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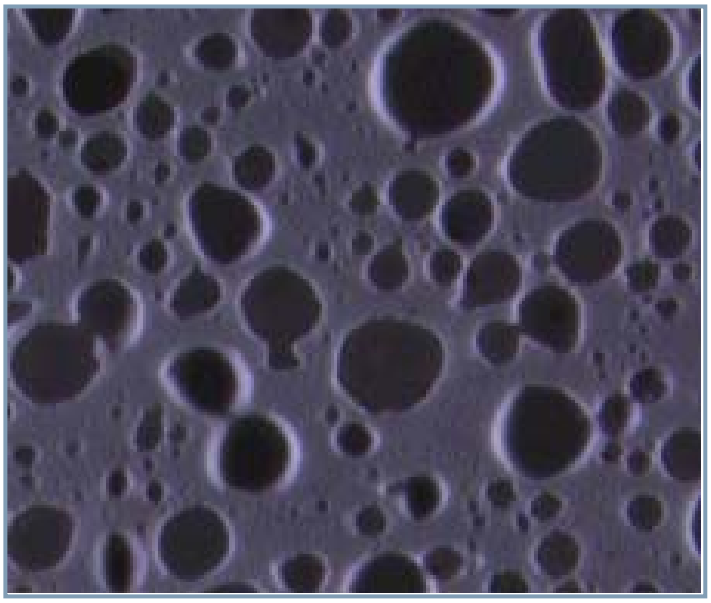
760

Wall Thickness Analysis



Prepared by Myriam Savard Eng.
Clemex Technologies Inc.
For USG Corp.

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Wall Thickness Analysis

Image Analysis Report # 760 - For USG Corp

Written by Myriam Savard Engineer

Sample Description

One image of Plaster of Paris sample showing pores was submitted for analysis.

Purpose of Analysis

To demonstrate that the Clemex Vision image analysis system can distinguish the pores and to perform thickness measurements on walls separating them from their nearest neighborhoods. Pores size and shape measurements are also of interest.

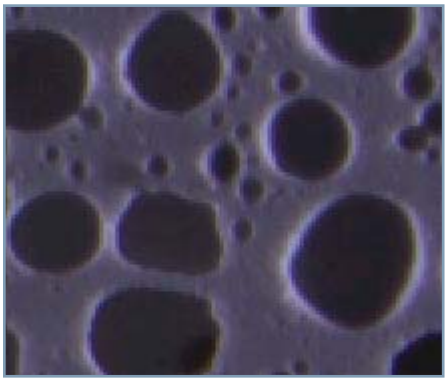


Figure 1: Part of the original image (11.22 microns/pixel).

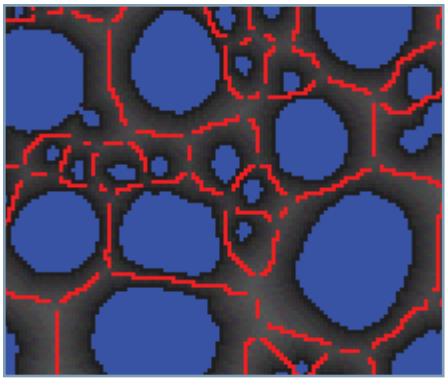


Figure 2: Pores as measured in blue and walls midlines in red.

Procedure[1]

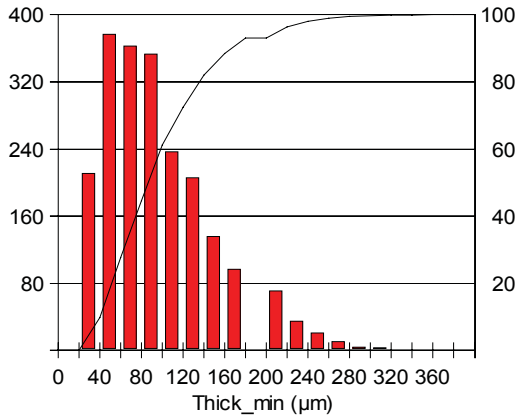
A Process Frame was used to decrease the size of the processing area excluding the encrusted scale line. Pores were binarized in blue using the Auto-Threshold tool. Features of 3 x 3 pixels were considered as noise and eliminated.

The blue binary features representing pores were grown to their maximum inf uence zone, and the result was inverted into the red bitplane to obtain a network of one pixel thick in the walls midline. The segments were disconnected using the Triple Points tool, so an individual line was found between each nearest neighbor.

The Outer Distance f lter was applied from the blue bitplane (pores) assigning a different gray level to each row of pixel from the pores going towards the middle of the walls. The gray level found under each segment is used to obtain an estimate of the wall thickness. Pores sectioned by the f eld of view were eliminated prior evaluating their size or shape. A Guard Frame should be used if processing more than one f eld.

