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Design of a dispersive lateral scanning surface profilometer

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1. Introduction

The aim of the research is to develop a laser scanning optical probe for an integrated optics measurement system (figure 1). The metrology tool is based on wavelength scanning and phase shifting interferometry. The optical probe being the one of the main constituents of the device, critically determines the performance of the metrology tool in terms of lateral resolution.

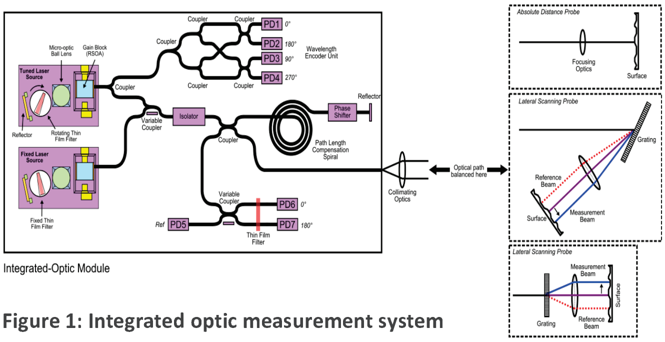

Figure 1: Integrated optic measurement system

2.Lateral Scanning Probe

A dispersive probe with a diffraction grating as an encoder is used to relate wavelengths into spatial information of the surface under test. The measurement accuracy of the tool depends upon the lateral and axial resolution of the probe system. The use of a grating alleviates the need of any mechanical scanners, which significantly simplifies the probe design and construction. The speed and durability of diffraction grating based scanner is naturally much higher compared to the mechanical ones.

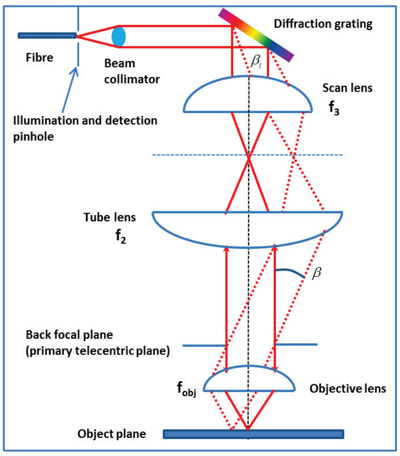

Figure 2: Lateral scanning profilometer

3. Objective

Design and optimisation of a lateral scanning probe for use with a chip tuneable laser (1500-1600 nm) as illumination source.

4. Optical Design Simulation

Thorlabs achromatic lenses AC-080-016-C and AC-254-050-C are used as scan lens and tube lens. The objective lens used is K_013 objective from the Zebase catalogue. The grating with line spacing 800lines/mm is used in the design. Zemax optical design software is used for the optical probe design. The system is optimised using the various parameters in the merit function.

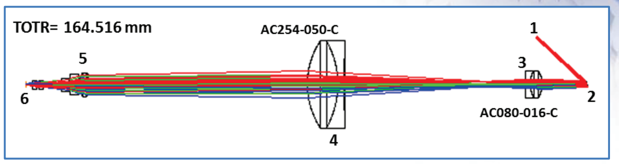

Figure 3: Optical layout (1 Collimated beam, 2 Grating, 3&4 Achromatic lenses, 5 K_013 Objective and 6 Object) of the probe in Zemax. The blue green and the red lines represent the scanned laser beam at the design wavelengths

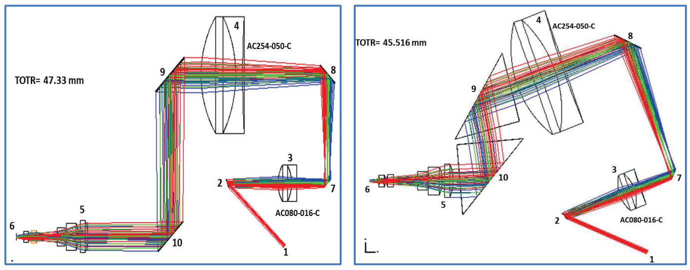

Figure 4: Optical layout of the compact probe in Zemax using the (a) Design 2: mirror pair (7-8, 9-10) and (b) Design 3 mirror (7-8) and prism pair (9-10) combinations.

5.Results and discussion

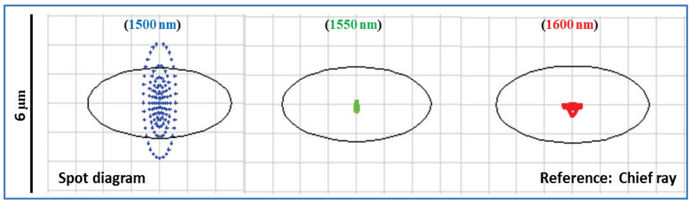

Figure 5: Simulated spot size diagrams of the probe system at (a) 1500 nm (b) 1550 nm (c) 1600 nm

Spot rays lie well within the airy radius indicating that the diffraction- limited performance is obtained at all the three design wavelengths

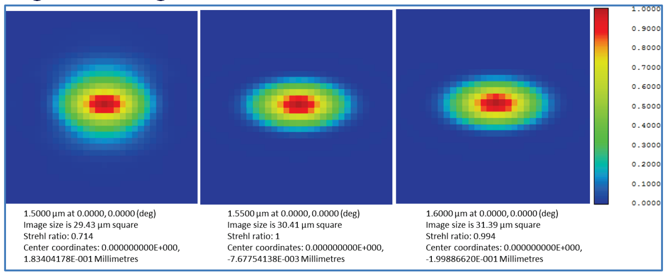

Figure 6: Huygens Point spread function (PSF) at (a) 1500 nm (b) at 1550 nm (c) 1600 nm

The PSF gives the Strehl ratio which is a measure of optical image quality for very high quality imaging systems. The Strehl ratio is 0.7 at 1500nm and ~1 at the other wavelengths. Perfect optical systems have Strehl ratio closer to unity.

6.Future work

- ❑Simulate and optimise a collimated fibre delivery using a collimating lens
- ❑Build and evaluate a bench top prototype for scanning using a suitable optical cage mounting system

7. Acknowledgements

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