Purpose:

Obtain surface cockle measurements using the TherMoire´ System at TAPPI conditions on the 4 samples provided (2 coated and 2 uncoated) on customer supplied samples pre and post rebuild. Customer states post rebuild samples are lumpy on the wire side. We attempt to quantify the severity of the surface undulations.

Background:

The TherMoire´ analysis is based on the geometric interference of a shadow grating projected on the sample surface and a real grating on a flat reference surface. The over lap of the shadow and real grating produces a series of dark and light fringes. If the sample is flat and parallel to the reference grating, no moiré pattern is produced. If however, the sample is curved moiré fringes are produced as a result of the geometric interference pattern created between the reference grating and shadow grating that defines the surface contours. The basic system is composed of four major components: light source, screen or reference grating, sample/sample holder and a camera. A computer is used to automatically analyze observed fringe pattern changes during four controlled vertical movement of the sample. The analysis yields a matrix of values containing the out-of-plane surface displacement across the entire sample. The displacements data is then presented as a 3-D surface plot.

About IPST Paper Analysis Laboratory:

Paper Testing at IPST has over 2800 square feet of lab space dedicated to address any paper, board, and specialty product testing needs in areas of strength, optical, surface, and structural properties. In addition to conventional Tappi method testing capabilities, the Paper Testing group can provide special services in the areas of environmental simulations and accelerated aging. Environmental chambers cover high and low

temperature and humidity conditions. Unique capabilities include precision paper grinding or sheet splitting to produce specific thickness sections, score cracking of linerboards, needle abrasion testing to predict relative slitter and knife blade wear caused by abrasive components in both base sheet and coating materials, nondestructive in-plane and out-of-plane (Z-directional) ultrasonic testing, optical 3D Moiré surface topography for the measurement of curl or cockle. Our labs also offer the latest automated capabilities for real time hygroexpansive response measurements, and horizontal plane static and kinetic coefficient of friction determinations. Humidity and temperature conditions are monitored and tracked continually to ensure proper standard Tappi conditions of 23 degrees C and 50 % RH.

The results from the IPST Paper Analysis Laboratory are guaranteed validated through IPST active participation in the Collaborative Testing Services Inc., and PAPRICAN Paper and Pulp Monitor programs. Over 400 technician hours are annually devoted to regular periodic round-robin intra-laboratory comparisons of testing results. This ensures that the equipment, methods and results are consistent with correct industry practice.

Method:

- The TherMoire´ System was used to obtain the 3-D surface plot. A 5 ″x 5″ range of interest was used within the sheet along the wire side of the sample having selecting the grating of 100 lines per inch. A series of three phase images are obtained and saved. The software used to generate a fringe pattern yields a maximum and minimum Z value and a Coplanarity value. The Coplanarity value is a representation of how flat the sample and is the difference between the maximum and minimum value generated from the calculated displacement. The final result is a 3-D topographical map of the sample's surface. A Moire Cockle analysis filtering program is used to post process the tpographical map to produce values for the maximum, minimum, standard deviation and volume/area from the high pass filtered cockled image. Original (unfiltered) images with results were recorded as well as examples using three other filtered sizes.

Data:

Pre Rebuild Coated Sample K160757-60				
	original	**20 filter**	**60 filter**	**70 filter**
max	19.8	7.394	8.756	9.259
min	-22.31	-11.448	-13.595	-14.099
std	8.343	1.059	2.614	2.999
volume/area	6.732	0.5759	1.889	2.215
Post Rebuild Coated Sample X162646-50				
	original	**20 filter**	**60 filter**	**70 filter**
max	20.2	10.127	13.993	14.967
min	-30.9	-15.751	-18.707	-19.526
std	9.421	.8679	3.386	4.009
volume/area	7.544	.4248	2.539	3.078
Pre Rebuild Un-Coated Sample E1614156				
	original	**20 filter**	**60 filter**	**70 filter**
max	16.1	5.930	6.956	7.052
min	-16.3	-6.737	-8.462	-8.799
std	7.336	.6586	1.719	2.063
volume/area	6.154	.4233	1.371	1.681
Post Rebuild Un-Coated Sample Q160906-10				
	original	**20 filter**	**60 filter**	**70 filter**
max	14.7	3.559	5.581	6.447
min	-35.4	-19.406	-20.63	-22.207
std	6.796	1.099	2.472	2.819
volume/area	4.924	.5593	1.507	1.759

Table 1: Results from the Thermoire´. The table reports in units of mils the maximum and minimum values of the surface topography, the standard deviation is calculated from the topographic height values and can be taken as a measure of the roughness of the surface topography on the scale of interest. Similarly, the calculation of the volume/area is a measure of the severity of the undulations of the surface. The various filter sizes is a means in which the operator can separate actual cockle from the noise. Increasing the filter size also increases the cockle topography. Using a filter size of 70 on the coated samples significantly increased the volume/area for the Post Rebuild. The Un-Coated Post Rebuild sample again is larger than the Pre Rebuild however the difference is not as great.