Results[2]

In addition to nearest neighbor wall thickness, global Mean Free Path and individual Area, Length, Circular Diameter, Roundness, and Aspect Ratio measurements were performed on pores. Automated statistics and graphs were generated and would be cumulated if analyzing several images (sample). Final results were printed directly from Clemex Vision and saved for further use. A customized report could be built using the Report Generator module. Raw data is linked to their respective objects for validation purposes. Raw data could also be exported in Excel format.



Minimum:	22.43 microns
Maximum:	358.95 microns
Mean:	96.01 microns
Std Dev.:	55.93 microns

Figure 3: Walls' minimum Thickness distribution and corresponding statistics.

Equipment

Image Analysis System:	Clemex Vision PE
Calibration:	11.2173 microns/pixel

Discussion

The Minimum Thickness precision is linked to the calibration. Consequently, a higher magnif cation or a higher resolution camera should be used if better precision is needed.

A f lter could be applied on the segments to eliminate the "furthermost" of the neighbors from the statistics, if desired.

If the Mean Free Path should be measured on multiple f elds, the same formula should be used over the global analysis using the Report Generator, for the average performed on individual f elds provides less precision than a global measurement.

1 *Images taken during the procedure are available in appendix A*

2 *Complete results are available in appendix B.*

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Appendix A: Image Analysis Steps

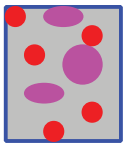

Image Analysis Steps

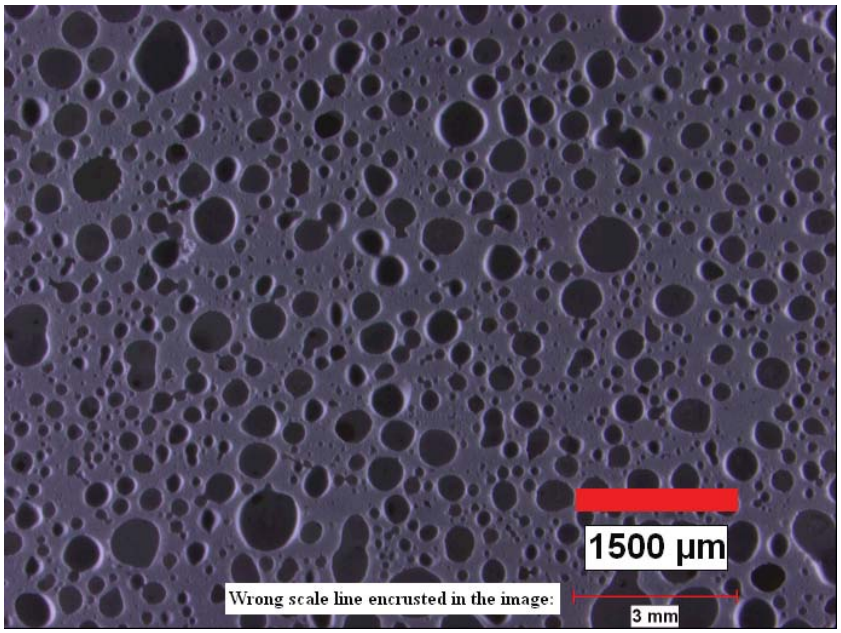

Image 1: Original image showing the wrong and the new scale lines.

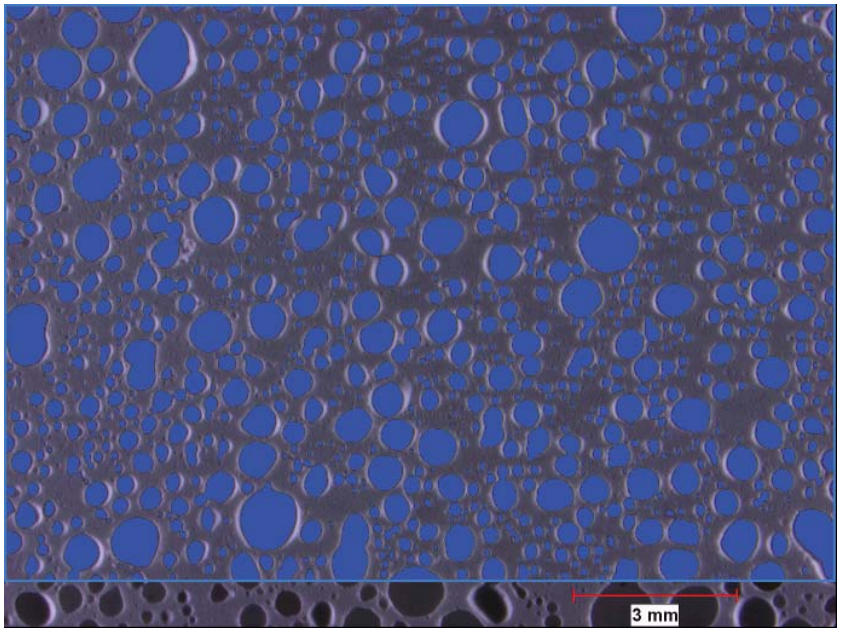

Image 2: A process frame is used to eliminate the wrong scale line from the analysis. All pores inside the process frame are binarized into a blue bitplane using Auto-Threshold tool.

