LIGO Laboratory / LIGO Scientific Collaboration

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Optical Profiling Device for Dimensional Characterisation of Ribbons/Fibres

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1 Introduction

This document summarises the development status of an optical profiling device for dimensional characterisation of silica ribbons, fibres and welds. The device is based on an optical edge detection technique. It is being developed as part of the development project for the CO_2 laser based pulling & welding machine for silica fibres and ribbons[1].

Dimensional profiling of silica fibres or ribbons is an important part of the characterisation process for the laser (or flame) fabricated elements.

- Quality check that the ribbon/fibre dimensions are within the tolerance specifications for Advanced LIGO[2]
- Tight dimensional tolerances lead to narrowing of the spread in violin mode frequencies
- Enables monitoring of the dimensions of the ribbon/fibre necks, giving feedback on the pulling machine parameters required to fabricate optimally shaped necks and precise dynamic flexure point locations to produce pendulum tilt stability and cancellation of thermo-elastic peak
- Enables accurate calculation of the breaking stress of ribbon/fibre using the cross sectional area.

2 Description of device

The prototype dimensional characterisation machine comprises a motorised imaging head made up of a Firewire web camera with suitable lenses to achieve the desired magnification. This resulted from the amalgamation of the best points from two initial concept ideas:

- Fixed optical microscope with CCD camera, imaging at intervals along the ribbon
- Flatbed scanning of the entire ribbon profile.

[1] Cantley et. al., "*Update on Development of a CO2 Laser Machine for Pulling and Welding Silica Fibres and Ribbons"*, T040213-00-K.

[2] Cagnoli, Cantley, "*Ribbon Tolerances and Alignment Requirements for Advanced LIGO Optics"*, T050212-00-K.

2. The Prototype characterisation apparatus.

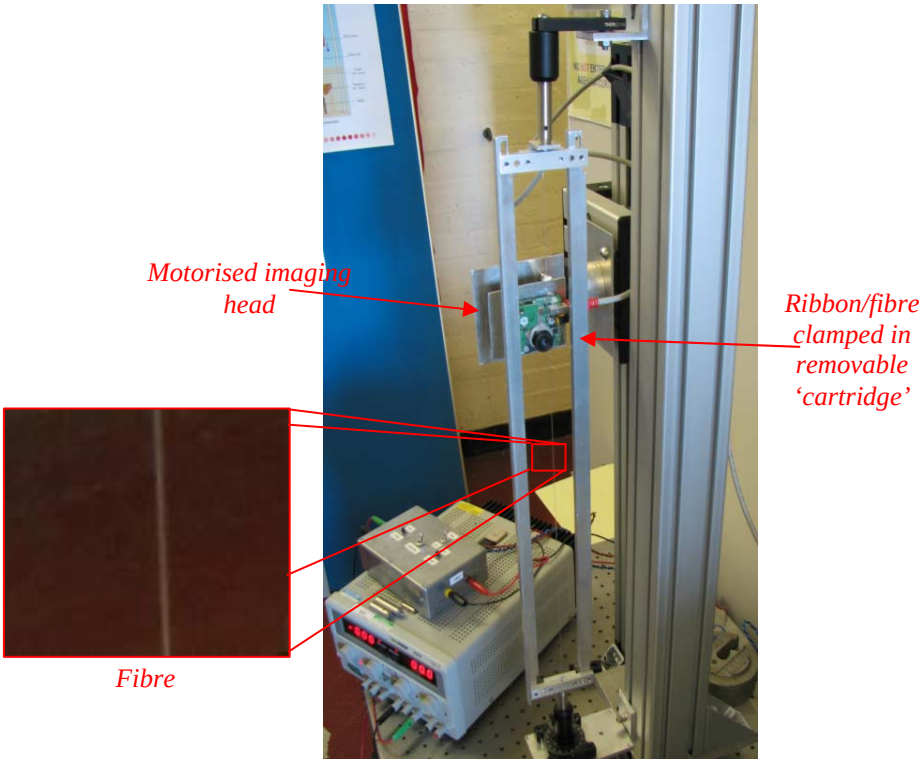

Figure 1 Apparatus for dimensional characterisation (view 1)