Observations:

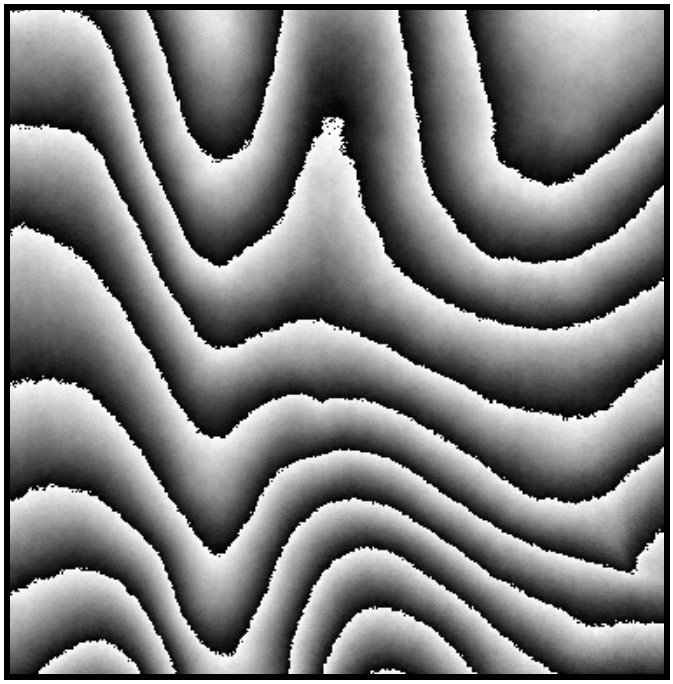

Figure 1. Phase Image of the Coated Post Rebuild Sample X162646-50

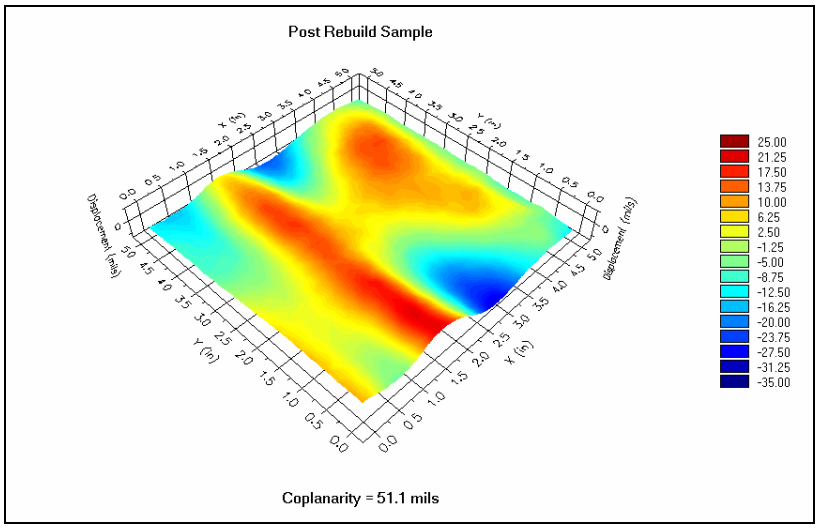

Figure 2. Original topographical Image - Coated Post Rebuild Sample X162646

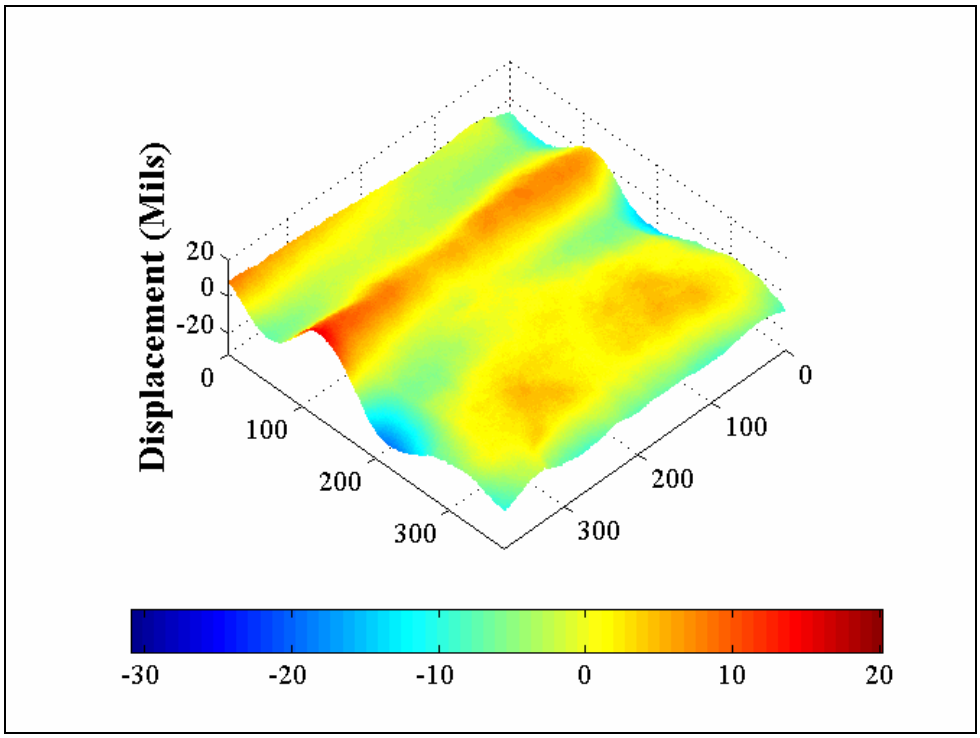

Figure 3. Filtered (70) Topographical Image – Coated Post Rebuild Sample X162646.

