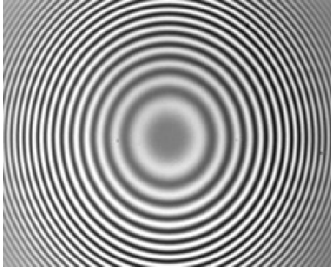
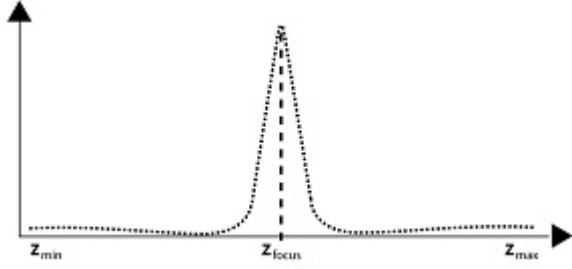
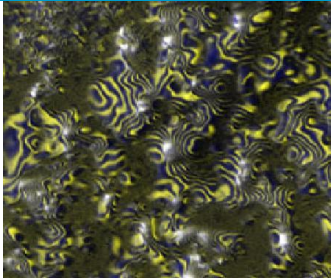
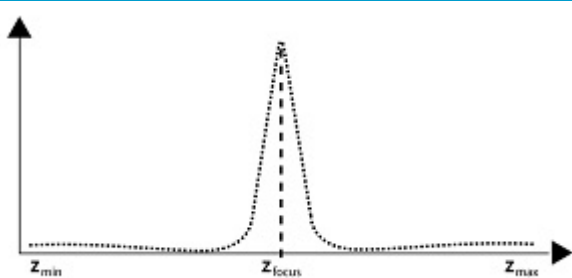
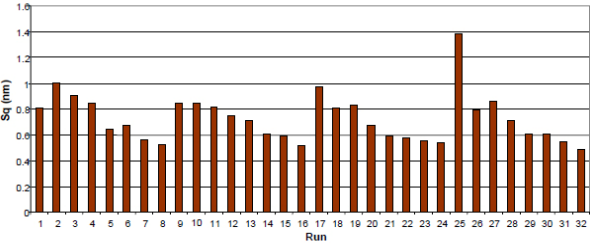
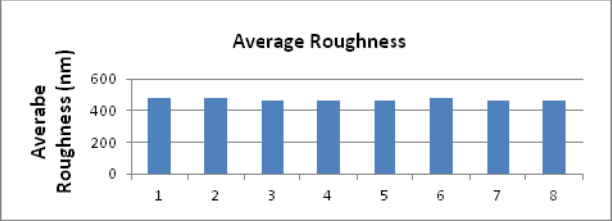


INTERFEROMETRY VS. CHROMATIC CONFOCAL

	<p>Coherence Scanning Interferometry (CSI) White Light “Scanning” Interferometry (WLI or WLSI) White light phase shifting interferometry (WLPSI) Also, may be referred as (CSI, VSI)</p>	<p>AXIAL CHROMATISM / CHROMATIC CONFOCAL</p>
What is physically measured?	Shifting Interference Patterns created by a mechanical movement and recorded by a video (Chapter 1, Reference 1)	Wavelength of light (color!) reflected in focus off the surface with the highest intensity in the visible light spectrum (Reference 3)
What do flat or generally smooth surfaces really look like?		
What do more complex surfaces really look like?		
How is the measurement performed?	Sample or optic is moved vertically and a series of images with fringes are registered. These images are combined to form 3D map of the surface. To create larger image, stitching is necessary. (Chapter 1, Reference 1 below)	Raster scan, each point associated to the wavelength of the maximum peak (Reference 3)
How does the measurement become height information?	Algorithms are used to analyze each point of the image in reference to the movement of either the optics or the samples. (Chapter 2, Reference 2 below)	Physical Wavelength for the specific optic calibrated directly to a traceable displacement (Reference 3)
Mathematical Algorithms used.	$I_x, y(\zeta) = I_0(\zeta) + IAC(\zeta - h_x, y) \cos[K_0(\zeta - h_x, y)]$ $IA, C\alpha[S_z] = \sqrt{(2I_z - 1 - 2I_z + 1)^2 + (-I_z - 2 + 2I_z - I_z + 2)^2}$ $I(A, C)\alpha[S_z] = \frac{1}{2} \left((2I_z - 1 - 2I_z + 1)^2 + (-I_z - 2 + 2I_z - I_z + 2)^2 \right)$ $\theta_z = \tan^{-1} \left(\frac{-I_z - 2 + 2I_z - I_z + 2}{2I_z - 1 - 2I_z + 1} \right)$ (Chapter 2, Reference 2)	None
Limitations	It is found that measurement uncertainty depends on both form and roughness of the surface itself as well as the scan algorithm, illumination bandwidth and measurement speed. <u>Known errors include Data Dropout, effect of surface gradient, surface tilt and rough surfaces, Fringe order errors, ghost steps, dissimilar materials, films, batwing effect, pitch related errors, and multiple scattering.</u> (Chapter 7, Reference 2, page 92)	Thin films with highly reflective substrate, surface tilt, relative axial and radial motions (not a concern during raster scan), self-imaging effects found on localized small shape the size of the focus point (Gost Foci).