Image Analysis Steps

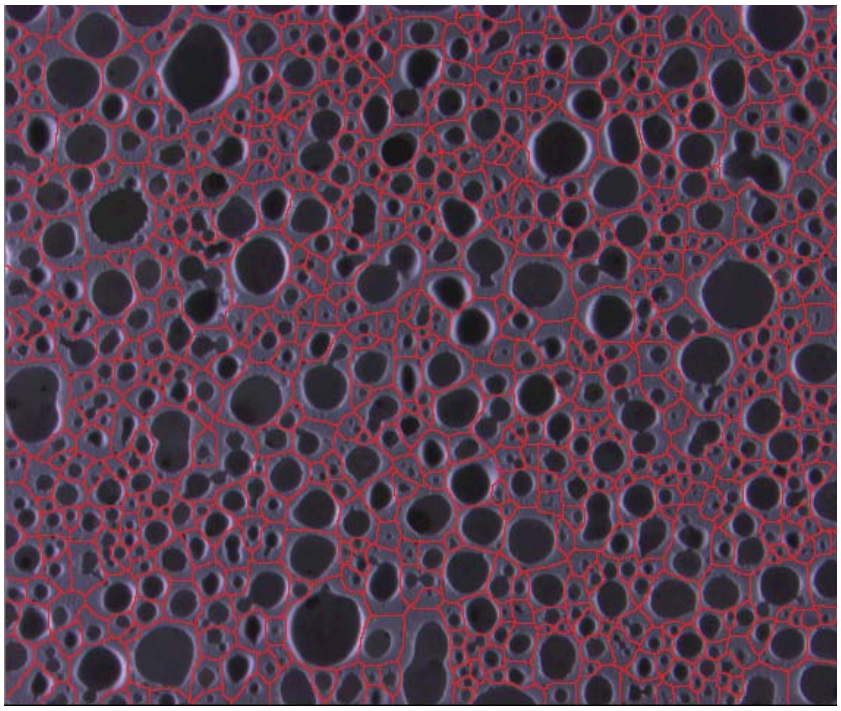

Image 3: The binary features representing the pores are grown to their maximum zone of influence and the result is inverted into a red bitplane.

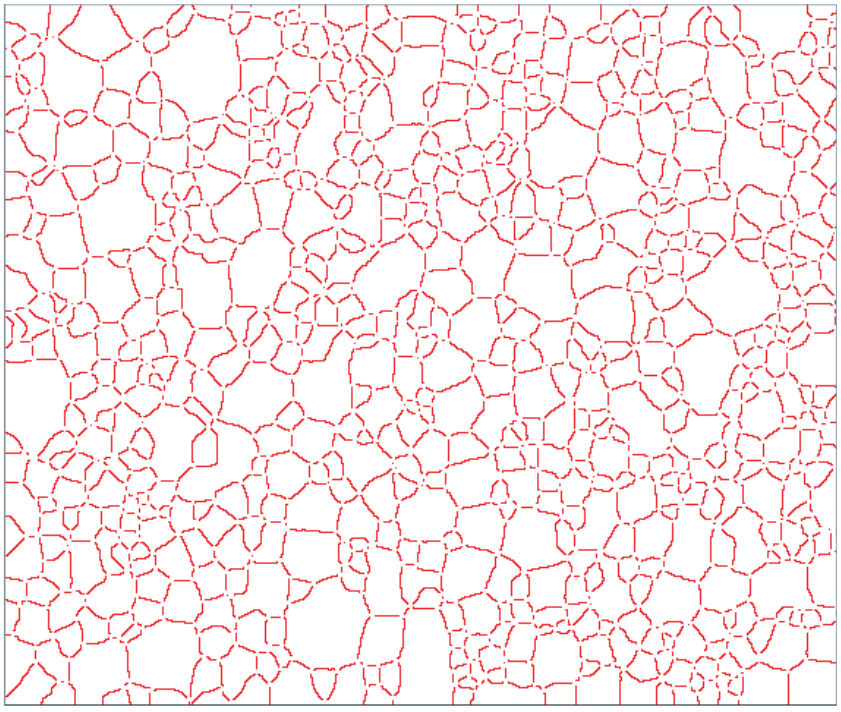

Image 4: The red bitplane is disconnected at each intersection. Each section represents a separation between two neighbors.