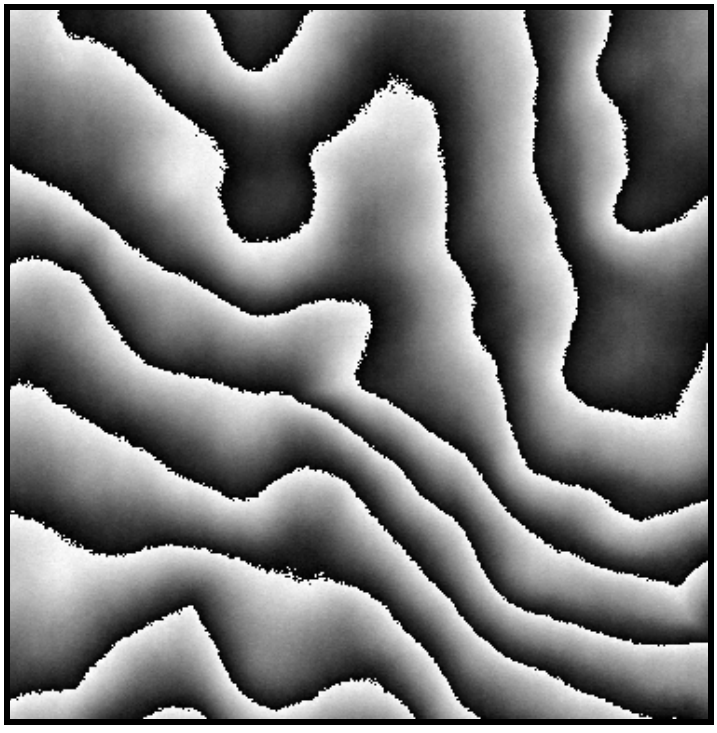

Figure 4. Phase Image of the Coated Pre Rebuild Sample K160757-60

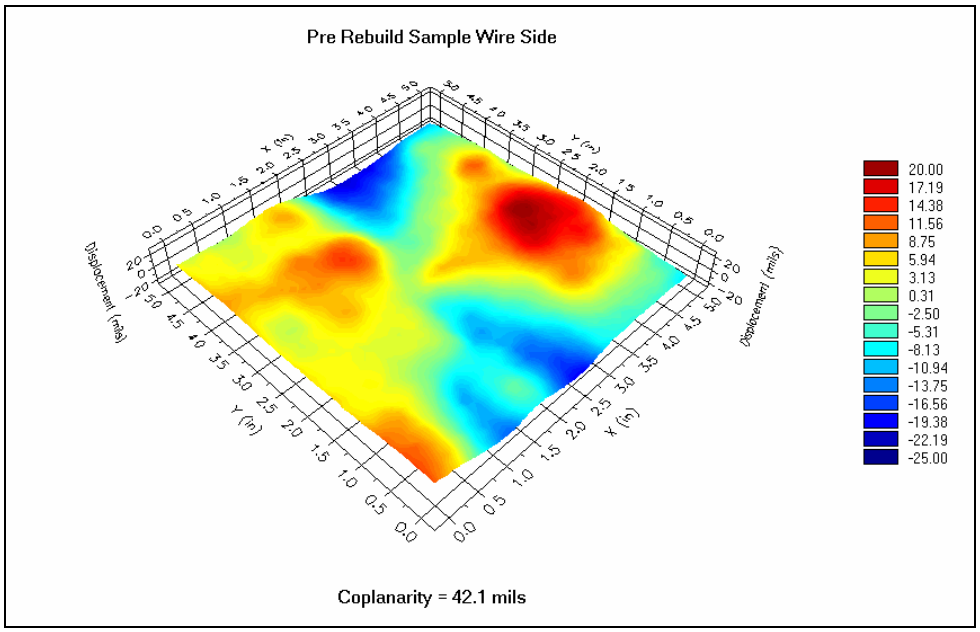

Figure 5. Original topographical