Consequence of limitations.	<p>Although modern well setup CSI instruments are able to measure step height with an accuracy of better than 1nm, this can rarely be repeated for more general surfaces. For the user, it is very difficult to estimate how these errors will influence the values of any areal parameters generated from the analysis of a surface. In some geometrically simple examples (for instance when surfaces are composed of very regular features) then it may be possible to systematically reduce the error terms present in the measurement and refine the confidence in the parameter values. <u>For surfaces that are geometrically complex (randomly rough surfaces) then many error sources may be simultaneously present and it may not be possible to remove, compensate for them or estimate their combined influences.</u> (Reference 2, Chapter 7 Page 110 and 112)</p>	<p>There are limits to the capability of the technique to measure angular surfaces. However these limits far surpass what is achievable with CSI for the same height range. Thin film with high reflective substrate can be taken in account using the specific selection of peaks at the specific wavelength as to follow one or the other. All variation related to edges is limited to the specific point measured because it is a scanning technique.</p>
Roughness Measurement.	<p>Estimates of surface roughness derived from CSI can differ significantly from other measurement techniques. Roughness is generally over estimated by CSI and this is attributed to multiple scattering. (Reference 1, Chapter 3, page 35)</p>	<p>Limited range of limitation results in more accurate roughness measurement.</p>
Resolution, Accuracy/ Precision and Repeatability for rough surfaces.	<p>Excellent resolution and poor accuracy/precision and repeatability. Large influence from measurement algorithms and setup parameters.</p>	<p>Good resolution but high accuracy/precision and repeatability.</p>
Effects of Changing Measurement Parameters.	<p>Technique is very sensitive to measurement parameters including: Fringe Setup Mode of Measurement Optical Zoom Light source Intensity which might need to be optimize for a specific material Measurement Speed</p>	<p>Technique is not sensitive to measurement parameters. Special care to making sure that the light source is not saturated.</p>
Consequences of changes to measurements parameters.	<p>Possible large variation in data measured such as roughness or overall appearance of the surface.</p>  <p>Figure 19. Variation in Sq with change in measurement variables</p> <p>Reference 1 chapter 4 page 42 and 43</p>	<p>Roughness of Aluminum sample: three acquisition speed (400, 1000 and 2000Hz) and three different heights (high, low, and medium). Please note that 400Hz and medium range created a saturation of light and this value was not taken into account. 473+/-7 nm or 1.4%.</p> 
Sample Setup and Environmental Sensitivity	<p>Leveling of the sample is a critical part of the sample setup. Setup of the focus is also critical to measurement.</p> <p>With resolution in the 0.1nm range, many environment issues need to be taken in account with care: Dirt , draft or airborne and ground base vibration, temperature gradient and vibration. Reference 1 chapter 3 page 32</p>	<p>No special leveling procedure is required.</p> <p>All of the same environment effects are present but since the resolution is 3nm, the effect is not as critical as for CSI.</p>

<p>References</p>	<p>1- Guide for the Measurement of Smooth Surface Topography using Coherence Scanning Interferometry By National Physical Laboratory NPL UK A National Measurement Good Practice Guide No. 108 (2008) http://publications.npl.co.uk/npl_web/pdf/mgpg108.pdf</p> <p>2- Guide for the Measurement of Rough Surface Topography using Coherence Scanning Interferometry By National Physical Laboratory NPL UK A National Measurement Good Practice Guide No. 116 (2010) http://publications.npl.co.uk/npl_web/pdf/mgpg116.pdf</p>	<p>3- Optical Measurement of Surface Topography, Richard Leach, 2011, Chapter 5, Chromatic Confocal Microscopy Page 71-106</p>
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