Image Analysis Steps

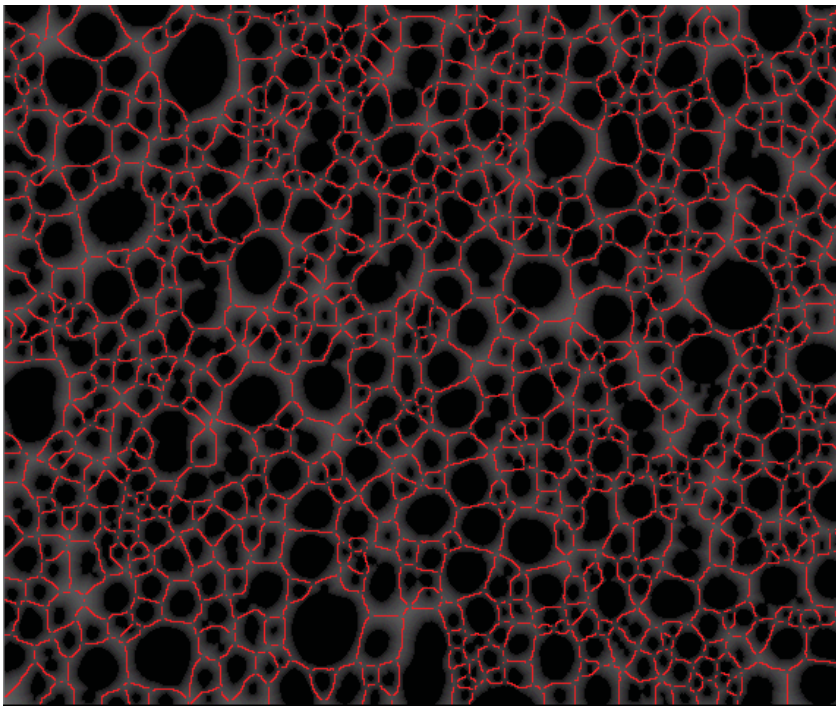

Image 5: The outer distance filter is applied on the detected pores. Measuring the minimum intensity under each section allows estimating the smallest wall thickness between two neighbor particles.

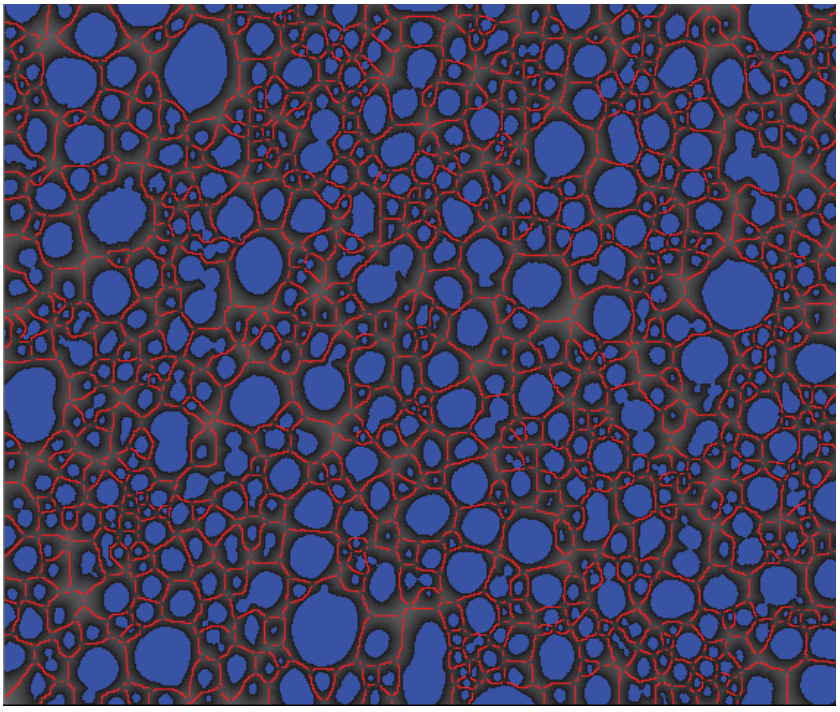

Image 6: Shows the pores and segments as measured overlaid against the image as processed by the Outer Distance filter.

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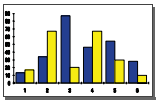
Appendix B: Results



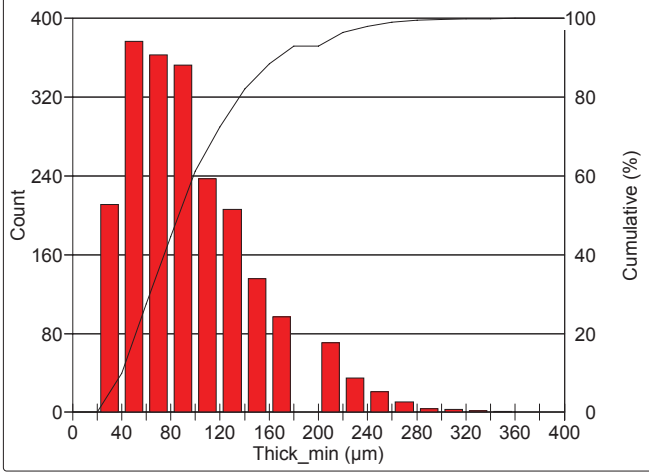
760 wall thickness

Organization:	**Clemex**	Date & Time:	**16/01/2008 11:21:53 AM**
Department:		Sample:	
User:	**Myriam Savard**		

