BUILDING LIQUID CRYSTAL LASERS TO TRANSFORM FLUORESCENCE MICROSCOPY

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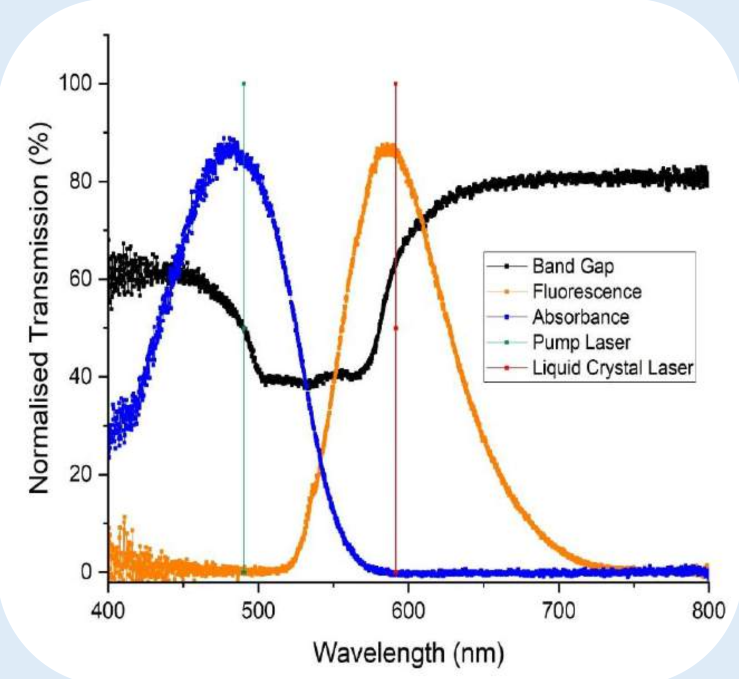
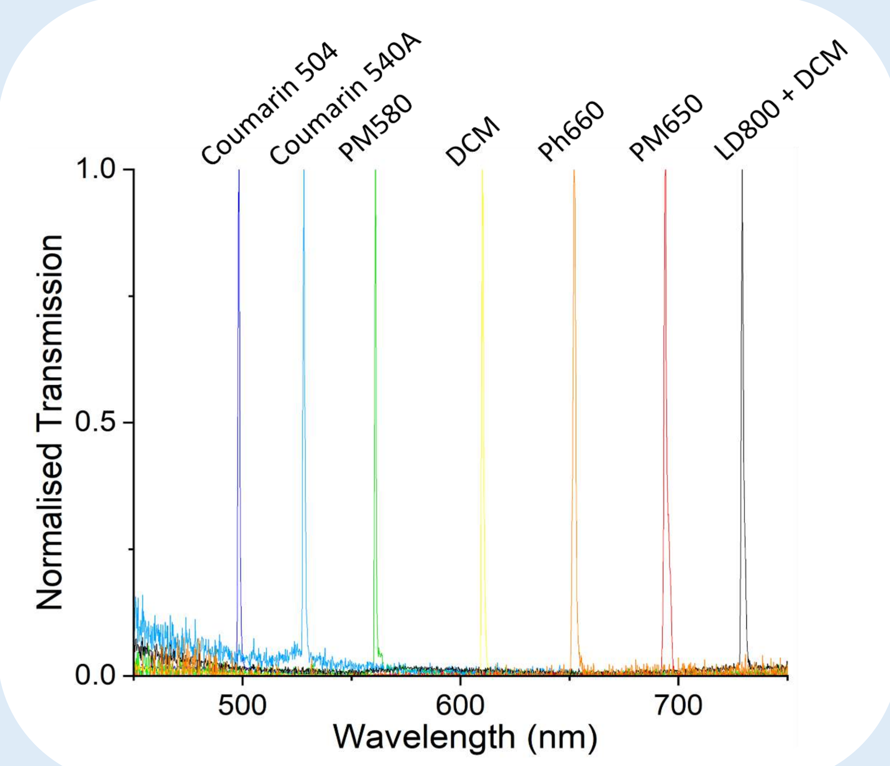
STEM for BRITAIN

What is a Liquid Crystal Laser?

- A mixture of chiral liquid crystal material and an organic laser dye, that spontaneously self-organises into a photonic nanostructure suitable for lasing. The chiral nematic provides resonance.
- The LCL output wavelength of the device is set, conventionally, by aligning the long photonic band edge of the band gap with the fluorescence maxima of the dye.
- The pump wavelength (pulsed regime) is chosen to match the absorption maxima of the dye.
- Gradient pitch cells can be made for continuous tuning.





