EDITORIAL
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# Editorial: Label Free Polarization Resolved Optical Microscopy for Biomedical Applications

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**Editorial on the Research Topic**

**Label Free Polarization Resolved Optical Microscopy for Biomedical Applications**

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Biophotonics is an interesting and important branch of biomedical science that has impacted modern healthcare by solving complex biomedical and clinical problems through its often simple and innovative approaches. The field has been evolving rapidly both at the fundamental/preclinical science levels and in actual clinical applications. Key developments in enabling technologies such as miniaturization of lasers, optical fibers, photodetectors, and spectrometers, and improved understanding of light-tissue interactions are greatly contributing to this rapid evolution and growth. Both diagnostic (often imaging) and therapeutic (e.g., photodynamic or photothermal therapies) applications abound, and their clever combinations ("theranostics") are also emerging; the latter are greatly enhanced by the rapid developments in nanophotonics. All in all, this is an exciting time to be a "light for life sciences" researcher!

Among the biophotonic diagnostic imaging tools, microscopes are perhaps the most common and the most useful. Recent Nobel-Prize-level advances in optical microscopic tools and processes have enabled nanometre scale imaging, much beyond the diffraction limit of traditional optical instruments [1, 2]. However, viewing the biological objects/processes at such high resolution often requires exogenous labelling, which may disturb the biological process under observation, cause sample preparation artifacts, and pose eventual *in-vivo* regulatory and toxicity challenges. Thus, label-free optical techniques without any external markers are actively being explored, and the use of polarization properties of light offers an attractive approach in this context [3]. For example, through polarization-sensitive second harmonic generation (psSHG) microscopy, biological microstructures can be revealed, and the quantification of various critical polarization parameters can serve to enhance early detection and track disease progression of various arthritic and cardiovascular pathologies [4–6]. This and similar polarization-enabled applications that help quantify important biophysics such as the cellular metabolic rate and collagen conformation noninvasively in healthy and disease states can impact basic research, drug development, and clinical diagnosis. In addition to the 'conventional' thin-slice microscopy as common in histopathology departments, polarization approaches can enhance examinations of bulk thick tissues (either in reflection or in transmission). In such applications, the common drawback of most biomedical optics technologies—shallow imaging depths due to extensive tissue scattering—can be potentially minimized with either adaptive optics or tissue clearing methodologies [7–9].

In this special issue of Frontiers in Physics entitled "*Label-Free Polarization Resolved Optical Microscopy for Biomedical Applications*", we've gathered four articles exploring various exciting aspects of optical polarization. These demonstrate a wide variety of valuable biophysical information obtainable via polarized light assessment, suggesting further exciting avenues of exploration, both in enabling technology development and important research as well as clinical applications. The first paper by Hogan et al. explores the anisotropic properties of myocardium using Mueller-matrix reconstruction in different phase planes in polarization microscopy, to comprehend how tissues are affected and respond to treatment in myocardial diseases. Next, Callegari et al. describe a scanning beam-based microscopy system utilizing the instantaneous emission of orthogonal polarization states from a Zeeman laser to acquire Mueller matrix images. It records interference signals of time-encoded polarization states from the tissue samples and helps to identify cancer regions based on this novel label-free polarization contrast. In a review article by Cisek et al., polarization-sensitive second harmonic generation (psSHG) microscopy is used to differentiate cancerous from healthy tissues using circular dichroism, polarization in and polarization out detection, and double-Stokes Mueller formalism. psSHG signals depict the ultrastructural changes in the collagen of cancerous tissue exhibiting deregulation and disorganization. The last Special Issue article by Karunendiran et al. utilizes psSHG microscopy to investigate the ultrastructure and organization of myosin in the striated muscle of somatic larva body wall of a fruit fly Drosophila melanogaster. The measured achiral and chiral susceptibility component ratios suggest that apart from myosin, another protein structure (located in isotropic bands of the striated muscle) is responsible for generating the SHG signals These articles highlight the wide variety of polarization-based label-free biophotonics techniques useful in the studies of biological tissues.

In summary, the breadth of presented polarization topics and the rigor of the associated studies give a glimpse of the exciting research frontier of tissue polarimetry. For example, polarization measurements integrated into many existing optical microscopy techniques can provide unparalleled biomolecular contrast, often with minimal inconvenience and low cost. Moving forth, we believe the future of this field is quite promising and bright, specifically through the involvement of advanced mathematical modelling using polarization data. Much research remains in developing robust hardware technology and analytical methods for successful tissue polarimetry, whether in thin-slice microscopy or thick bulk tissue paradigms. If successful, exciting research opportunities exist in diverse fields including nanotechnology, material science, developmental biology, molecular biology, drug delivery, and tissue engineering. The wide spectrum of potential applications in biomedicine will likely focus on early disease detection, prognostication studies, and treatment response monitoring/therapy feedback personalization. Overall we hope that this small sampling of representative polarimetric research articles has given the Frontiers in Physics readers a sense of the excitement and possibilities in this domain which can be further explored for the betterment of healthcare.

## AUTHOR CONTRIBUTIONS

NM, FJK, KM, and AV wrote and reviewed this manuscript.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.