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Coherent Raman Scattering Microscopy

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Ji-Xin Cheng and Xiaoliang Sunney Xie, 610 pages, ISBN 978-1-4398-6765-5, CRC Press (2012) $159.95, hardcover.

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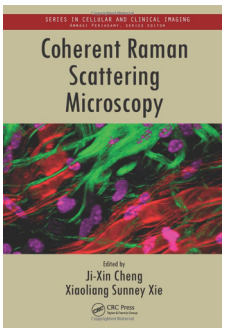

Research and development of modern optical microscopes are guided by several aspects, from resolution obsession to imaging of living specimens, from a low-level of perturbation to long-term experiments on biological systems. One of the most outstanding goals is the possibility of performing at the highest current levels, including 4-D (x, y, z, t) nanoscopy/superresolution, label-free imaging. Coherent Raman scattering (CRS) microscopy represents a key label-free imaging method for studying living cells and tissues at a high time rate. Ji-Xin Cheng and Xiaoliang Sunney Xie, two of the most representative scientists in this area, assembled the perfect book for disseminating the method. Their experience as scientists and authors and their robustness and consideration in the field allowed them to edit a great book that, starting from the foundation of CRS microscopy, covers the field in a comprehensive and exhaustive way.

The great start with Part I: Theory, which is split into basic and advanced issues, is maintained in Parts II and III, Platforms and Applications. In the Platforms section, one can find important papers that stimulate and effectively describe the construction of a Raman-based microscope from a "classical" coherent Raman microscope—brilliantly written by Sunney Xie and Brian Saar—to state-of-the-art advanced architectures. The chapter related to the miniaturization of the CRS microscope describes a very interesting platform with applications for atherosclerosis. Another interesting implementation is the one described by Jesacher et al. on wide-field CARS microscopy. The collection of papers in the Platforms section is informative for readers interested in implementing different setups. In fact, this section contains the latest concepts for the translation of a Raman signature to advanced instrumentation, including coupling to phase, harmonic generation, and two/multiphoton excitation microscopy. The treatment of beam profiles and methods for improving resolution adds value to the section chapters and the whole book.

Due to its label-free contrast mechanism, CRS microscopy opens an important window on those applications in medicine and biology that can be potentially translated to *in vivo* approaches. We can find here how such an approach and the related family of implemented techniques can be relevant for the detection of cancer *in vivo*; an improved comprehension of mechanisms underlying the normal or pathological functioning of the nervous system; lipid metabolism studies towards obesity risks and dietary fat absorption for health; and drug delivery/uptake levels in tissues and tissue engineering. It is particularly challenging to understand how myelin studies can be carried out *in vivo* following the understanding of the Raman signature and the development of tailored approaches to extract relevant signals from a not-negligible background. In addition, the demonstration of studies *in vivo* on white matter, and the imaging access to cardiovascular diseases, point to the potential of bringing CRS-related methods to the patient's bedside for a potentially real-time approach to medical diagnosis. Methods are also proven useful for liquid crystal studies in a comprehensive and critical chapter.

This book is a unique and extremely well-balanced collection of chapters for an emerging topic in microscopy and spectroscopy due to the immense value given by the allowance of label-free imaging. In the last 20 years there has been an incredible race to get unpredictable improvements in the spatial resolution of the optical microscope. A fundamental reason for focusing research on the optical microscope is its unique, powerful ability to image 4-D (x, y, z, t) live cells and tissues. Such a possibility is not achievable when using an electron microscope, despite the excellent spatial resolution available. Nowadays we can say, after the demonstration of the achievement of 2.4-nm resolution using optical nanoscopy, that the diffraction limit is no longer a limiting factor in fluorescence optical microscopy. A localization precision of single molecules at the nanoscale and a practically unlimited resolution can be achieved. Despite these advances in superresolution in live-cell and 4-D tissue imaging, it is still limited by the need for labeling. The fundamental limitation here stems from working in living systems at room temperature where the role of the Boltzmann constant is more relevant than the diffraction limit. It's so great that Xie et al. demonstrated the achievement of "ultra" spatial resolution using label-free approaches. This is exciting and an important driving force for new achievements in terms of optical platforms and applications given a solid theoretical approach.

Interested readers can find an excellent mix of such ingredients in this book, which is the first one dealing in a comprehensive and exhaustive way with CRS microscopy and related techniques. No one involved in optical microscopy and spectroscopy should miss this text, which is able to offer new exciting scenarios and, for sure, at least one new idea after the reading.