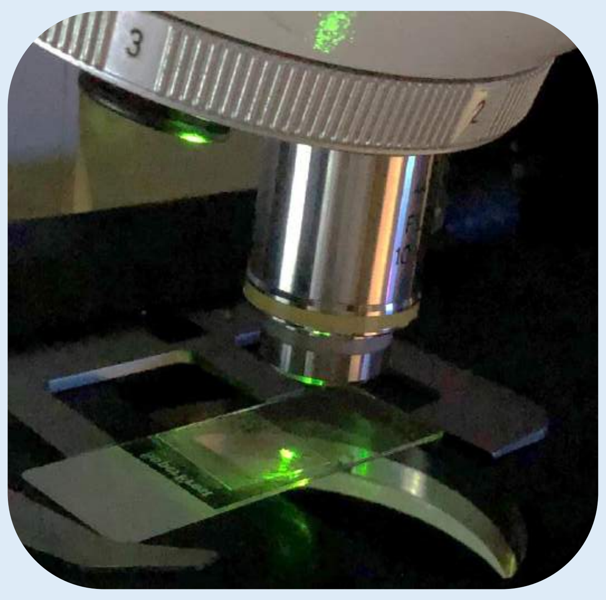
LCL output wavelength is **narrow linewidth** and **tuneable**, enabling the **selection of any wavelength** in the visible/ NIR range (450 – 850 nm)

Why Fluorescence Microscopy?

Fluorescence microscopes provide specificity and high-sensitivity. They have been an essential tool in contributing to our current understanding of cell physiology and will continue to open our eyes to the inner workings of the microscopic world around us.

However, there are some key challenges associated with this technique:

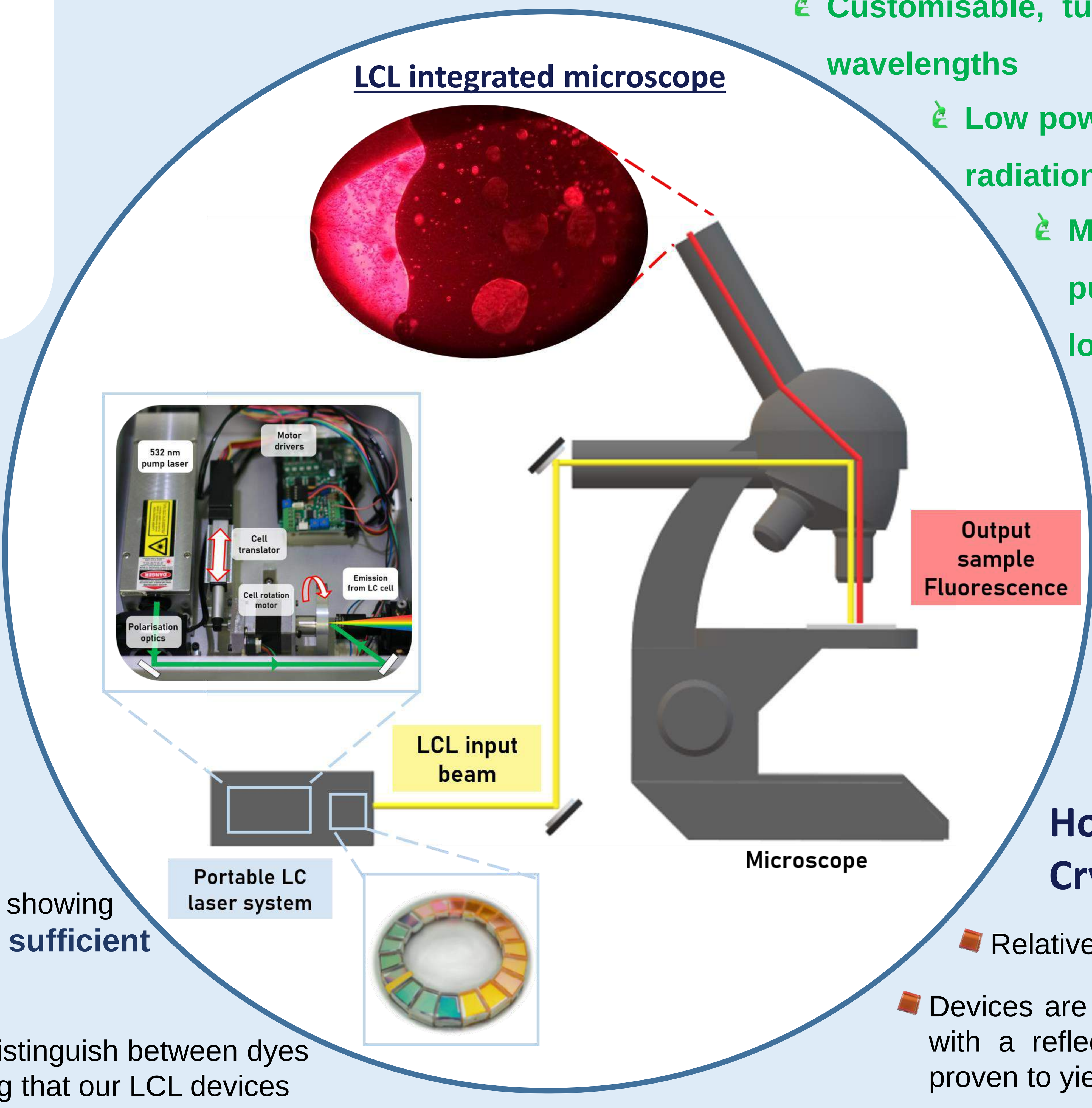
- **Commercial light sources are expensive**
- **Photobleaching of fluorophores**
- **Crosstalk between fluorophores**



