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Measurement of Surface Topography

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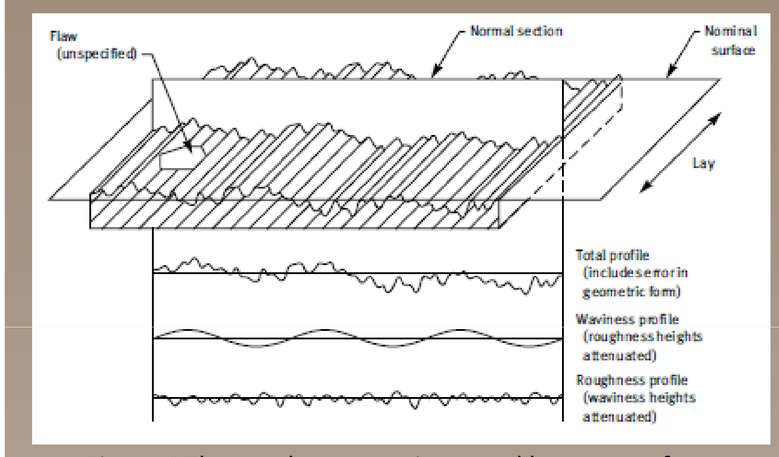
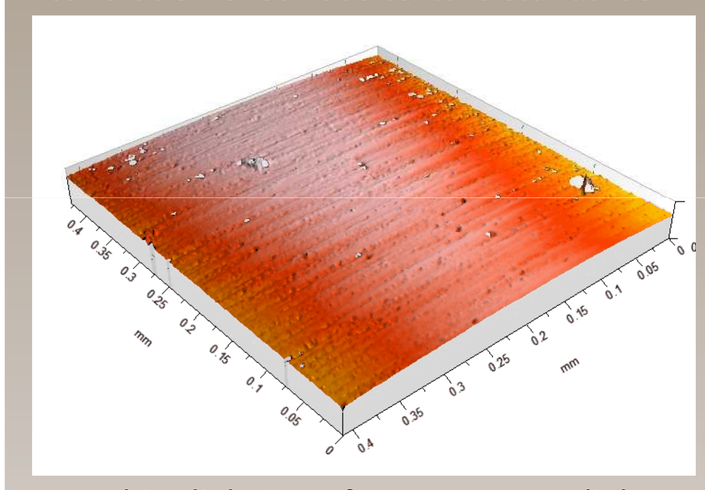


Figure 1 The roughness, waviness and lay on a surface.

Objective:

Qualifying a non-contact system for calibration of surface texture standards



A white light interferometer uses light to measure the surface texture on a sample. This is illustrated in Figure 3. The instrument actually uses a scale to measure the topography during a scan (Figure 4).

Measurements using light interference instead of direct contact allows for full aerial pictures to be taken of the sample, making it easier to see the actual shape of the texture measured.

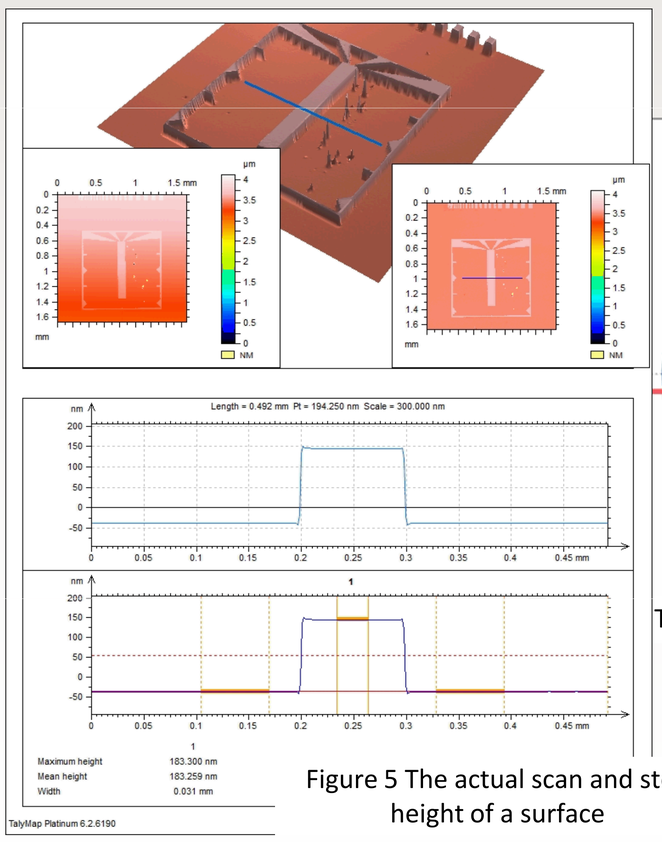
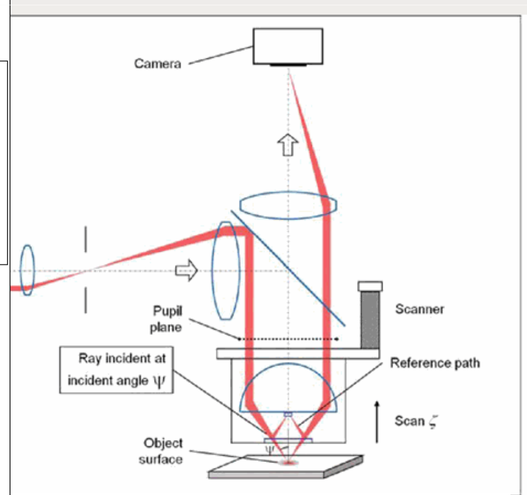