Image - Coated Pre Rebuild Sample K160757-60

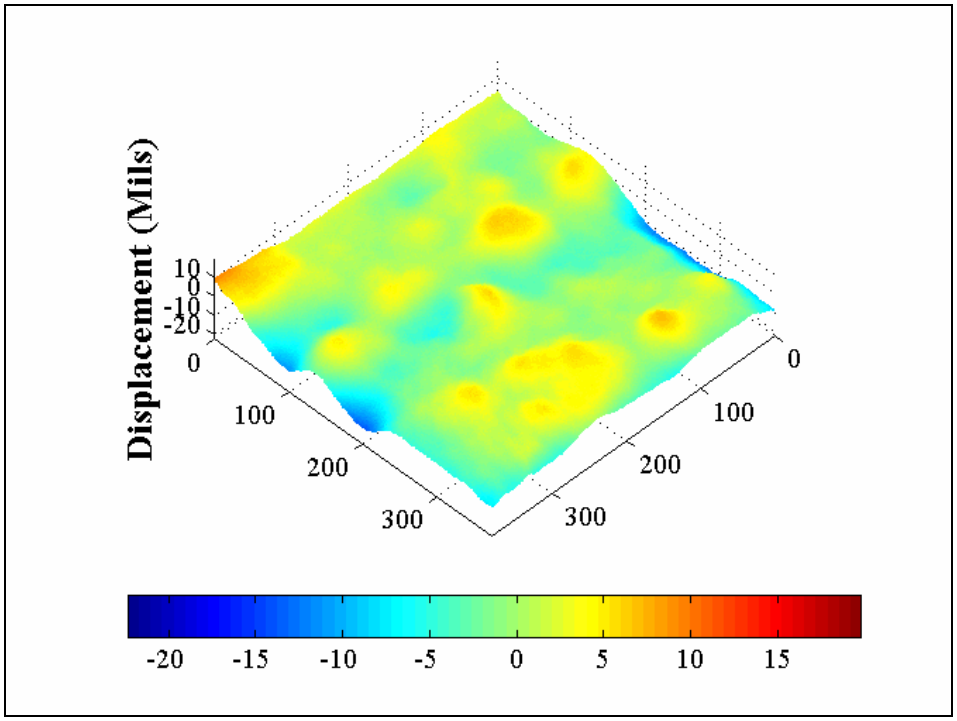

Figure 6. Filtered (70) Topographical Image – Coated Pre Rebuild Sample K160757-60