How can LCLs help?

Liquid crystal laser technology can address these hurdles by offering a unique set of advantages within the world of light sources:

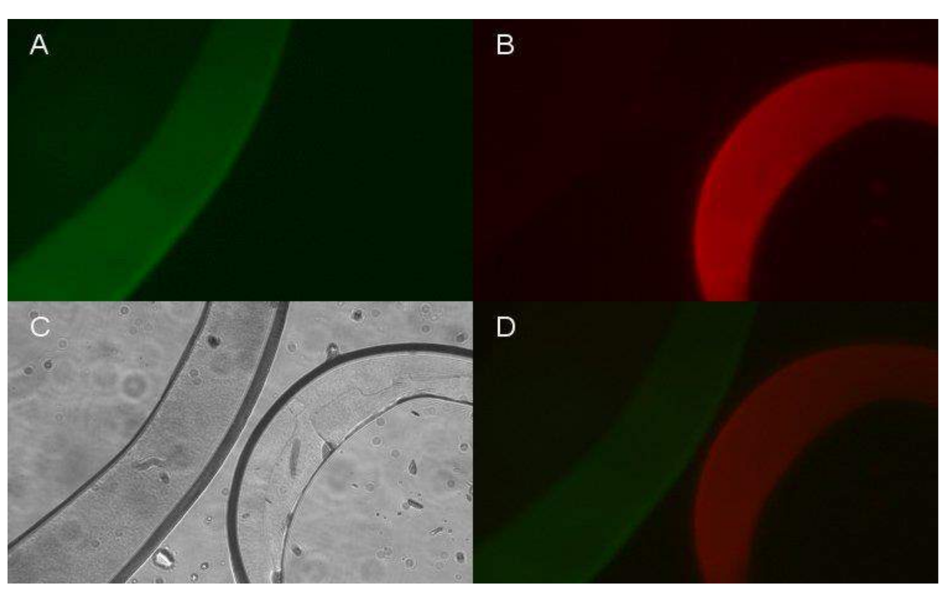
- **Customisable, tuneable and narrow linewidth wavelengths**
- **Low power output (reducing incident radiation)**
- **Multi-wavelength with one pump source (compact and lower-cost)**



A record **3.5 mW** of LCL power was achieved using a repetition rate of 10kHz [1]. This is of the order of power used in commercial fluorescence imaging systems