OBJM1 Count - Thick_min

Magn.: line.5 Calib.: 11.2173 µm/pixel Bitplane: Wall

Chart



Values

Thick_min Intervals (µm)		Count	%	Cumul%
0	- 20	0	0	0
20	- 40	211	9.92	9.92
40	- 60	377	17.72	27.63
60	- 80	363	17.06	44.69
80	- 100	353	16.59	61.28
100	- 120	237	11.14	72.42
120	- 140	206	9.68	82.10
140	- 160	136	6.39	88.49
160	- 180	97	4.56	93.05
180	- 200	0	0	93.05
200	- 220	71	3.34	96.38
220	- 240	35	1.64	98.03
240	- 260	21	0.99	99.01
260	- 280	11	0.52	99.53
280	- 300	4	0.19	99.72
300	- 320	3	0.14	99.86
320	- 340	2	0.09	99.95
340	- 360	1	0.05	100
360	- 380	0	0	100
380	- 400	0	0	100

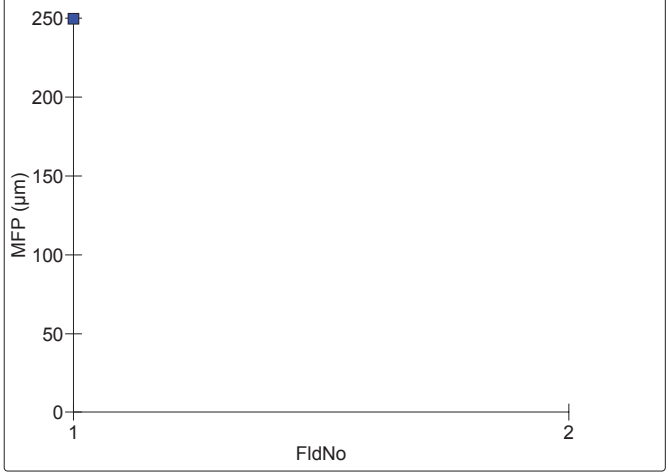
Statistics

Minimum:	22.43	µm
Maximum:	358.95	µm
Mean:	96.01	µm
Std Dev.:	55.93	µm
Sum:	204311.11	µm
Count:	2128	
Under:	0	
Over:	0	
Accepted:	100	%
Field Count:	1	
Field Area:	44.58e+06	µm²
Total Area:	44.58e+06	µm²
D10:	22.54	µm
D50:	74.49	µm
D90:	164.49	µm

FLDM3 MFP - FldNo

Magn.: line.5 Calib.: 11.2173 µm/pixel Bitplane: Pore

Chart



Values

FldNo	MFP (µm)
1	249.98

Statistics

Minimum:	249.98	µm
Maximum:	249.98	µm
Mean:	249.98	µm
Std Dev.:	0	µm
Sum:	249.98	µm
Count:	1	
Under:	0	
Over:	0	
Accepted:	100	%
Field Count:	1	
Field Area:	41.38e+06	µm²
Total Area:	41.38e+06	µm²

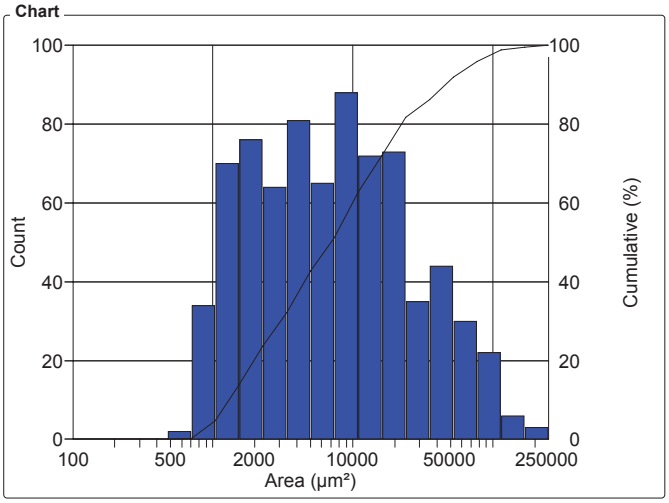
760 wall thickness

Organization:	**Clemex**	Date & Time:	**16/01/2008 11:22:27 AM**
Department:		Sample:	
User:	**Myriam Savard (signed on 2008-Jan-15 11:24:13 -05'00')**		

