Theory and Practice of Scanning Optical Microscopy

By Tony Wilson and Colin J. R. Sheppard

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The commercial availability of reliable and inexpensive lasers, along with a current wealth of potential applications, has generated in the past few years increased interest in the scanning optical microscope. Simple versions of such instruments have already been commercialized in inspection equipment used in the semiconductor industry and no doubt will expand in that area and extend into other areas in the near future. This reason and the fact that no other complete text exists on this subject make this work timely and a valuable addition.

Chapter 1 introduces the concept of sequential imaging used in the scanning microscope and discusses its advantages over parallel processing. An overview of applications is presented, numerous references cited, and several examples illustrated.

Chapters 2 and 3 review, respectively, the theory of Fourier optics and its specific application to image formation in scanning microscopes. The fundamental concepts of transfer functions, coherent and incoherent imaging, aberrations, etc., are discussed. Those unfamiliar with the basic principles of imaging optics may want to first review a basic text, such as Jenkins and White's "Fundamentals of Optics," before reading Chapters 2 and 3. Chapter 4 deals in more detail with specific imaging modes such as dark field, interference, and differential microscopy. Synthetic aperture imaging and stereoscopic microscopy are also discussed. Interesting illustrations demonstrate several of the techniques.

The first four chapters of the text are basically theoretical in emphasis. Chapter 5 begins an orientation toward practical applications which the remaining chapters treat in detail. In Chapter 5, a discussion of depth discrimination and extended depth of field imaging is presented. Chapter 6, titled "Super-Resolution in Microscopy," treats one of the major advantages in sequential imaging, namely, digital signal processing. Auto-focus, contrast and edge enhancement are explained and illustrated. An interesting configuration, referred to as the "scanning incoherent confocal fluorescence microscope," offers the possibility of a fourfold improvement in spatial frequency bandwidth over a conventional microscope and is reviewed in some detail. The direct view scanning microscope, where the source and detector are both scanned together, is treated in Chapter 7. Although difficult to realize in practice, it offers interesting applications possibilities for large depth discrimination.

Chapters 8 and 9 will probably be the most interesting for those readers working on or contemplating specific applications. Chapter 8 discusses the major components incorporated in any scanned microscope; namely, the light source, objective lenses, detectors, image processing electronics and scanning hardware. For a thorough treatment, the reference list could be expanded considerably. However, the detail in the text is adequate and consistent with the detail in the book in general. Chapter 9 concentrates on applications to semiconductors. An entire text could be written on this area alone. However, the authors treat the subject well, discussing OBIC, photoluminescence, electroreflectance, etc., with useful comparisons to SEM images and the EBIC technique. The reference list is complete although already somewhat dated.

The text concludes with Chapter 10, reviewing non-linear scanning microscopy, discussing the possibilities of image enhancement by stimulating non-linear effects in the objects under examination.

In general, the book provides both a good theoretical and practical overview of a timely and expanding technology. The background and theoretical discussions will prove useful for many years to come. The chapters emphasizing applications could easily become dated; however this is a problem for any text treating a rapidly expanding area. I recommend the book without reservation.

Reviewer: Vincent J. Zaleckas is research leader, optics and optoelectronics, at AT&T's Engineering Research Center, Princeton, NJ, responsible for R&D of optical technologies and their applications in semiconductor device manufacture.