Non-linear optical microscopy

Michiel Müller\textsuperscript{a}, Hilde A. Rinia\textsuperscript{a}, Rajesh S. Pillai\textsuperscript{a),} Fred Brakenhoff\textsuperscript{a)}, Erik M. Vartiainen\textsuperscript{b} M. Bonn\textsuperscript{c} and Jeff A. Squier\textsuperscript{d}

\textsuperscript{a}Biophysics and Microscopy Group, Swammerdam Institute for Life Sciences, University of Amsterdam, P.O. Box 94062, 1090 GB Amsterdam, The Netherlands
\textsuperscript{b}Department of Physics, Lappeenranta University of Technology, B.O. Box 20, FI-53851 Lappeenranta, Finland.
\textsuperscript{c}FOM Institute for Atomic and Molecular Physics [AMOLF], Kruislaan 407 Amsterdam, The Netherlands.
\textsuperscript{d}Department of Physics, Colorado School of Mines, Golden (Co), USA
E-mail: muller@science.uva.nl

KEY WORDS: Ultrashort pulse propagation, dispersion compensation, CARS microscopy, Non-linear optics, Maximum entropy method, Phase retrieval, SFG spectroscopy, THG microscopy.

In this poster we provide an overview of recent results in the field of nonlinear optical microscopy. We demonstrate that delivery of optical pulses as short as 15 fs can be realised with the appropriate dispersion pre-compensation schemes. Both the total dispersion induced by high numerical aperture objectives and its radial variation are discussed. We show that ultrashort IR pulses can be used for data storage in glass, using the phenomenon of laser-induced breakdown. The written patterns can subsequently be read-out using third-harmonic generation (THG) microscopy. THG microscopy is sensitive to changes in either refractive index and/or non-linear susceptibility. We have investigated the fundamental properties of the third-harmonic signal generation process and used the technique in both material science and biological applications. Furthermore we present recent results of multiplex coherent anti-Stokes Raman scattering (CARS) microscopy. This third-order nonlinear optical analogue of spontaneous Raman spectroscopy, provides chemical and physical specificity without labeling the specimen. Various applications in microscopy and spectroscopy will be presented. Finally we will show recent results of sum-frequency generation experiments on lipid chain packing in monolayers. A novel phase transition has been observed and the effects of ions in the subphase on the lipid chain phase behaviour is discussed.