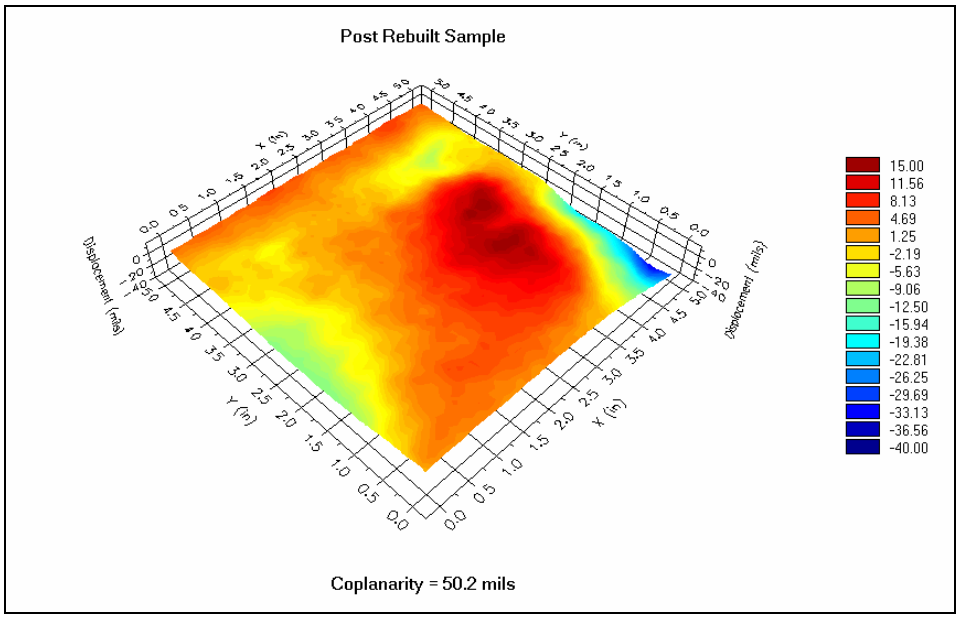

Figure 7. Original topographical Image of Un-Coated Post Rebuild Sample Q160906

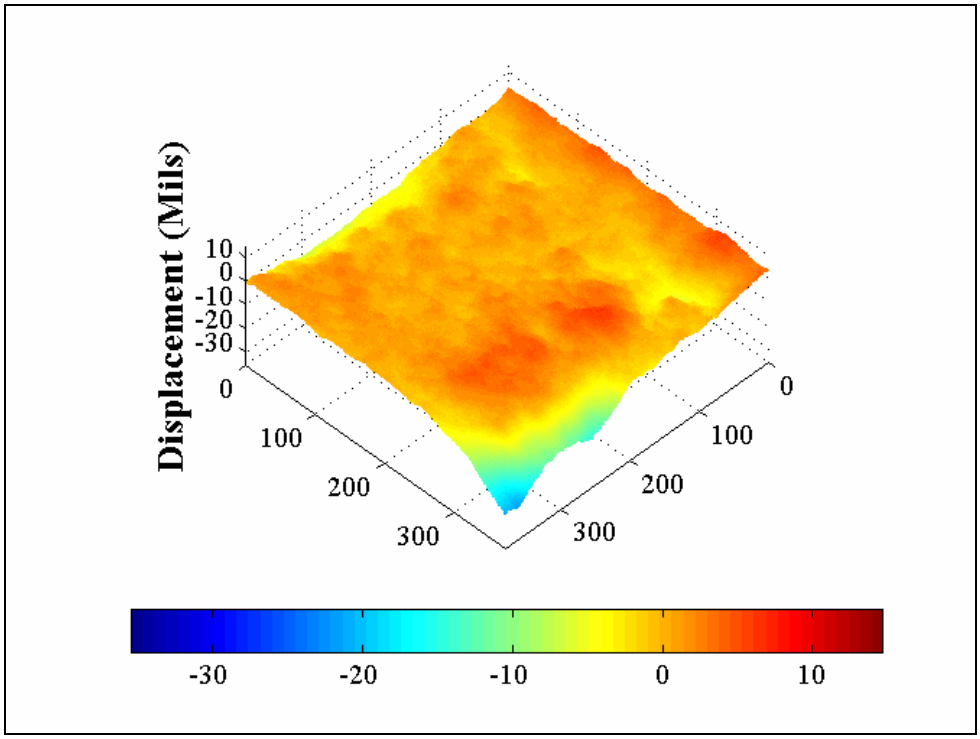

Figure 8. Filtered (70) Topographical Image – Un-Coated Post Rebuild Sample Q160906. Note the fine scale bumpy structure here.

