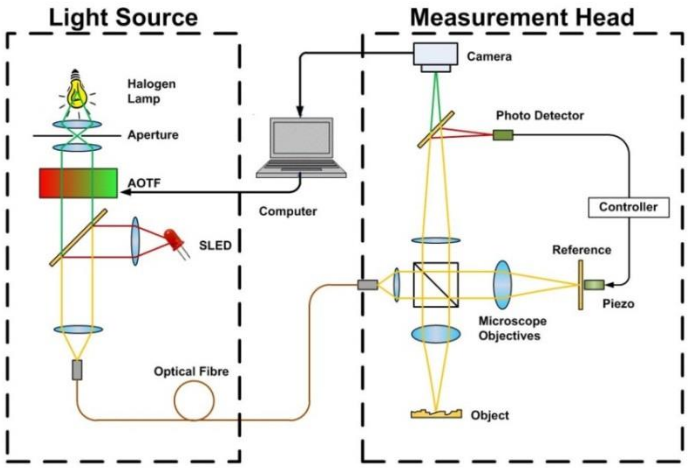
ARINNA - Wavelength Scanning Interferometer

Ultra-high precision metrology of 3D surfaces

IBS Precision Engineering and the University of Huddersfield have collaborated in the development of a new optical measurement system, based on Wavelength Scanning Interferometry (WSI). For on-line or in-process surface metrology at the micro and nanoscale, ARINNA uniquely combines high speed, large vertical range, nanometer resolution and millimetre area sampling.

ARINNA measurement system



Schematic drawing of the WSI setup[1].

Unlike many other interferometric systems, large steps and structured surfaces can be measured by ARINNA.

Challenging environments such as in-line roll-to-roll are also possible due to patented vibration isolation technology.

Measurement Principle

The WSI measurement principle employed by ARINNA is established on determining the phase shift of the reflected optical signal from a wavelength scanned light source. Wavelength scanning is achieved from a white light source using an acousto-optic tuneable filter (AOTF). The system comprises two interferometers that share a common optical path. The first interferometer, sourced by a white light source, is used for measuring the surface topography. The second, super-luminescent diode (SLED) sourced interferometer, is used to monitor sample surface movement due to vibration, so that active servo control can auto compensate for object vibrations.

Prototype development on roll-to-roll line

During scanning, a set of interferograms is captured by a camera; each pixel in the obtained interferogram represents a specific point on the sample. Isolating a single pixel from the interferogram set, a sinusoidal change of intensity with wavelength (frame number) is apparent, as shown in figure 1.

The overall phase shift across the wavelength scan range can be obtained from the intensity signal using Fourier transforms. The height of the point represented by the pixel can then be calculated by:

$$h(x,y) = \frac{\Delta\varphi(x,y)}{4\pi\left[\frac{1}{\lambda_{max}} - \frac{1}{\lambda_{min}}\right]} = \frac{\#periods}{2\pi\left[\frac{1}{\lambda_{max}} - \frac{1}{\lambda_{min}}\right]}$$

where $h(x,y)$ is the height of the specific point, and $\Delta\varphi(x,y)$ the calculated phase shift of the pixel over the scan range. λ_{max} and λ_{min} are the upper and lower wavelengths of the scan range respectively.

[1] *Gao, F., Muhamedsalih, H. and Jiang, X. (2012) Surface and thickness measurement of a transparent film using wavelength scanning interferometry. Optics Express, 20 (19). p. 21450. ISSN 1094-4087*

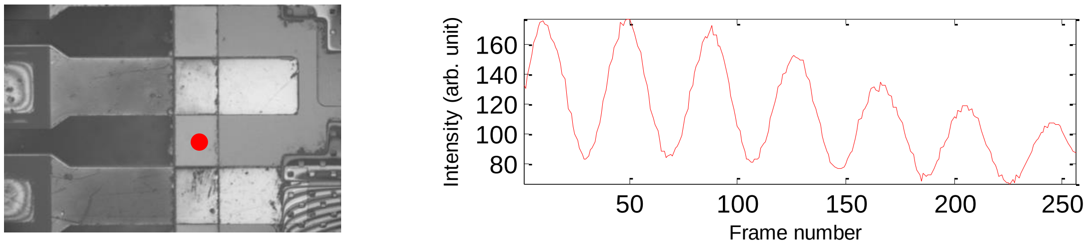


Figure 1. *Measurement multi-step IC (left); single pixel data over multiple wavelengths (right).*

In the figures below, several experimental results are given.

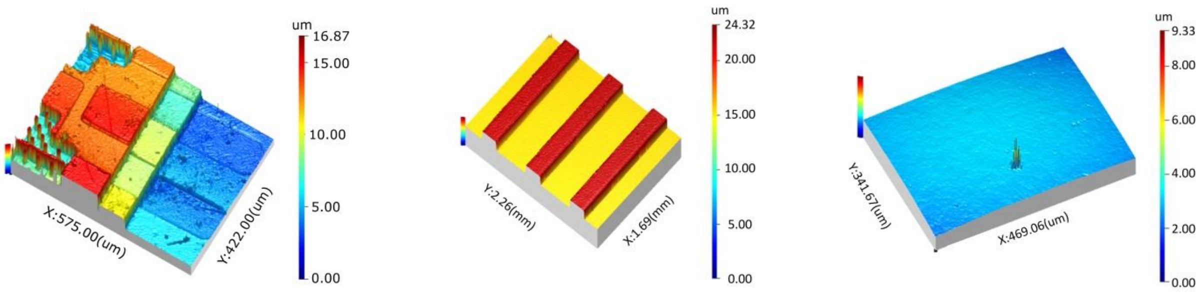
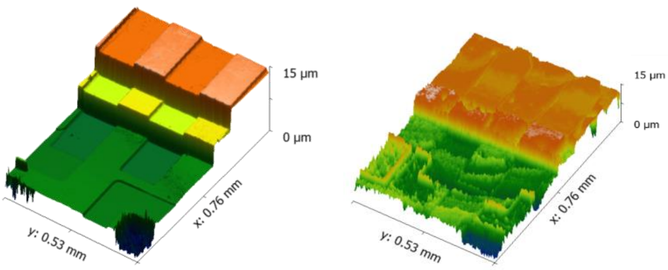


Figure 2. *Multi-step IC (left), 4.707 µm step sample (middle) and 3D particle characterisation (right).*

Vibration compensation

For many applications, the ability to measure in-line can critically enhance the value provided by the metrology system. For in-line use, a patented vibration compensation technique has been integrated into the design of ARINNA. In Figure 3, data capture with and without the vibration compensation option applied is shown, highlighting the significant improvement in surface measurement data achieved following such noise removal.

Figure 3. *Surface scan on stepped surface with (left) and without (right) vibration compensation*



System Specifications

ARINNA Specification	*Value*	*Unit*
Vertical Range (lens dependent)	96 (2x objective) / 14 (5x objective)	µm
Vertical Resolution	<2	nm
Lateral Range (lens dependent)	2.8 x 2.8 (2x objective) / 1.1x1.1. (5x objective)	mm
Lateral Sampling	1000 x 1000	pixels
Lateral Resolution (lens dependent)	5 (2x objective) / 2 (5x objective)	µm
Measurement time	< 1	sec.
Stabilisation Bandwidth	< 500	Hz

Part of the development of the WSI technology has been done within the EU FP7 NanoMend project. The authors would like to thank the EC for funding this work (NanoMend NMP4 LA-2011-280581).

IBS Precision Engineering BV
Esp 201, 5633AD Eindhoven, The Netherlands
Telephone: +31 40 290 1270
E-mail: info@ibspe.com
www.ibspe.com