75-1 μm	0.2503 μm
1-1.25 μm	0.2513 μm
1.25-1.5 μm	0.2503 μm
1.5-1.75 μm	0.2503 μm
1.75-2 μm	0.2503 μm
2-2.25 μm	0.2503 μm
2.25-2.5 μm	0.2513 μm
2.5-2.75 μm	0.2492 μm
2.75-3 μm	0.2513 μm
3-3.25 μm	0.2492 μm
3.25-3.5 μm	0.2503 μm
3.5-3.75 μm	0.2503 μm
3.75-4 μm	0.2503 μm
4-4.25 μm	0.2503 μm
4.25-4.5 μm	0.2503 μm
4.5-4.75 μm	0.2503 μm
4.75-5 μm	0.2544 μm
<i>Sum</i>	<i>5.018 μm</i>
Average	0.25088 μm
2-Sigma *	0.00401 μm

Excluding 1 st and last lines	
Average	0.25031 μm
2-Sigma *	0.00119 μm

0.1 μm Line X-direction	Pitch
0-0.1 μm	0.1081 μm
0.1-0.2 μm	0.0989 μm
0.2-0.3 μm	0.1009 μm
0.3-0.4 μm	0.0999 μm
0.4-0.5 μm	0.0999 μm
0.5-0.6 μm	0.0999 μm
0.6-0.7 μm	0.0999 μm
0.7-0.8 μm	0.1009 μm
0.8-0.9 μm	0.1009 μm
0.9-0.1 μm	0.0989 μm
1.0-1.1 μm	0.1009 μm
1.1-1.2 μm	0.0989 μm
1.2-1.3 μm	0.1009 μm
1.3-1.4 μm	0.1009 μm
1.4-1.5 μm	0.0999 μm
1.5-1.6 μm	0.0999 μm
1.6-1.7 μm	0.0989 μm

1.7-1.8µm	0.1009 µm
1.8-1.9µm	0.0999 µm
1.90-2.0µm	0.0999 µm
2.0-2.1µm	0.1009 µm
2.1-2.2µm	0.0999 µm
2.2-2.3µm	0.0999 µm
2.3-2.4µm	0.1009 µm
2.4-2.5µm	0.0999 µm
2.5-2.6µm	0.0999 µm
2.6-2.7µm	0.0999 µm
2.7-2.8µm	0.0999 µm
2.8-2.9µm	0.1009 µm
2.9-3.0µm	0.0999 µm
3.0-3.1µm	0.0999 µm
3.1-3.2µm	0.0999 µm
3.2-3.3µm	0.1009 µm
3.3-3.4µm	0.0999 µm
3.4-3.5µm	0.1009 µm
3.5-3.6µm	0.0999 µm
3.6-3.7µm	0.0989 µm
3.7-3.8µm	0.1009 µm
3.8-3.9µm	0.0999 µm
3.9-4.0µm	0.0999 µm
4.0-4.1µm	0.1009 µm
4.1-4.2µm	0.0989 µm
4.2-4.3µm	0.1009 µm
4.3-4.4µm	0.0999 µm
4.4-4.5µm	0.0999 µm
4.5-4.6µm	0.1009 µm
4.6-4.7µm	0.0989 µm
4.7-4.8µm	0.1009 µm
4.8-4.9µm	0.0999 µm
4.9-5.0µm	0.0999 µm
5.0-5.1µm	0.1061 µm

Sum 5.119 µm

Average	0.10038 µm
2-Sigma *	0.00317 µm

Excluding 1 st and last lines	
Average	0.10011 µm
2-Sigma *	0.00143 µm

5 µm Line Y-direction	Pitch
0-5µm	5.005 µm
5-10µm	5.005 µm
10-15µm	5.005 µm
15-20µm	5.010 µm
20-25µm	5.010 µm
25-30µm	5.005 µm
30-35µm	5.005 µm
35-40µm	5.003 µm
40-45µm	5.000 µm
45-50µm	5.008 µm
50-55µm	5.000 µm

Sum 55.057 µm

Average	5.0051 µm
2-Sigma *	0.0079 µm

2 µm Line Y-direction	Pitch
0-2µm	2.031 µm
2-4µm	2.003 µm
4-6µm	2.001 µm
6-8µm	2.003 µm
8-10µm	2.001 µm
10-12µm	2.001 µm
12-14µm	2.003 µm
14-16µm	1.998 µm
16-18µm	2.003 µm
18-20µm	2.001 µm
20-22µm	2.001 µm
22-24µm	2.001 µm
24-26µm	2.003 µm
26-28µm	2.001 µm
28-30µm	2.003 µm

Sum 30.051 µm

Average	2.0034 µm
2-Sigma *	0.0173 µm

Excluding 1 st and last lines	
Average	2.0013 µm
2-Sigma *	0.0036 µm

1 µm Line Y-direction	Pitch
0-1µm	1.005 µm
1-2µm	1.001 µm
2-3µm	1.002 µm
3-4µm	1.002 µm
4-5µm	1.001 µm
5-6µm	1.002 µm