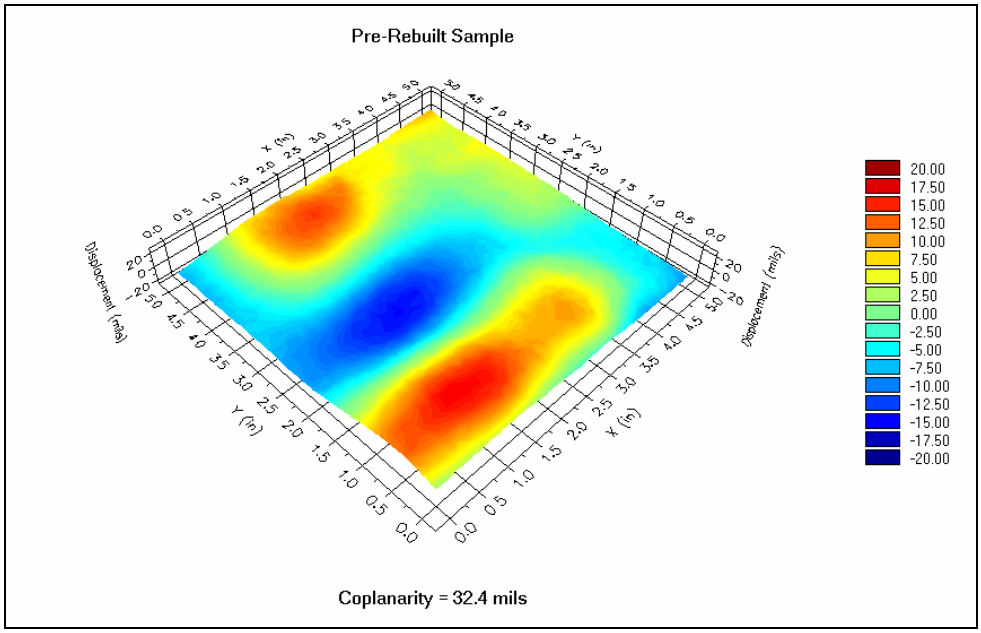

Figure 9. Original topographical Image – Un-Coated Pre Rebuild Sample E1614156

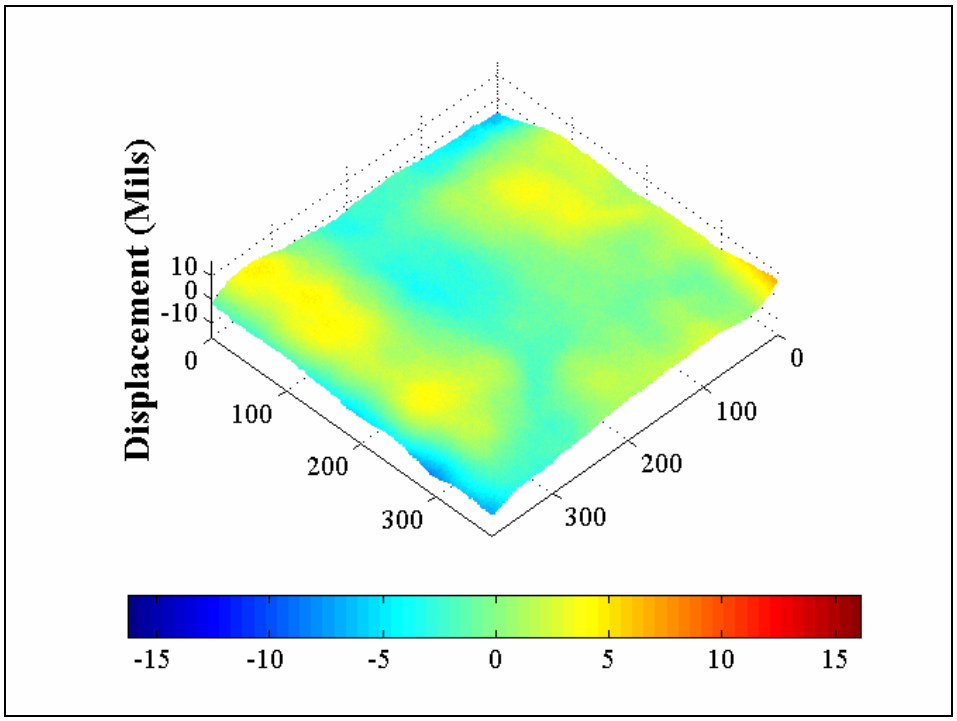

Figure 10. Filter (70) Topographical Image – Un-Coated Pre Rebuild Sample E1614156