The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

MANUFACTURING METROLOGY TEAM

Open Day

December 6th 2016 10am-5pm

The Team has a range of state-of-the-art equipment for the measurement of surface texture and form. We are happy to discuss potential measurement issues and collaborative research

Manufacturing Metrology Team
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The University of Nottingham
University Park
Nottingham, NG7 2RD

Please visit:
www.nottingham.ac.uk/research/manufacturing-metrology
for more information and/or register for a free measurement of your sample

Alicona G5 focus variation measuring instrument

The **Alicona G5 Infinite Focus** is a focus variation measuring instrument. It vertically scans the object's surface and captures a stack of 2D microscope images. For each image, the sharpness of each pixel is calculated. Detection of the object's surface, for each pixel, is achieved by finding the corresponding *z*-location having the highest sharpness.

Advantages:

- Wide applications: form and surface texture measurement
- Relatively fast measuring time
- Up to 5-axis measurement. Beneficial for complex geometries, e.g. micro-tool measurement
- True colour of measured object's surface

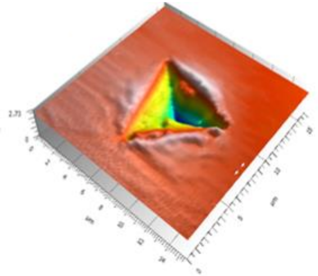
Limitations:

- Difficult to measure very smooth surfaces with $Ra < 10$ nm
- Difficult to measure optical or transparent surfaces

Specifications:

Objective	**Unit**	**2.5×**	**5×**	**10×**	**20×**	**50×**	**100×**
Lateral sampling distance	µm	3.25	1.76	0.88	0.44	0.18	0.09
Min. lateral resolution	µm	58.71	23.48	11.74	8.8	6.4	4.4
Min. Repeatability (vert.)	µm	6.92	3.49	1.75	0.88	0.64	0.44
Vertical resolution	nm	2300	410	100	50	20	10
Working distance	mm	8.8	23.5	17.5	13	10.1	3.5
Field of view *X*	µm	5716	2858	1429	715	286	143
Field of view *Y*	µm	4351	2175	1088	544	218	109
Max. height	mm	8	22	16	12	9	3.2
Step height accuracy	%	-	0.05	0.05	0.05	0.05	0.05
Min. meas. roughness (*Ra*)	nm	7000	1200	300	150	60	30
Min. meas. roughness (*Sa*)	nm	3500	600	150	75	30	15

Mitaka MLP-3SP point autofocus measuring instrument



The **Mitaka MLP-3SP** is a point autofocus measuring instrument. It measures surface texture by automatically focusing a laser beam at a point on a specimen surface, moving the specimen surface in a fixed measurement pitch using an XY scanning stage, and measuring the specimen surface height at each focused point. During measurement the autofocus sensor detects the laser spot displacement and feeds back the information to the autofocus mechanism in order to keep the objective at in-focus position.

Advantages:

- Large measuring range with high resolution
- High speed contour measurement
- Capable of measuring steep angles over 45 °
- High autofocus repeatability (nanometre level)
- Immune to surface reflectance properties

Limitations:

- Long 3D measurement time compared to typical areal measurement instruments
- Smaller acceptable slope angle for specular surfaces
- Only one objective lens can be mounted

Specifications:

axis	moving range	scale resolution	measuring accuracy	positioning repeatability
X	120 mm	10 nm	±4.4 µm / 120 mm	3 µm p-v
Y	120 mm	10 nm	±4.4 µm / 120 mm	3 µm p-v
Z	130 mm	10 nm	±4.6 µm / 130 mm	3 µm p-v
AF	40 mm	1 nm	±2.8 µm / 40 mm	σ=0.015 µm (100×) σ=0.015 µm (50×)
θ	360°	0.0002°	±0.01°	±0.005°

Nub3D fringe projection system

The **Nub3D fringe projection system** is used to scan objects from different views and re-create the 3D point cloud of the scene from the perspective of an integrated camera. Registration of the different views is carried out automatically with photogrammetry targets that can be attached to the object or the rotary table. Unlike traditional laser triangulation scanners, this instrument uses full frame image capture via use of phase shifting spatial profiles (fringes) to determine the depth information of every pixel in the image. The instrument can be used on multiple materials with the condition that they produce a high enough amount of diffuse reflection and objects of up to (550×390×200) mm in volume.

Advantages:

- Fast measurement of large areas
- Flexibility of instrument configuration
- Multi-materials measurement

Limitations:

- Limited to macro form measurement
- Difficult to measure surfaces with a high degree of specular reflection

Specifications:

Measuring volume type	**Volume 1**	**Volume 2**	**Volume 3**	**Volume 4**
Volume	(120×80 X60) mm	(200×150 ×90) mm	(340×260 X200) mm	(550×390 ×240) mm
Optics	28 mm	20 mm	20 mm	20 mm
Accuracy	0.011 mm	0.015 mm	0.023 mm	0.038 mm
Precision (1σ)	0.006 mm	0.007 mm	0.011 mm	0.019 mm
Points spacing	0.075 mm	0.75 mm	0.25 mm	0.375 mm
Working distance	330 mm	330 mm	700 mm	1200 mm
Measurement points (per photo)	1,400,000	1,400,000	1,400,000	1,400,000

Nikon MCT225 computed tomography system

The **Nikon MCT 225** is an X-ray computed tomography system for metrology of the external and internal features of samples. The instrument takes a number of 2D X-ray images at varying angles around the sample to capture the internal and external geometries of the sample. These 2D images are then reconstructed to form a 3D model, which can then be used to perform dimensional measurements of the sample.

