The Supercontinuum Laser as a Flexible Source for Quasi-Steady State and Time Resolved Fluorescence Studies

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Commercial Fluorescence Lifetime Spectrometers have long suffered from the lack of a simple, compact and relatively inexpensive broad spectral band light source that can be flexibly employed for both quasi-steady state and time resolved measurements (using both Time Correlated Single Photon Counting (TCSPC) and Multi-Channel Scaling (MCS) techniques).

This paper reports the integration of an optically pumped, photonic crystal fiber, supercontinuum source[1] with a pulse picker (Fianium model SC400PP) as a light source in a combined Steady State and Fluorescence Lifetime Spectrometer (Edinburgh Instruments model FLS920), with double excitation and emission monochromators and with single photon counting detectors (micro-channel plate photomultiplier and a near-infra-red photomultiplier) covering the UV to NIR range.

The spectrally corrected output from the supercontinuum laser (repetition rate selectable up to 20MHz) has been measured over the range 375-1700nm and shown to have the same order of higher spectral brightness as a 450W Xenon lamp over the majority of the range. The pulse height distribution and leading edge jitter of the output pulses has been measured and the performance optimised.

Alternative methods to select the emission wavelength and bandwidth from the supercontinuum output will be reported. These include using a tunable acousto-optic filter with up to 16 channels, which can be superimposed to provide a variable bandwidth, or the novel use of two motorised linear variable wedge interference filters, one low pass and the other high pass. Performance will be contrasted and compared.

Although the master oscillator within the supercontinuum laser has a short pulse width of ca 6ps it is known that the output pulse is significantly broadened by dispersion in the optical fibre. A key parameter which controls the precision of a TCSPC measurement is the Instrumental Response Function (IRF), which has been measured and shown to be <150ps over the majority of the tuning range.

The "Proof of Concept" of using the supercontinuum laser as a source for TCSPC measurements has been shown by measuring several known materials. A sample of antrathcene in cyclohexane (5×10^{-5}M) was studied as this is one of the most documented standards of fluorescence lifetime spectroscopy with a lifetime of 5.1ns when degassed. However, the excitation spectrum has a longest wavelength peak at 375nm with no absorption above ca 390nm. This showed the supercontinuum laser can be used at these short wavelengths. More challenging applications to measure shorter lifetimes of erythrosine B in water (lifetime ca 88ps) and pinacyanol chloride (lifetime ca 13ps) with excellent "Goodness of Fit" parameter will be shown.

By varying the repetition rate with the pulse picker, the supercontinuum laser is capable of measuring fluorescence lifetimes up to 50μs using the TCSPC. The possibility of using bursts of pulses in a variable envelope as a longer pulse width source for phosphorescence lifetime measurements in the micro- and milli-second range using the MCS technique will be discussed.

In conclusion, the supercontinuum laser offers the possibility of measuring fluorescence lifetimes down to a few 10's of picoseconds with the advantages of broadband tunability. The use of new supercontinuum sources with output further into the UV spectral region will be discussed.

References: [1] J.M. Stone, J.C. Knight Opt. Express 16 (2008) 2670-2675