

## OPTICAL PARAMETRIC OSCILLATOR SYSTEM FOR CARS MICROSCOPY

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Coherent anti-Stokes Raman scattering (CARS) microscopy as a labelling free nonlinear imaging technique has been extensively researched and been employed for many applications, e.g. live cell imaging, cell membrane studies, tissue imaging as well as brain tumour imaging [1]. The most common optical system for CARS microscopy employs two tightly synchronised ultra-short pulsed lasers overlapped temporally and spatially. Not only is this expensive, however, but this approach is also complex and the stability of the system is almost entirely dependent upon the electronic locking mechanism. For CARS microscopy to become routinely applied in a research or a clinical environment, improved photonics technology is clearly required. As a consequence of this need, we demonstrate a flexible CARS imaging system based on a synchronously pumped optical parametric oscillator (OPO) based upon a periodically poled lithium niobate (PPLN) crystal. This approach circumvents the need for two costly platform laser sources yet provides a wide wavelength tuning range to facilitate a wide range of CARS imaging experiments.

The pump laser was a Ti:Sapphire source (Coherent Mira Dual), operating at a 76MHz repetition rate, which provided a maximum average power at the PPLN crystal of  $\sim 1$ W. By merit of the Ti:Sapphire design, ps- and fs-pulsed output was possible and hence the OPO could be pumped with ps- or fs-pulses. The multi-period crystal led to a signal and idler wavelength tuning range from  $\sim 0.94\mu\text{m}$  to  $\sim 1.19\mu\text{m}$  and  $\sim 2.01\mu\text{m}$  to  $\sim 3.61\mu\text{m}$  respectively. With a ps-pulsed pump, the maximum signal power was around 200mW with a pump power of 970mW at 747nm. The wavelength tuning characteristics of the OPO through varying the crystal temperature, crystal periods and cavity length will be presented, along with the performance of the fs-pulsed OPO. Considering the signal output of the OPO and a fraction of the Ti:Sapphire laser as the Stokes beam and the pump beam respectively, the 1800 to 4200 $\text{cm}^{-1}$  of the Raman spectrum is accessible.

After overlapping temporally and spatially, the two laser beams were coupled into an Olympus FV300 microscopy system which was been modified in-house in order to optimise the forward CARS detection. The two beams were focused onto the sample with a water immersion objective (Olympus UPLSAPO 60xW/IR) and the CARS signal was collected using a condenser with NA of 0.55 and was guided through two 700nm short-pass filters to the external PMT detector. The system was evaluated by performing CARS imaging of polystyrene beads and these results will be presented, along with a fuller description of the pump parameters and OPO output.

[1]. C. L. Evans, and X. Sunney Xie, "Coherent Anti-Stokes Raman Scattering Microscopy: Chemical Imaging for Biology and Medicine," Annual Review of Analytical Chemistry, Vol. 1, pp. 883-909, 2008.