Comparing the Ti:Sapphire Laser to a Fibre Laser

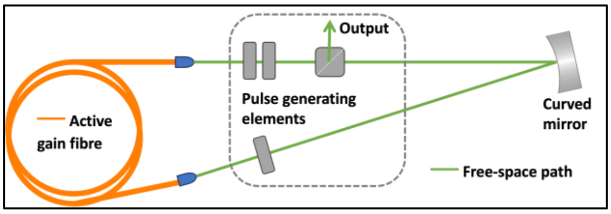
The benefits of a modern fibre laser

Ultrafast Technology

Traditionally, ultrafast sources have been solid state lasers such as the Ti:Sapphire laser. These work via a bulk gain medium (a crystal or doped glass), which is pumped by a laser (or sometimes a flashlamp in legacy systems). The light travels in free space and classical optics are used for beam control.

Fibre lasers, as the name suggests, use a fibre to generate the laser light and confine it within the small core of the fibre. Chromacity has chosen to make their 1040 system a hybrid part fibre and part free space system. Both solid state and fibre lasers use mode-locking techniques to achieve stable ultrafast operation.

Chromacity Architecture



The patented Chromacity architecture uses an ultra-efficient oscillator design, capable of removing the requirement for a pre-amplifier for up to 5W average powers.

A classical Ti:Sapphire system provides ultrafast light in the red to near-infrared spectrum and provides tuneability across a range. They usually operate at 80MHz and provide femtosecond outputs. These systems require water cooling of the gain crystal, either with active chillers or closed loop systems as the Ti:Sapphire crystal is pumped with a high-power source and so heats up significantly. This means that a Ti:Sapphire laser typically requires a water-cooling system.

Although pump technology has become smaller, many Ti:Sapphire systems require separate pump systems (or larger integrated pump systems, usually operating at 532nm) and so these systems are usually not very compact. If they are compact, the power tends to be commensurately lower. Ti:Sapphire systems operate at a peak efficiency at 800nm and powers are often quoted here. They have a range of wavelengths over which they operate, depending on the manufacturer. A standard range is 650-1040nm and sometimes this is extended to 1100-1300 or only starts at 680nm or 700nm. The system is tuned via the movement of the optics (usually an end-mirror and a prism/etalon setup) to get a specific wavelength to pass through the gain medium. Power output is not the same across the spectral tuning curve (representative curves shown below).

An Ytterbium doped fibre laser such as the Chromacity 1040 works on the principle that a pump diode (usually at 980nm) is used to excite an ytterbium doped fibre that has a doped core that acts as the laser gain medium. The output is then confined within the small core of the laser.

In many traditional application areas, fibre lasers are beginning to supplant the Ti:Sapphire systems due to their many benefits. In the Chromacity 1040 system, a mode-locking cavity is created inside the system with the fibre at one side and an output coupling mirror at the other. The output from this is then compressed or stretched using transmission gratings (factory set) to enable the customer to choose between 100fs and 1.5ps pulse width. The Chromacity 1040 has a free space output (not fibre) due to this customisation option.

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Chromacity™

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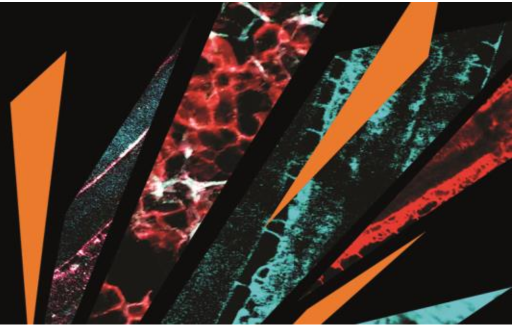

Advantages of Fibre Lasers

- High stability at high powers as cooling of the fibre is easier
- Does not require water cooling – air cooled operation is standard
- Turnkey operation – no need for user to have physics degree to operate
- Lower cost of ownership
- Compact size

Dis-Advantages of Fibre Lasers

- Not tuneable
- At higher pulse energies spectrum becomes more structured
- Nonlinear effects at higher powers (such as self phase modulation and Raman conversion) cause power loss

Advantages of Ti:Sapphire Lasers

- Tunability
- Higher energy (due to water cooling and larger beam)
- Shorter pulses possible (down to few femtoseconds but normally not required)

Dis-Advantages of Fibre Lasers

- Weak stability, and free space drift an issue
- Higher cost of total ownership (upfront costs and maintenance costs are higher)
- Bulky and sometimes has external pump source
- Requires water cooling
- Harder to operate (though some are now more automated which may lead to a higher prices)
- More sensitive to environmental changes
- Repeatability of power output away from peak efficiency at 800nm is not ideal.

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