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Lingyan Shi

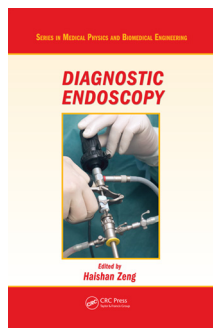


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Diagnostic Endoscopy

Haishan Zeng, 272 pages, ISBN: 13:978-1-4200-8346-0, CRC Press, New York (2013) \$99.95, hardcover.

Reviewed by Lingyan Shi, research assistant and PhD candidate, Department of Biomedical Engineering, The City College of the City University of New York



Diagnostic Endoscopy, edited by Haishan Zeng, is a new book recently published by CRC Press. This book is clearly organized and incorporates both well-established and new theories and principles of endoscopy that are used in laboratory and clinical practice. It will help enlighten the medical community to unlock the value of applying spectroscopy to medicine, and to educate undergraduate and graduate students in the field of biomedical optics.

As stated by the editor, Dr. Zeng, flexible optical fiber endoscopy was invented in 1958 and its applications were evolved into medical visual diagnosis and treatment in the 1960s. The use of optical spectroscopy to develop smart tools in medicine dates back to 1984 when advanced endoscopy and new methods were employed to detect cancers. In the early 1990s, applications of fluorescence endoscopy were combined with CCD/CMOS video cameras and improved optical fibers. When coupled with optical spectroscopy, endoscopy would become smarter and more advanced for visual representation in clinical applications by using fluorescence and Raman maps.

The use of endoscopic optical biopsy—fluorescence, Raman, near-infrared (NIR) absorption, Stokes shift, two-photon fluorescence, second harmonic, coherent anti-Stokes Raman scattering (CARS), or stimulated Raman scattering (SRS)—makes medical diagnostics even smarter. Optical biopsy promises a novel diagnostic and therapeutic approach for detecting whether a tissue is diseased (such as cancer) without removing any part of the tissue from the body.¹ The analysis of emitted fluorescence, absorbed, or scattered photons (Raman and Rayleigh) provides the signature of chemicals and physiological changes that may occur inside the tissue. This will help clinicians determine whether the tissue is normal, benign, or malignant.² It will also help locate cancer tissue margins in the surgery.

Diagnostic Endoscopy is organized into 5 sections, containing 13 chapters. The editor selected a handful of key topics in the biomedical optics field to facilitate a comprehensive exploration for researchers and clinicians in this rapidly expanding area. Section I introduces basic theories of endoscope and radiative transport. Sections II and III describe different visual-based endoscopy, fluorescence, and point Raman approaches, respectively. Section IV demonstrates the latest endoscopes that use confocal microscopy, optical coherence tomography (OCT), and nonlinear optics. This section also introduces the MEMS/MOEMS technology applied in the development of catheters for plaque detection, such as OCT and Raman. The final section

reviews clinical applications of spectroscopy for the lungs and the GI tract, respectively, and stresses the importance of diagnostic endoscopy for future applications of biomedical photonics in medicine.

Some highlights of the book are as follows. It is the first book that summarizes and describes in detail the principles and applications of endoscopic imaging. Four sections in the book illustrate the essential principles of endoscope and light-tissue interactions, which demonstrate the underlining optical processes and equations. Figure 1.3 (p. 9) clearly illustrates the energy levels of molecules with major processes including absorption, fluorescence, Raman, two-photon fluorescence, and second harmonic generation (SHG). Various important elements of the endoscope are reviewed. Several key coefficients in tissue are also clearly presented, including the absorption, scattering, and attenuation coefficients, u_a , u_s , u_t , with $u_t = u_a + u_s$, and the reduced scattering coefficient u_s' in tissue (Table 3.1, p. 34). Values of u_a and u_s are given in Fig. 3.3 (p. 35) for lung tissue. The inverses of these coefficients lead to the penetration lengths in tissue, where $l_a (= 1/u_a)$ is the absorption length, $l_s (= 1/u_s)$ is the mean free scattering length, and $l_{tr} (= 1/u_s')$ is the transport length, i.e., the travel distance to change the photon direction by 90 deg. Also, $l_{tr} = l_s/(1 - g)$, where g is the anisotropic angular deflection, $g = \cos \Theta$, and Θ is the scattering angle. Typical values for g is ~ 0.9 and l_s is 330 μm for the lung. The transmission (T) of the unscattered light, also known as the ballistic light, is described by Beer's law, $T = \exp(-u_t z)$, where z is the penetration distance into the tissue (Eq. 3.12, p. 33). The ballistic and snake photons are known to carry image information in tissues for OCT, one-photon and two-photon microscopy, spectroscopy, etc.

Diagnostic Endoscopy has some weaknesses. It is incomplete in reviewing early applications of optical spectroscopy for cancer detection.^{1,2} For example, Alfano's group at the City College of New York in 1984 presented the pioneering work of using optical spectroscopy for *ex vivo* cancer detection, including fluorescence² and Raman spectroscopy; however, their work is not mentioned in the book. Similarly, Feld's group in MIT and Bigio's group in Boston University are not introduced in Chapter 6 for their contributions in the application of fluorescence spectroscopy.

The optical window is the most important for deep imaging penetration through one- and two-photon microscopy.^{3,4} However, Fig. 4.1 (p. 42) only shows hemoglobin and oxygenated hemoglobin displaying together with water and creating a therapeutic window spanning from 650 to 1100 nm. Furthermore, some recent applications have not been reviewed in the book. For example, a second and a third optical window ranging from 1250 to 1750 nm have been noted for deeper tissue imaging with reduced scattering. It is well known that scattering blurs images and a reduction of scattering will generate clearer images. With the advent of the NIR CCD/CMOS camera using InSb and InGaN camera detectors, it is now possible to image tissues by using these new optical windows. However, applications of the new camera, for the detection of NIR or midinfrared (MIR) from

1000 nm to 5000 nm depending on the combination of vibrational modes of molecules, are not covered in the book.

A major advance in endoscopy is the invention of the pill “camera” (PillCam[®]) by Covidien Corp. for visual inspection with wireless communications, which is currently FDA approved for clinical use in the GI tract. This is described in Chapter 2, but the next generation of “exploration ships” with optical spectroscopy is not introduced. The pill-sized capsule endoscopy with spectroscopy and LEDs inside enables one to extend and enhance detection of diseases in the GI tract.⁵ With the future development of nanotechnology, it is possible to make much smaller scale endoscopic ships to travel and explore in arteries, while these smart ships should also be biodegradable.

Moreover, optical biopsy is based on spectral fingerprints of key chromophores that cover 290 to 550 nm in tissue, such as tryptophan, collagen, elastin, NADH, and flavins. This book would be more comprehensive if it included the absorption and fluorescence spectra of the above mentioned key molecules that build the tissue. The two photon, SHG, CARS, and SRS imaging could have been introduced and discussed in more detail in Section IV. References to Guo^{1,3} and Denk⁴ are missing in Chapter 10. More updated reference books^{6,7,8} can be found for various biomedical optics applications to improve readers’ knowledge.

In conclusion, despite these weaknesses, *Diagnostic Endoscopy* is highly recommended. It is the first to offer details on how optical spectroscopy of tissue is merged into endoscopy for a potential real-world smarter diagnostic unit. This is an

excellent beginning, with room for enhancement. The book focuses on tissue optics, physics, and engineering principles, and integrates photonics into medical tools to introduce biomedical photonics into medicine. This book serves as an instrumental reference for the state-of-the-art optical spectroscopy development in medical imaging. A new armamentarium will be added to other medical tools using light.

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