A FIBER-DELIVERED CARS SYSTEM

Quentin Beaufils, Charles-Henri Hage, Laurent Héliot
PhLAM, UMR 8523, CNRS and University of Lille 1
Bât. P5 - USTLF-59655 Villeneuve d'Ascq cedex
E-mail : quentin.beaufils@gmail.com

KEY WORDS: Non-linear microscopy, CARS, Raman, femtosecond laser.

We present a new light source for Coherent Anti-Stokes Raman Scattering (CARS) spectroscopy. The CARS technique allows for label free optical imaging of molecules of biological interest in the 600 cm^{-1} – 3000 cm^{-1} range with high contrast and has been used as a biomedical imaging method on *ex vivo* samples [1,2] as well as in *in vivo* studies [3]. It relies on coherent non-linear conversion of two lasers (Pump and Stokes) into a third one (Anti-Stokes) via resonant four-wave mixing in the sample of interest.

Our design aims at converting femtosecond pulses delivered by a Ti:sapphire laser into pairs of synchronized pump and Stokes pulses. It relies on the use of Soliton Self Frequency Shift [4] in a non-linear fiber to create tunable (800 nm – 1000 nm) Stokes pulses. The spectral focusing technique [5] is then used to allow for 20 cm^{-1} resolution while keeping a high power spectral density. Both the pump and Stokes beams are combined and linearly chirped in a common end fiber which make this design suited for integration on microscopes and endoscopes.

In a first investigation on the effect of fiber nonlinearity and dispersion on the spectral resolution as well as on the possibility to use parabolic amplification on the Stokes pulses, we obtained up to 50 mW of 1.5-4 ps pulses for both pump and Stokes beams.

[1] C. L. Evans, X. Y. Xu, S. Kesari, X. S. Xie, S. T. C. Wong and G. S. Young, "Chemically-selective imaging of brain structures with CARS microscopy", *Opt. Express*, 2007, 15, 12076–12087.

[2] C. Krafft, A. A. Ramoji, C. Bielecki, N. Vogler, T. Meyer, D. Akimov, P. Rosch, M. Schmitt, B. Dietzek, I. Petersen, A. Stallmach and J. Popp, "A comparative Raman and CARS imaging study of colon tissue " *J. Biophotonics*, 2009, 2, 303–312.

[3] H. G. Breunig, R. Buckle, M. Kellner-Hofer, M. Weinigel, J. Lademann, W. Sterry and K. Konig, " Combined in vivo multiphoton and CARS imaging of healthy and disease-affected human skin" *Microsc. Res. Tech.*, 2012, 75, 492–498.

[4] J. H. Lee, J. Van Howe, C. Xu, and X. Liu, "Soliton self-frequency shift: Experimental demonstrations and applications," *IEEE J. Sel. Top. Quantum Electron*. **14**, 713–723 (2008)

[5] T. Hellerer, A. M. K. Enejder, and A. Zumbusch, "Spectral focusing: High spectral resolution spectroscopy with broad-bandwidth laser pulses," *Appl. Phys. Lett.* **85**, 25–27 (2004).

Project financed by SATT Nord and the Agence National de la Recherche (DynamIC-12-BSV5-0018-02 and G2Progess 13-BSV2-0016).