6-7µm	1.001 µm
7-8µm	1.001 µm
8-9µm	1.004 µm
9-10µm	1.001 µm
10-11µm	1.000 µm
11-12µm	1.002 µm
12-13µm	1.001 µm
13-14µm	1.001 µm
14-15µm	1.004 µm
15-16µm	1.004 µm

Sum 16.033 µm

Average	1.0021 µm
2-Sigma *	0.0032 µm

Excluding 1 st and last lines	
Average	1.0017 µm
2-Sigma *	0.0026 µm

0.5 µm Line Y-direction	Pitch
0-0.5µm	0.5046 µm
0.5-1µm	0.5015 µm
1-1.5µm	0.4995 µm
1.5-2µm	0.5015 µm
2-2.5µm	0.5005 µm
2.5-3µm	0.5005 µm
3-3.5µm	0.5005 µm
3.5-4µm	0.5015 µm
4-4.5µm	0.4995 µm
4.5-5µm	0.5026 µm
5-5.5µm	0.4985 µm
5.5-6µm	0.5005 µm
6-6.5µm	0.5026 µm
6.5-7µm	0.4985 µm
7-7.5µm	0.5005 µm
7.5-8µm	0.5015 µm
8-8.5µm	0.4995 µm
8.5-9µm	0.5026 µm
9-9.5µm	0.5026 µm

Sum 9.519 µm

Average	0.50100 µm
2-Sigma *	0.00341 µm

Excluding 1 st and last lines	
Average	0.50070 µm
2-Sigma *	0.00285 µm

0.25 µm Line Y-direction	Pitch
0-0.25µm	0.2575 µm
0.25-0.5µm	0.2503 µm
0.5-0.75µm	0.2503 µm
0.75-1µm	0.2503 µm
1-1.25µm	0.2513 µm
1.25-1.5µm	0.2503 µm
1.5-1.75µm	0.2503 µm
1.75-2µm	0.2503 µm
2-2.25µm	0.2503 µm
2.25-2.5µm	0.2513 µm
2.5-2.75µm	0.2492 µm
2.75-3µm	0.2513 µm
3-3.25µm	0.2492 µm
3.25-3.5µm	0.2503 µm
3.5-3.75µm	0.2503 µm
3.75-4µm	0.2503 µm
4-4.25µm	0.2503 µm
4.25-4.5µm	0.2503 µm
4.5-4.75µm	0.2503 µm
4.75-5µm	0.2544 µm

<i>Sum</i>	<i>5.018 µm</i>
Average	0.25088 µm
2-Sigma *	0.00401 µm

Excluding 1 st and last lines	
Average	0.25031 µm
2-Sigma *	0.00119 µm

0.1 µm Line Y direction	Pitch
0-0.1µm	0.1081 µm
0.1-0.2µm	0.0989 µm
0.2-0.3µm	0.1009 µm
0.3-0.4µm	0.0999 µm
0.4-0.5µm	0.0999 µm
0.5-0.6µm	0.0999 µm
0.6-0.7µm	0.0999 µm
0.7-0.8µm	0.1009 µm
0.8-0.9µm	0.1009 µm
0.9-0.1µm	0.0989 µm
1.0-1.1µm	0.1009 µm
1.1-1.2µm	0.0989 µm
1.2-1.3µm	0.1009 µm
1.3-1.4µm	0.1009 µm
1.4-1.5µm	0.0999 µm
1.5-1.6µm	0.0999 µm
1.6-1.7µm	0.0989 µm
1.7-1.8µm	0.1009 µm
1.8-1.9µm	0.0999 µm
1.90-2.0µm	0.0999 µm
2.0-2.1µm	0.1009 µm
2.1-2.2µm	0.0999 µm
2.2-2.3µm	0.0999 µm
2.3-2.4µm	0.1009 µm
2.4-2.5µm	0.0999 µm
2.5-2.6µm	0.0999 µm
2.6-2.7µm	0.0999 µm
2.7-2.8µm	0.0999 µm

2.8-2.9µm	0.1009 µm
2.9-3.0µm	0.0999 µm
3.0-3.1µm	0.0999 µm
3.1-3.2µm	0.0999 µm
3.2-3.3µm	0.1009 µm
3.3-3.4µm	0.0999 µm
3.4-3.5µm	0.1009 µm
3.5-3.6µm	0.0999 µm
3.6-3.7µm	0.0989 µm
3.7-3.8µm	0.1009 µm
3.8-3.9µm	0.0999 µm
3.9-4.0µm	0.0999 µm
4.0-4.1µm	0.1009 µm
4.1-4.2µm	0.0989 µm
4.2-4.3µm	0.1009 µm
4.3-4.4µm	0.0999 µm
4.4-4.5µm	0.0999 µm
4.5-4.6µm	0.1009 µm
4.6-4.7µm	0.0989 µm
4.7-4.8µm	0.1009 µm
4.8-4.9µm	0.0999 µm
4.9-5.0µm	0.0999 µm
5.0-5.1µm	0.1061 µm

<i>Sum</i>	<i>5.119 µm</i>
Average	0.10038 µm
2-Sigma *	0.00317 µm

Excluding 1 st and last lines	
Average	0.10011 µm
2-Sigma *	0.00143 µm

End of report.