Figure 5 The actual scan and step height of a surface



The path of the light in the interferometer

Abstract

Surface Metrology is the study and measurement of surface textures. “It is now reasonably established that the surface metrology has two roles; one to help control the manufacture, including the process and machine tool, and the other to help optimize the function.” (Whitehouse)
Surface texture is measured either with contact or non-contact instruments. Throughout my time in the PSL I have helped qualify measurements through non-contact, a CCI white light interferometer. Results of different measurements show with homogeneous surfaces the measurement uncertainty is much smaller while non-homogeneous surfaces cause limitations in the machine. The CCI machine will be used in the lab making measurements easier and faster.

Figure 2 The white light interferometer

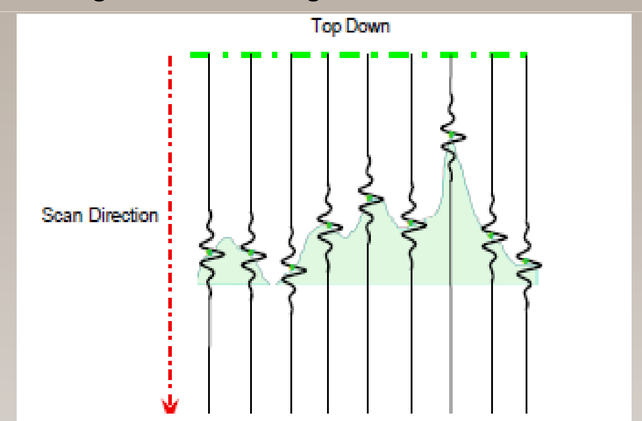


Figure 4 The peak fringes from the scan

Contributions

In qualifying this machine the uncertainty of the measurements were reduced by an order of magnitude while the speed of the measurements was increased. The limitations of the white light interferometer are when measuring surfaces which do not have a homogeneous material or have a transparent film coating.
PSL (org 02541) will have an increased ability to support Sandia and Nuclear Weapons enterprise through calibrating reference standards for external customers such as Y12, KCP, Pantex and also internal customers such as Neutron Generators and Microsystems.

Results

Step heights ranging from 8 nanometers to 50 micrometers were measured. Five different measurements were taken and recorded along 9 different places on the step height. The results have proven that non-contact measurements with the white light interferometer are within tolerances and can be used in the future. The uncertainty of measurements through this process decreased from the previous uncertainties. Table 1 shows the measurements taken of different step heights and the respective uncertainties. The CCI machine, though, is not ideal for in-homogenous materials, where measurements showed large percent errors.

	Value	Value	Value	Value	Value	Value	Units
CV	949.2	949.2	949.2	949.2	949.2	49505	nm
MV	933.149	933.25	932.577	933.12	933.12	48651.199	nm
SF	1.0172	1.0171	1.01782	1.01723	1.01723	1.01755	none
m	7.796	46.087	177.923	443.89	2635.993	12428.584	nm
y (UUT)	7.93	46.9	181.1	451.5	2681	12647	nm
UUT (previous cal, k=2)	8.7±0.75	47.4±0.90	180.1±3.0	449.5±4.4	2684±55	12660±64	nm
1. $u_{CV\ (B)}$	4.792	4.792	4.792	4.792	4.792	230.94	nm
2. $u_{MV\ (A)}$	0.396	0.463	0.582	1.192	1.192	13.52	nm
u_{SF}	0.0052	0.0052	0.0052	0.0053	0.0053	0.004755	dim'less
3. $s_{m\ (A)}$	0.036	0.079	0.221	0.389	2.019	5.254	nm
4. $u_{z\ (B)}$	0.522	0.522	0.522	0.522	0.522	0.522	nm
$u_{m\ (RSS\ 3\text{-}4)}$	0.524	0.528	0.567	0.652	2.085	5.28	nm
$m*u_{SF}$	0.04	0.238	0.921	2.351	13.963	59.101	nm
u_y	0.53	0.58	1.08	2.44	14.12	59.34	nm
$U_{y\ (k=2)}$	1.05	1.2	2.2	4.9	28	119	nm

Table 1 The values measured with the respective uncertainties

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References

1. Leach, R. K. *Optical Measurement of Surface Topography*. Berlin: Springer, 2011. Print
2. Whitehouse, David. *Surfaces and Their Measurement*. London: Hermes Penton Science, 2002. Print