Production and characterisation of fused silica suspension ribbons for Advanced LIGO

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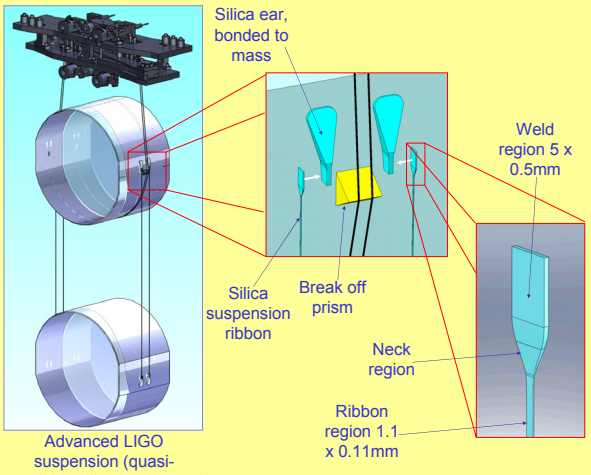
Ultra low thermal noise suspensions

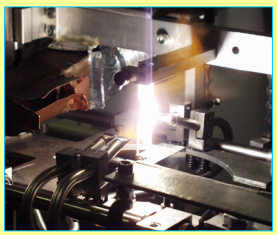
Quasi-monolithic mirror suspension technology was developed for the GEO600 interferometric detector to minimise thermal noise effects. Circular cross section fused silica fibres are welded to silica ears, which are silicate bonded onto the sides of the test masses. Upgrade to Advanced LIGO will extend this technology, further reducing thermal noise, by use of rectangular cross section ribbon fibres.



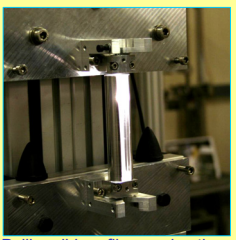
Advanced LIGO suspension (quasi-monolithic silica lower stage)

CO_2 laser production of silica fibres

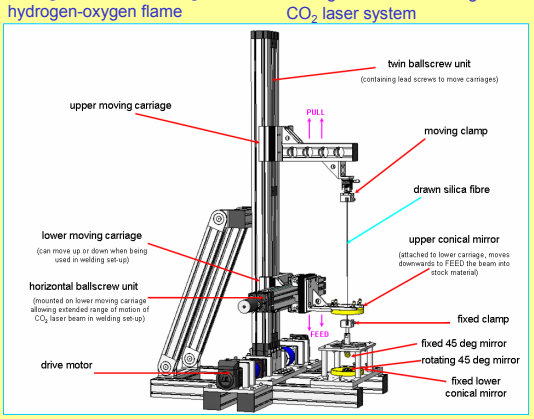
Fused silica fibres for GEO600 were manufactured by heating silica rods using a hydrogen-oxygen flame and pulling them down into fibres. For the upgrades to LIGO, however, increased tolerances on ribbon fibre dimensions are required. A new fibre pulling system, based on heating with a CO_2 laser, was designed to give improved control.



Pulling ribbon fibres using hydrogen-oxygen flame



Pulling ribbon fibres using the CO_2 laser system

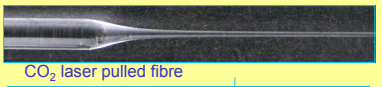


Solidworks design of CO_2 laser based fibre pulling machine

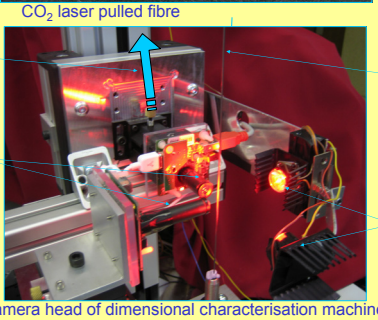
Dimensional characterisation

In conjunction with the pulling machine, a non-contact ribbon dimension measurement system has been developed. This system uses two Firewire web-cameras with high magnification lenses to focus on the thick and thin ribbon dimensions. Ribbons require accurate dimensional measurements to ensure they are within the required tolerances, and measurement of neck shapes is important in understanding the effective pendulum length, and quantifying suspension thermal noise.

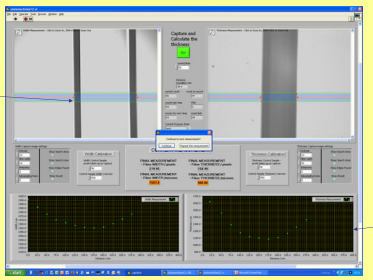
The cameras are mounted on a motorised carriage and traverse the length of the fibre. A *LabVIEW* control program performs an edge detection measurement to obtain fibre cross sectional dimensions. Particular emphasis is placed on the neck region with measurements performed at up to every 1.5μm, providing ample resolution to allow detailed dimension profiles to be obtained.



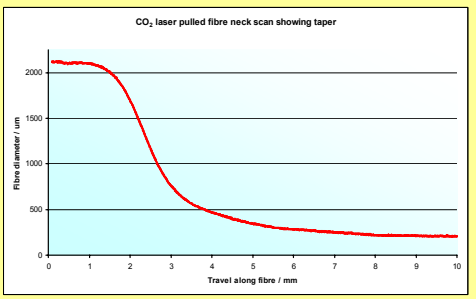
CO_2 laser pulled fibre



Camera head of dimensional characterisation machine



LabVIEW control and measurement program



Typical plot of diameter of CO_2 laser pulled fibre

Both the CO_2 pulling and dimensional characterisation machines are at an advanced development stage, and duplicate machines will be installed at the LIGO LASTI test facility at M.I.T. over coming months in preparation for fabrication of the first Advanced LIGO thermal noise prototype.

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