OBJM2 Count - Area

Magn.: line.5 Calib.: 11.2173 µm/pixel Bitplane: Pore

Chart



Values

Area Intervals (µm²)		Count	%	Cumul%
100	- 148	0	0	0
148	- 219	0	0	0
219	- 323	0	0	0
323	- 478	0	0	0
478	- 707	2	0.26	0.26
707	- 1046	34	4.44	4.71
1046	- 1546	70	9.15	13.86
1546	- 2287	76	9.93	23.79
2287	- 3381	64	8.37	32.16
3381	- 5000	81	10.59	42.75
5000	- 7394	65	8.50	51.24
7394	- 10934	88	11.50	62.75
10934	- 16168	72	9.41	72.16
16168	- 23909	73	9.54	81.70
23909	- 35355	35	4.58	86.27
35355	- 52282	44	5.75	92.03
52282	- 77312	30	3.92	95.95
77312	- 114326	22	2.88	98.82
114326	- 169061	6	0.78	99.61
169061	- 250000	3	0.39	100

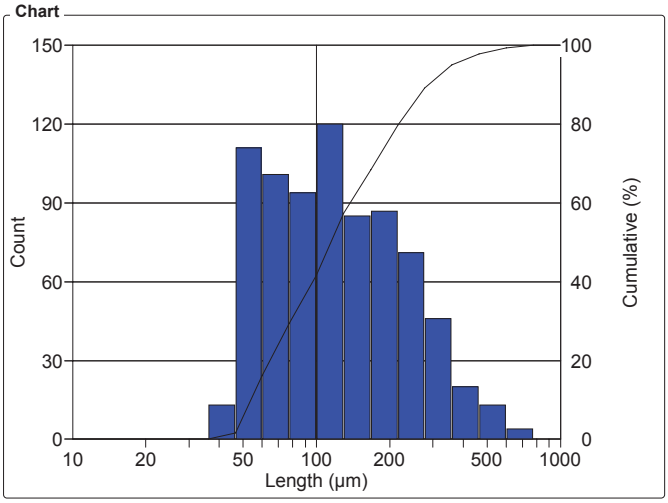
Statistics

Minimum:	503.31	µm²
Maximum:	232024.67	µm²
Mean:	16547.63	µm²
Std Dev.:	26009.03	µm²
Sum:	12.66e+06	µm²
Count:	765	
Under:	0	
Over:	0	
Accepted:	100	%
Field Count:	1	
Field Area:	44.58e+06	µm²
Total Area:	44.58e+06	µm²
D10:	1250.06	µm²
D50:	6951.92	µm²
D90:	44856.88	µm²

OBJM2 Count - Length

Magn.: line.5 Calib.: 11.2173 µm/pixel Bitplane: Pore

Chart



Values

Length Intervals (µm)		Count	%	Cumul%
10	- 12.90	0	0	0
12.90	- 16.70	0	0	0
16.70	- 21.50	0	0	0
21.50	- 27.80	0	0	0
27.80	- 36	0	0	0
36	- 46	13	1.70	1.70
46	- 60	111	14.51	16.21
60	- 77	101	13.20	29.41
77	- 100	94	12.29	41.70
100	- 129	120	15.69	57.39
129	- 167	85	11.11	68.50
167	- 215	87	11.37	79.87
215	- 278	71	9.28	89.15
278	- 359	46	6.01	95.16
359	- 464	20	2.61	97.78
464	- 599	13	1.70	99.48
599	- 774	4	0.52	100
774	- 1000	0	0	100

Statistics

Minimum:	44.87	µm
Maximum:	702.48	µm
Mean:	148.15	µm
Std Dev.:	106.90	µm
Sum:	113337.75	µm
Count:	765	
Under:	0	
Over:	0	
Accepted:	100	%
Field Count:	1	
Field Area:	44.58e+06	µm²
Total Area:	44.58e+06	µm²
D10:	48.54	µm
D50:	113.75	µm
D90:	282.53	µm

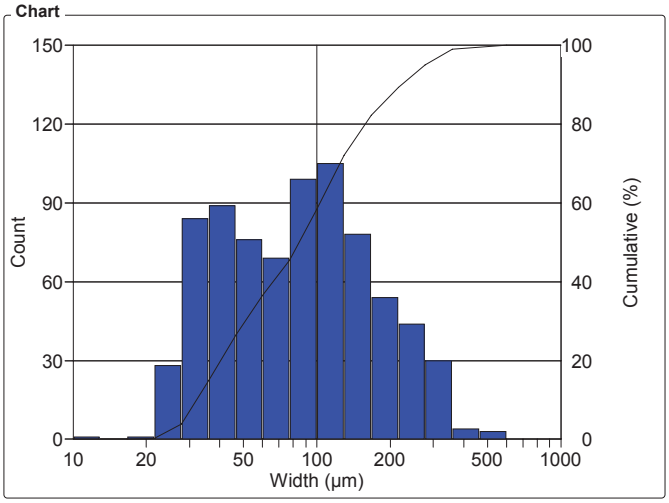
760 wall thickness

Organization:	**Clemex**	Date & Time:	**16/01/2008 11:22:27 AM**
Department:		Sample:	
User:	**Myriam Savard (signed on 2008-Jan-15 11:24:13 -05'00')**		