Advantages:

- The most accurate method of measuring internal geometry non-destructively
- Measurement of pore morphology and distribution is possible
- STL output for reverse engineering via additive manufacturing
- Specific metrology focussed system with quoted maximum permissible error of 9 µm + L/50 and 2 µm feature detectability

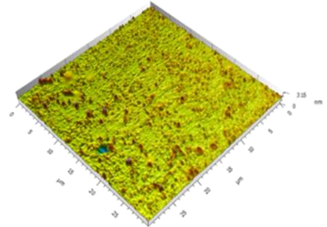
Limitations:

- X-ray penetration of part materials limits part size
- Increased X-ray power required for higher attenuation samples reduces accuracy

Specifications:

Accuracy (µm) MPE	9+L/50 (L in mm)	**X-ray source**	225 kV/225 W open tube
Sample size (maximum)	Diameter 250 mm, height 450 mm	**X-ray spot**	3 µm micro-focus
Sample weight (maximum)	5 kg	**Enclosure temperature**	19 to 21 °C
Manipulator travel	X 480 mm, Y 450 mm, Z 730 mm R 360°	**Ambient temperature**	17 to 25 °C
Source to detector	1165 mm (nominal)	**Radiation protection (DIN 54113-2, IRR 99)**	< 1 µSv/hr
Detector	16 bit 4 Mpx (2000 px × 2000 px)	**Enclosure dimensions**	W 2214 mm × S 1275 mm × H 2205 mm
Magnification	1.6× to 150×	**System weight**	4200 kg
Feature detectability (minimum)	2D radiography 2 µm		

BRUKER Atomic Force Microscope D3100



The **Bruker D3100** atomic force microscope is a scanning probe microscope that measures nanometre-scale 3D surface topography. It works by raster scanning a cantilever with a sharp tip across the surface and monitoring the deflection of the cantilever due the presence of surface features. There are three main modes for the AFM to collect surface information: contact mode, tapping mode and magnetic mode.

Advantages:

- There is no optical diffraction limitation
- Additional information beside surface texture data, e.g. surface elastic modulus, surface hardness, magnetic and electrical properties
- Almost any type of surface can be measured, even organic (soft) surfaces
- Ability to measure a very smooth and transparent surfaces

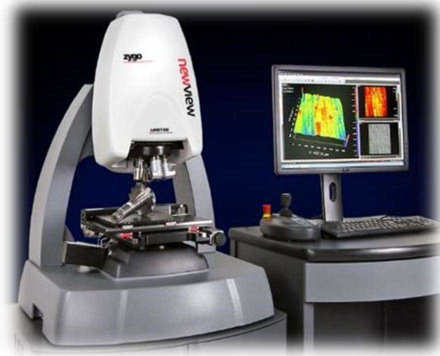
Limitations:

- Very limited areal scanning range
- Need longer measuring times compared to optical instruments
- Limited vertical and lateral scanning ranges
- Not effective for very rough surfaces due to the physical and mechanical limitations of the cantilever

Specifications:

Operating mode	**Tapping mode, contact mode and magnetic mode**
Maximum travel range ($X \times Y \times Z$)	(90×90×6) mm
Electronic resolution (analog-to-digital)	16 bits (all axes)
Z-resolution	50 nm (for 90 µm scan size)
	2 nm (for 10 µm scan size)
Accuracy	1% for all axes
Stylus tip diameter	approximately 10 nm
Maximum sample size	(100×125×50) mm

Zygo NewView™ 8300 coherence scanning interferometer



The **Zygo New View™ 8300** coherence scanning interferometer is a 3D optical surface profiler and provides powerful versatility in non-contact optical surface profiling. All measurements are non-destructive, fast, and require no sample preparation. Advanced software tools characterize and quantify surface roughness, step heights, critical dimensions, and other topographical features, with excellent precision and accuracy.

Advantages:

- Profile heights can range from < 1 nm up to 20000 µm, at high speeds
- Sub-nanometre surface topography repeatability
- Measure a wide range of surface types, including smooth, rough, flat, sloped, and stepped

Limitations:

- Measurement uncertainty of surface texture may increase for highly sloped and rough surfaces due to the fundamental limitation of CSI

Specifications:

Vertical Scan Range	150 µm with precision Piezo drive; 20 mm with extended scan
Surface Topography Repeatability	0.12 nm
Repeatability of RMS	0.01 nm
Optical Lateral Resolution	0.34 µm (100X objective)
Spatial Sampling	0.04 µm (100X objective 2X zoom)
Maximum Data Scan Speed	96 µm/sec
Step Height Repeatability	0.1%
Height Response Linearity	≤30 nm

Objective lens Specifications:

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