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# A Chip Device for On-line Assessment in Nano-scale Surface Manufacture

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## ❖ Abstract

This project aims to create a novel system based on interferometry and wavelength spatial scanning techniques using breakthrough micro-/nano-technology and optical methodologies. The system will be used for on-line nano-scale surface measurement, which represents an important step change in the fields of surface metrology.

## ❖ Introduction

Micro-/nano-structure and freeform surfaces are widely used in optics, photonics, telecommunications, micro-electro-mechanical system (MEMS), micro fluidics, and the micro moulding industries that all critically rely on ultra precision surfaces. There is however a fundamental limiting factor to manufacture such surfaces, namely the ability to measure products at such high level accuracy, and on-line, consequently no efficient metrology tools to monitor and control the quality of the surfaces.

This project proposes a novel system to realise on-line surface measurements. It involves an interdisciplinary team of researchers and industrialists: the Surface Metrology Group at the University of Huddersfield (UoH), the Centre for Integrated Photonics Ltd (CIP), Taylor Hobson Ltd (TH) and the James Webb Space Telescope lens manufacturing centre in Wales OpTic. The group's combined activities include 'state of the art' capabilities in surface metrology, photonics, instrument and ultra-precision manufacturing.

## ❖ The proposed system

The proposed system consists of two main parts, an optical chip and an on-machine optical probe. The optical chip integrates the essential optical components of an interferometer including a tuneable laser, an isolator, a directional coupler and a photodetector on a single optical chip. The probe consists of a gradient index lens, a phase grating and an objective lens. These two parts are connected by optical fibre. The key part is the optical chip. The framework of the system is shown in Figure 1.

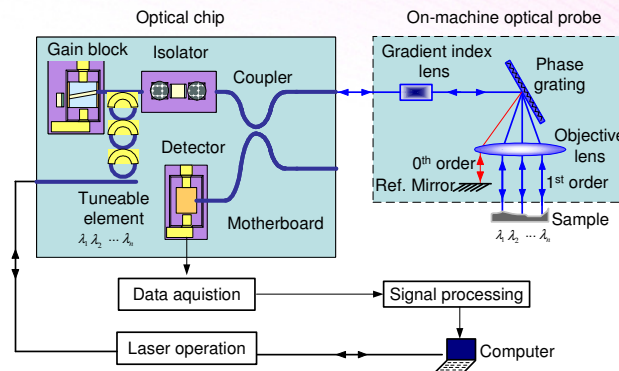


Figure 1. The framework of the proposed system

## ❖ System development

In order to reduce risk in fabrication, the development of the chip will be achieved in the following four stages. (1) The integration of a semiconductor gain block with a tuneable feedback element to realise the tuneable laser. (2) The integration of a hybrid free space optical isolator with the tuneable laser. (3) The integration of an edge coupled photodetector with a directional coupler. (4) The development of the fully integrated hybrid. Currently, the laser and isolator fabrication is going to be finished. The photodetector with the directional coupler are in the development.

**>Tuneable laser development:** The main circuits is made using 0.75% delta waveguide material. That is too low to be able to make ring resonators with the required free spectral range. Therefore, a new approach for wavelength tuning using thin film filter (TFF) is proposed (shown in Figure 2). A custom designed TFF is placed in the path of a collimated output (micro-optic ball lens) from the gain block. The filter is rotated to allow a selected wavelength to pass through. This wavelength is then retro-reflected back from a reflector mirror, through the filter a second time and back into the gain block. The lasing wavelength can be tuned by changing the filter angle with a micromotor.

**>Isolator development:** The isolator consists of a pair of ball lenses to collimate the optical output from the waveguide and refocus into the waveguide at the isolator output, and a pair of isolator cores and the required birefringent wedges to displace the optical beams. A schematic diagram of the isolator structure is shown in Figure 3.

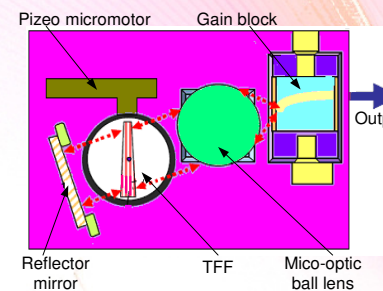


Figure 2. Tuneable laser

## ❖ Testing

**>Tuneable laser testing:** Figure 4 shows the wavelength tuning over approximately 12 nm. With an optimally designed filter with a broader gain bandwidth chip, the tuning range reaches 50 nm (shown in Figure 5).

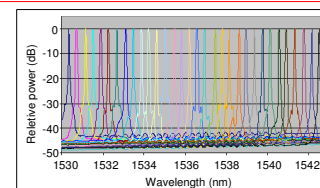


Figure 4. Wavelength tuning

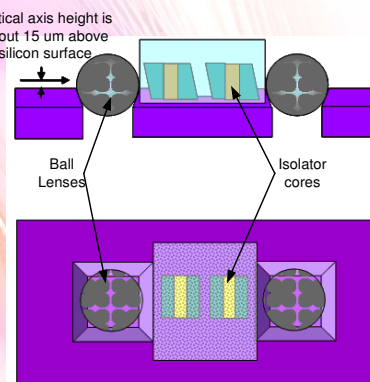


Figure 3. Optical isolator

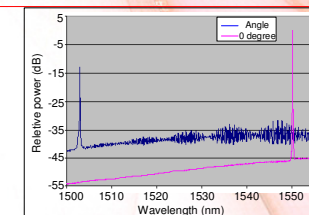


Figure 5. Available tuning range

**>Isolator testing:** The isolator is tested at a centre wavelength of 1550 nm and a bandwidth > 60 nm. The testing results show that the isolation is more than 46 dB and the insertion loss is ~ 0.9 dB.

## ❖ Conclusions and future work

The tuneable laser and the isolator have been developed. Future work will focus on developing the photodetector with the directional coupler to realise the hybrid optical chip. Then build the chip interferometry system and apply it to surface measurements.

## ❖ Acknowledgement

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