OBJM2 Count - Width

Magn.: line.5 Calib.: 11.2173 µm/pixel Bitplane: Pore

Chart



Values

Width Intervals (µm)		Count	%	Cumul%
10	- 12.90	1	0.13	0.13
12.90	- 16.70	0	0	0.13
16.70	- 21.50	1	0.13	0.26
21.50	- 27.80	28	3.66	3.92
27.80	- 36	84	10.98	14.90
36	- 46	89	11.63	26.54
46	- 60	76	9.93	36.47
60	- 77	69	9.02	45.49
77	- 100	99	12.94	58.43
100	- 129	105	13.73	72.16
129	- 167	78	10.20	82.35
167	- 215	54	7.06	89.41
215	- 278	44	5.75	95.16
278	- 359	30	3.92	99.08
359	- 464	4	0.52	99.61
464	- 599	3	0.39	100
599	- 774	0	0	100
774	- 1000	0	0	100

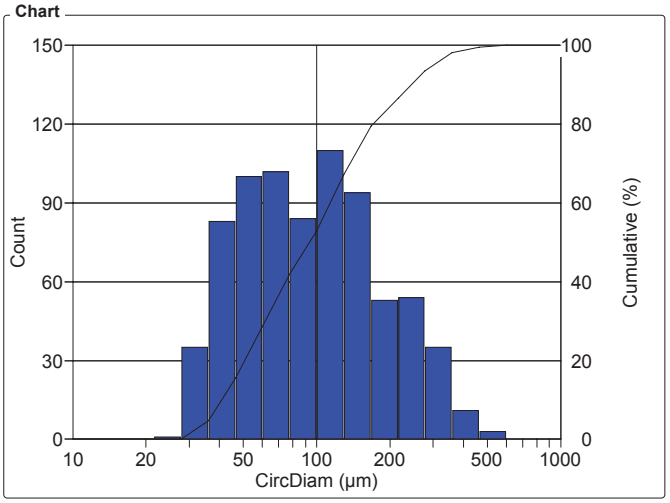
Statistics

Minimum:	11.22	µm
Maximum:	524.41	µm
Mean:	106.05	µm
Std Dev.:	78.53	µm
Sum:	81126.00	µm
Count:	765	
Under:	0	
Over:	0	
Accepted:	100	%
Field Count:	1	
Field Area:	44.58e+06	µm²
Total Area:	44.58e+06	µm²
D10:	32.94	µm
D50:	84.83	µm
D90:	220.84	µm

OBJM2 Count - CircDiam

Magn.: line.5 Calib.: 11.2173 µm/pixel Bitplane: Pore

Chart



Values

CircDiam Intervals (µm)		Count	%	Cumul%
10	- 12.90	0	0	0
12.90	- 16.70	0	0	0
16.70	- 21.50	0	0	0
21.50	- 27.80	1	0.13	0.13
27.80	- 36	35	4.58	4.71
36	- 46	83	10.85	15.56
46	- 60	100	13.07	28.63
60	- 77	102	13.33	41.96
77	- 100	84	10.98	52.94
100	- 129	110	14.38	67.32
129	- 167	94	12.29	79.61
167	- 215	53	6.93	86.54
215	- 278	54	7.06	93.59
278	- 359	35	4.58	98.17
359	- 464	11	1.44	99.61
464	- 599	3	0.39	100
599	- 774	0	0	100
774	- 1000	0	0	100

Statistics

Minimum:	25.31	µm
Maximum:	543.53	µm
Mean:	118.53	µm
Std Dev.:	83.84	µm
Sum:	90675.25	µm
Count:	765	
Under:	0	
Over:	0	
Accepted:	100	%
Field Count:	1	
Field Area:	44.58e+06	µm²
Total Area:	44.58e+06	µm²
D10:	39.89	µm
D50:	94.08	µm
D90:	238.98	µm