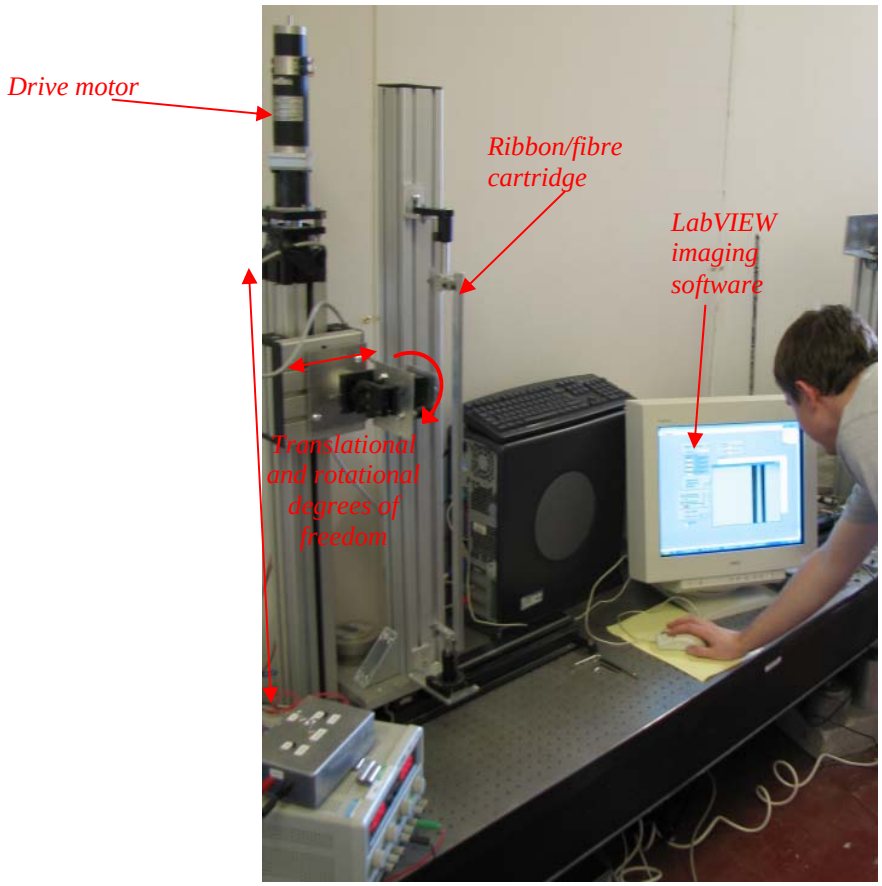

Figure 2 Apparatus for dimensional characterisation (view 2)

The apparatus consists of the Firewire webcam with several degrees of rotational and translational freedom to allow accurate focussing of the ribbon/fibre. This in turn is motorised to allow the imaging head to traverse the length of the ribbon. The ribbon is held taut in a removable cartridge which permits safe transportation of the ribbon/fibre from the CO_2 laser pulling machine. Precise measurement of the position along the ribbon/fibre length is provided by a linear encoder.

The dimensional measurement is achieved using a *LabVIEW* edge detection program which displays an on screen image of the measurement. A typical screen capture is shown below using a CO2 laser pulled fibre of ~400μm:

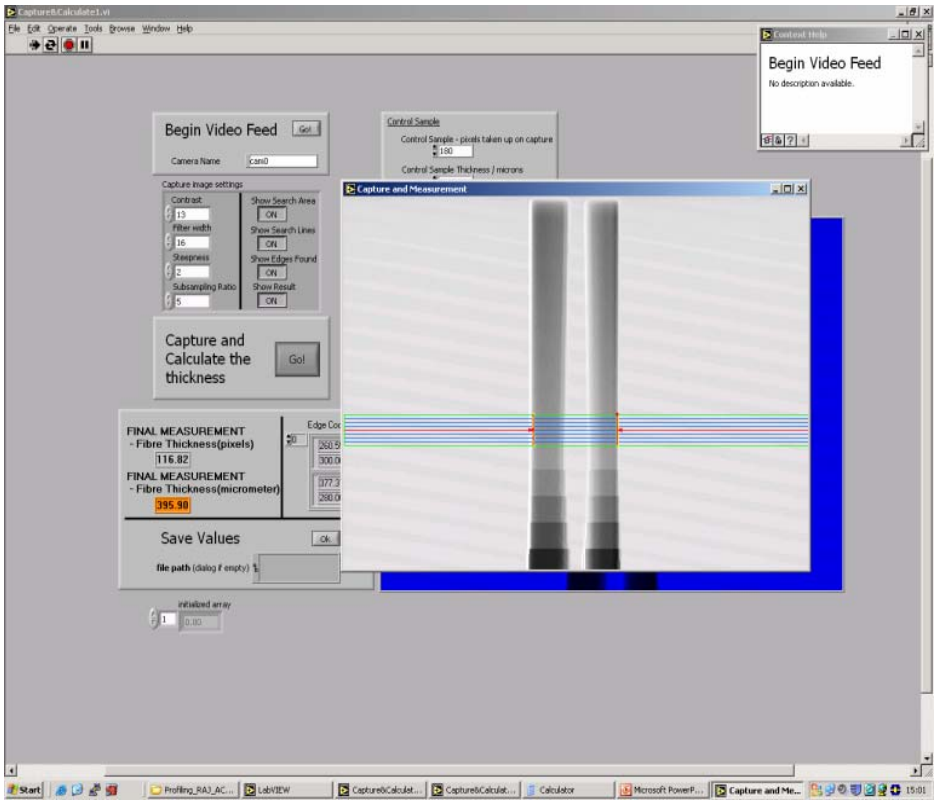

Figure 3 Typical screen capture using a CO_2 laser pulled fibre of ~400μm

3 Typical profile

The plot below shows a typical profile obtained for a CO_2 laser pulled fibre.

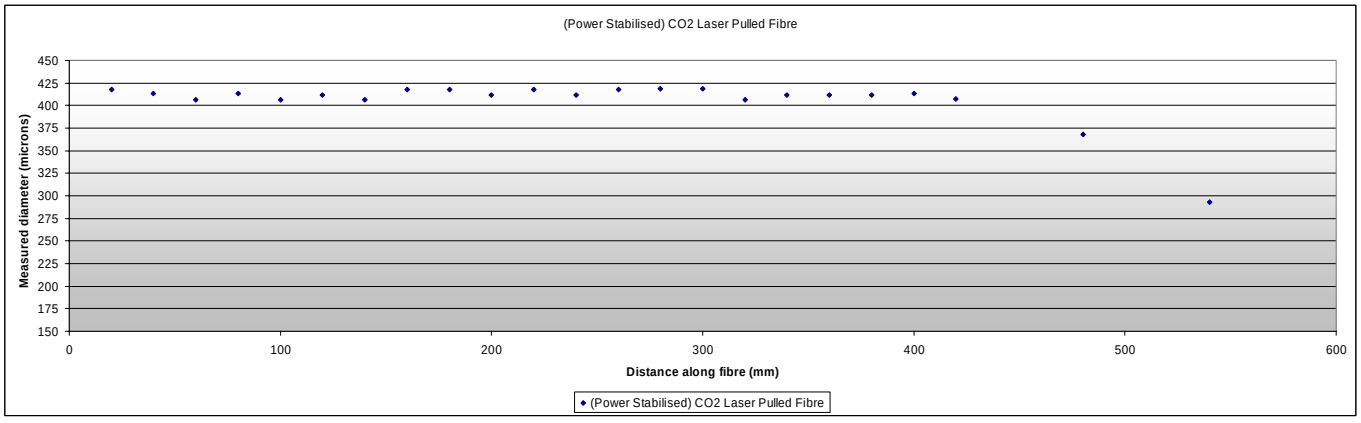

Figure 4 Profile of an early CO_2 laser pulled fibre of ~400μm

4 Future development

Pending improvements to the current apparatus include:

- Simplified machine layout with ribbon/fibre cartridge held from lead screw tower.
- Precision alignment of cartridge relative to camera head.
- Optimising the optical setup to provide the correct magnifications for differently dimensioned fibres and the two ribbon dimensions.
- Automation of the imaging procedure.