Miniature tunable dye laser

Single mode tunable lasers are powerful tools for spectroscopy and metrology as they allow controlled and continuous sweeping of the laser wavelength across a specified range. In Oxford we are building miniature optically pumped dye lasers with vertical cavity geometry that offer single mode operation and wavelength tuning over 50 nm or more. Operation wavelengths spanning the visible and near infrared can be realised, with average output powers up to 100 nW demonstrated corresponding to 10 pJ /pulse. The lasers produce unpolarised beams with intensity distribution and divergence that can be engineered during manufacture, and can be constructed as arrays for signal multiplexing and advanced spectroscopic applications. They provide an inexpensive and flexible alternative to existing widely tunable laser systems.

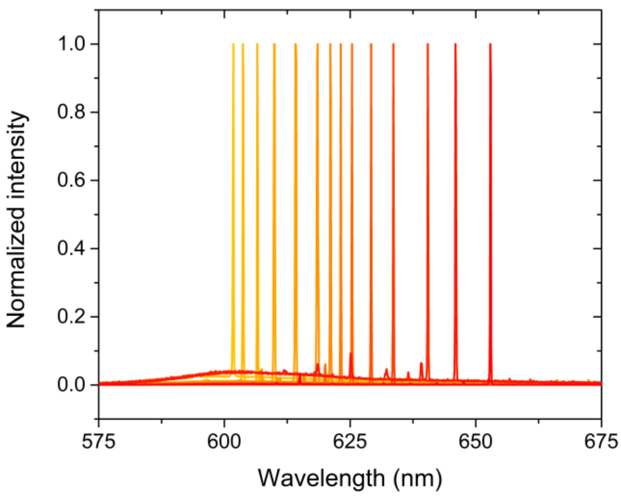

Fig 1. Single mode tunable lasing over a wavelength range of 150 nm (Rhodamine 640 dye). The dye is pumped at λ = 532 nm with ~ 300 pJ pulses.

The lasers are based around a microscopic resonator with a mode volume of ~1-100 μm^3 that provide a free spectral range large enough for single mode lasing with no additional mode selection or filtering. The resonator itself is a simple tunable etalon into which the dye is placed. By perfecting the fabrication of the mirrors we are able to achieve resonator finesse in excess of 1000 for efficient optical feedback. The laser is pumped optically using a pulsed source with a wavelength at which the resonator mirrors are transparent.

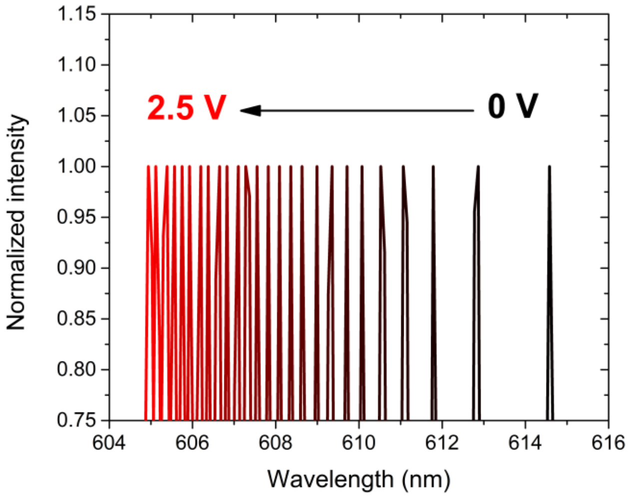

Fig 2. Tuning the laser wavelength with a dc voltage

To demonstrate our design we have constructed lasers that are continuously tunable between 600 and 650 nm using Rhodamine 640 dye (figure 1). Tuning is achieved via a simple dc voltage applied to a piezoelectric actuator that controls the cavity length. Since the resonator is only a few micrometres in length, the free spectral range is very large and single mode lasing is straightforward to achieve. The dye in the demonstrator was pumped with a λ = 532 nm frequency doubled YAG laser delivering 3 ns pulses, whereupon lasing thresholds of ~250 pJ were observed (figure 3).

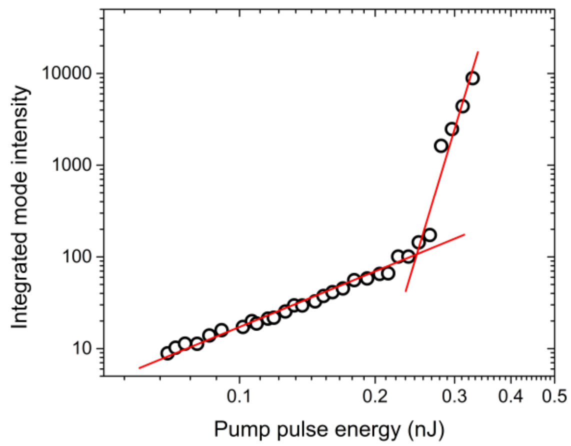

Fig 3. Output intensity of the laser as a function of excitation pulse energy, showing a lasing threshold of 250 pJ.

The ultra-small laser cavities providing the optical confinement have been developed in our lab and are central to the device performance. Dye is introduced into the cavity from a small reservoir such that circulation is achieved by diffusion under ambient conditions. No injection of the dye through the resonator is required. The result is a compact device (a cylinder ~20 mm diameter x 10 mm length) that requires only ~ 100 microlitres of dye for ~10,000 hours of operation.

We have patent protection for the dye lasers described here and are currently looking for companies to help us develop commercial products. We are also working on sensor platforms and tunable optical filters based on the same resonator technology, and which are inter-compatible with the dye microlasers described here. For more information on any of these programmes or to register your interest please contact us using the address below.

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