Objectives achieved

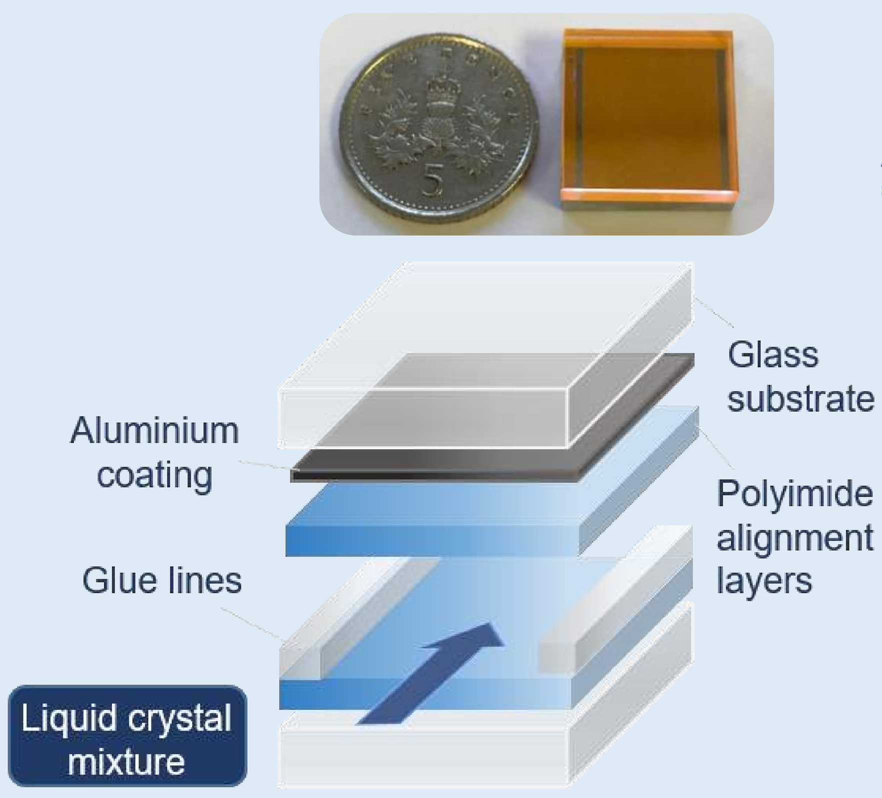
- Proof of principle image capture showing that our current LCL system has **sufficient power**.
- Demonstration of the ability to distinguish between dyes and their concentrations showing that our LCL devices produce sufficiently **narrow linewidths** with **sufficient sensitivity**.
- First successful LCL lasing while pumping with a laser diode (445nm) **reducing footprint** and cost whilst opening the possibility to 'bluer' wavelengths [3].

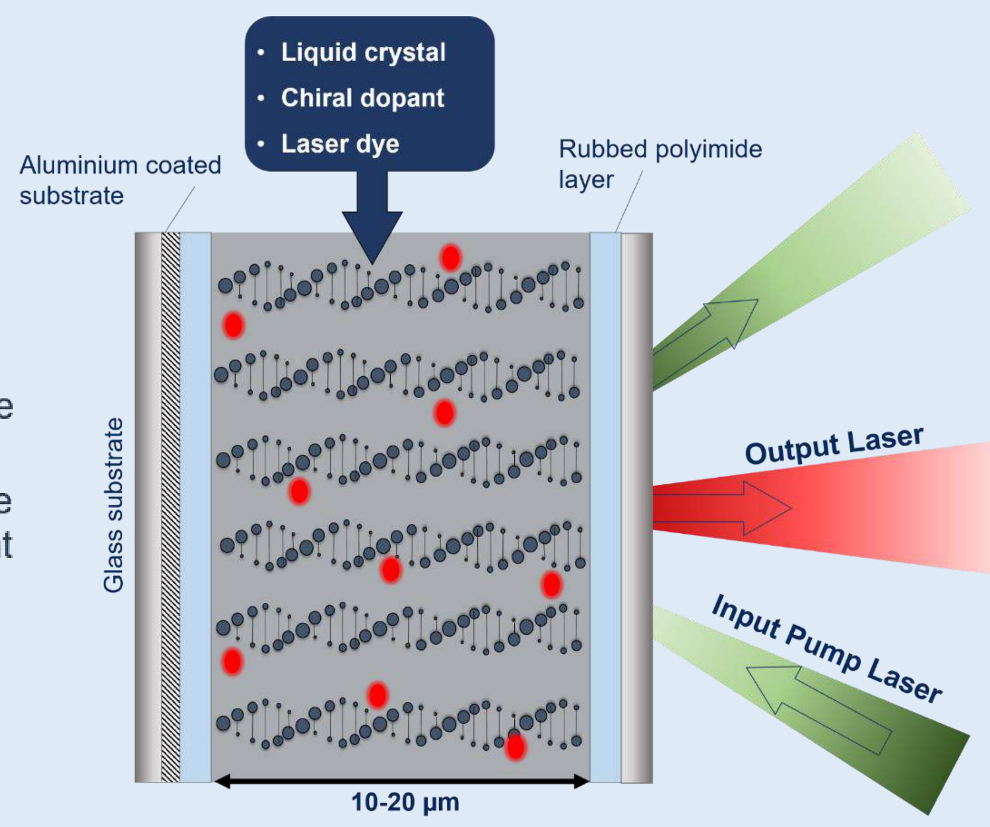


All fluorescence images taken at 1kHz repetition rate. A) 640 nm illumination B) 561nm illumination. C) White light illumination D) Overlay image showing the mixed droplet sample of 1% LD800 mixed with 1% Ph660 LC/glycerol droplets.

How do we make Liquid Crystal Lasers?

- Relative ease and low cost of fabrication.
- Devices are made in house in batches usually with a reflective geometry as this has been proven to yield better laser performance [2].
- Mixtures are filled by capillary action thus requiring small volumes of materials.
- Devices are tuneable via thermal, electrical and gradient pitch mechanisms.





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