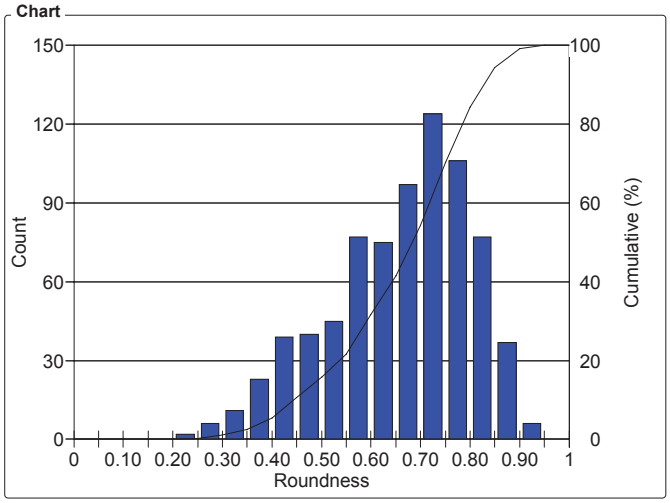
760 wall thickness

Organization:	**Clemex**	Date & Time:	**16/01/2008 11:22:27 AM**
Department:		Sample:	
User:	**Myriam Savard (signed on 2008-Jan-15 11:24:13 -05'00')**		

OBJM2 Count - Roundness

Magn.: line.5 Calib.: 11.2173 µm/pixel Bitplane: Pore

Chart



Values

Roundness Intervals		Count	%	Cumul%
0	- 0.05	0	0	0
0.05	- 0.10	0	0	0
0.10	- 0.15	0	0	0
0.15	- 0.20	0	0	0
0.20	- 0.25	2	0.26	0.26
0.25	- 0.30	6	0.78	1.05
0.30	- 0.35	11	1.44	2.48
0.35	- 0.40	23	3.01	5.49
0.40	- 0.45	39	5.10	10.59
0.45	- 0.50	40	5.23	15.82
0.50	- 0.55	45	5.88	21.70
0.55	- 0.60	77	10.07	31.76
0.60	- 0.65	75	9.80	41.57
0.65	- 0.70	97	12.68	54.25
0.70	- 0.75	124	16.21	70.46
0.75	- 0.80	106	13.86	84.31
0.80	- 0.85	77	10.07	94.38
0.85	- 0.90	37	4.84	99.22
0.90	- 0.95	6	0.78	100
0.95	- 1	0	0	100

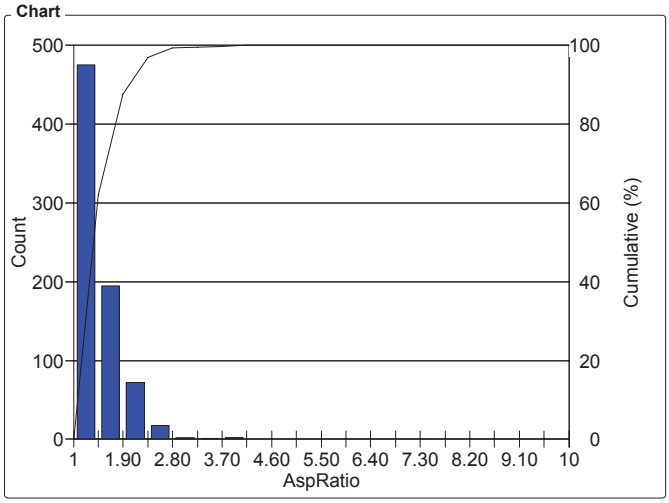
Statistics

Minimum:	0.21	
Maximum:	0.93	
Mean:	0.659	
Std Dev.:	0.143	
Count:	765	
Under:	0	
Over:	0	
Accepted:	100	%
Field Count:	1	
Field Area:	44.58e+06	µm²
Total Area:	44.58e+06	µm²
D10:	0.44	
D50:	0.68	
D90:	0.82	

OBJM2 Count - AspRatio

Magn.: line.5 Calib.: 11.2173 µm/pixel Bitplane: Pore

Chart



Values

AspRatio Intervals		Count	%	Cumul%
1	- 1.45	475	62.09	62.09
1.45	- 1.90	195	25.49	87.58
1.90	- 2.35	72	9.41	96.99
2.35	- 2.80	18	2.35	99.35
2.80	- 3.25	2	0.26	99.61
3.25	- 3.70	1	0.13	99.74
3.70	- 4.15	2	0.26	100
4.15	- 4.60	0	0	100
4.60	- 5.05	0	0	100
5.05	- 5.50	0	0	100
5.50	- 5.95	0	0	100
5.95	- 6.40	0	0	100
6.40	- 6.85	0	0	100
6.85	- 7.30	0	0	100
7.30	- 7.75	0	0	100
7.75	- 8.20	0	0	100
8.20	- 8.65	0	0	100
8.65	- 9.10	0	0	100
9.10	- 9.55	0	0	100
9.55	- 10	0	0	100

Statistics

Minimum:	1.04	
Maximum:	4	
Mean:	1.47	
Std Dev.:	0.365	
Count:	765	
Under:	0	
Over:	0	
Accepted:	100	%
Field Count:	1	
Field Area:	44.58e+06	µm²
Total Area:	44.58e+06	µm²
D10:	1.14	
D50:	1.36	
D90:	1.99	

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