

# Feature issue introduction: biophotonic materials and applications

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**Abstract:** Biophotonics can be defined as the interplay of light and biological matter. The percolation of new optical technology into the realm of biology has literally shed new light into the inner workings of biological systems. This has revealed new applications for optics in biology. In a parallel trend, biomolecules have been investigated for their optical applications. Materials are playing a central role in the development of biophotonics. New materials, fabrication methods, and structures are enabling new biosensors, contrast agents, imaging strategies, and assay methods. Similarly, biologic materials themselves can be used in photonic devices. In this context, two open-access, rapid-publication journals from The Optical Society of America (OSA), *Optical Materials Express* and *Biomedical Optics Express*, will publish a joint feature issue covering advances in biophotonics materials.

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**OCIS codes:** (280.1415) Biological sensing and sensors; (160.1435) Biomaterials; (060.2370) Fiber optics sensors; (170.0170) Medical optics and biotechnology; (220.4000) Microstructure fabrication; (250.5403) Plasmonics.

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Ever since the discovery of lenses optical devices have played a central part in biological science. The advent of lasers and the availability of a wide variety of them have seen lasers playing an ever important role. Confocal microscopy and more recently two-photon microscopy is playing important role in translational cancer research [1]. The emergence of optogenetics and stimulated emission depletion (STED) microscopy in the last decade are creative examples how optical technology is developing in close relation with biology [2,3]. The remarkable control over size and shape of optical materials as well as the evolving understanding of their properties in the past few decades has contributed to many new approaches in sensing of biomolecules and biological phenomena. This convergence of optical sciences and biology has also led to the increased exploration of biological materials and templates for their optical applications [4]. In this context we present this feature issue on Biophotonic Materials and Applications.

This feature issue brings together articles to be published in the sister journals *Optical Materials Express* and *Biomedical Optics Express* under the broad theme of Biophotonic Materials and Applications. In keeping with the interdisciplinary spirit of the subject we have considered articles approaching biophotonics from the twin realms of optical materials and biomaterials. In *Biomedical Optics Express*, Anvari and associates discuss doping of biologically derived membranes with a dye followed by antibody functionalization to achieve targeting and imaging of cancer cells in the near-IR region [5]. Also included in this issue of *Biomedical Optics Express* is Zheng and associates' *in-vivo* studies on fluorescence guided delineation of the tumor boundaries [6]. The clear delineation of tumors is a prerequisite to effective surgical care, in this case they address oral carcinoma.

*Optical Materials Express* features three expert reviews on different aspects of bioimaging. Theranostic application of upconverted luminescence by excitation control is reviewed by He et. al. [7]. This review puts the emerging Nd<sup>3+</sup>-sensitized upconversion nanoparticles (UCNPs) into focus based on their ability to modulate excitation of upconversion luminescence. Nanoprobes for cellular imaging are extensively reviewed by Kim and associates, they elaborate on material engineering size, surface nature, morphology, and composition of nanoprobes for detection and diagnosis [8]. Two-photon uncaging presents on-demand light-triggered fluorescence which is vital in understanding certain biological phenomena. Piant et. al. present their review of two-photon uncaging groups employed in neurological imaging and discuss their wider application in material science [9]. Yanase et. al. presents an extensive review of surface plasmon sensing of immediate type allergy (type I allergy). They elaborate on the use of this technique in clinical diagnosis [10].

The issue features articles on wide ranging approaches in material science for imaging of biological samples, as well as sensing and detection of biomolecules. Two-photon induced release of kainate at the focus of a laser for neuronal studies is explored by Dalko et. al. [11]. A highly biocompatible peryleneimide-based two-photon probe and its application in imaging are presented by Lee et. al. [12]. The optical properties of a marine diatom are studied by Wang and associates, they have demonstrated the role of the quasi-regular structure of the diatom to give sharp fluorescence bands with low FWHM [13]. The ability of thin gold films on taro leaf to act as metamaterial is explored by Kajikawa and associates. They saw that the leaf showed low reflectivity even with gold coating due to the nanostructures on its surface [14]. Two-photon photoreduction of silver precursors by two-photon lithography to fabricate three-dimensional silver containing structures for volumetric surface-enhanced Raman scattering is described by Baldeck et. al. [15]. Inorganic CuS nanoplatelets are studied by Tatsuma and associates for their localized surface plasmon resonance (LSPR) applications in the second biological window (1100-1250 nm). They show that the refractive index sensitivity and operation wavelength can be readily controlled by modulating conditions of synthesis [16]. Nanohole arrays present a simple easy to fabricate sensing platform, control of their size and hexagonal arrangement of plasmonic nanoholes over large areas and their optical properties are investigated by Sannomiya and associates, They describe the fabrication of the plasmonic nanohole arrays and study their properties and scope through simulations [17]. Gold nanorods deposited on indium tin oxide (ITO) is explored as a substrate for surface assisted laser desorption ionization (SALDI) by Nidome and associates. They have discovered the role of fusion-ablation phenomena in gold nanohole assemblies on the efficiency of the SALDI process [18]. Furthering the discussion on NIR active nanoplatelets, Sugawa et. al. describe the use of anisotropic palladium nanoplatelets and their application in refractive index based sensing. The platelets show high refractive index susceptibility comparable to some anisotropic gold nanoparticles. The nanoplatelets show a surface plasmon resonance at 620 nm, which is very close to the first biological optical window (650-950 nm) [19].

Gold disk arrays are employed by Shih et. al. for photothermal inactivation of heat-resistant bacteria. This is accomplished by NIR irradiation of bacterial cells deposited on top of a dense random array of nanoporous gold disks (NPGD). The strong light absorption of the sturdy thermally stable NPGDs in the tissue optical window has high potential in nanotherapeutics [20]. Aggregation induced enhancement (AIE) fluorescence in hydrophobic two-photon dyes is seen as a beneficial phenomenon aiding their use as micelle delivered nanoprobes for *in vivo* cellular imaging. Lee and associates have synthesized and studied a two-photon dye based on 2,5-bis(phenyl-acrylonitrile)thiophene for its AIE properties [21]. Tokonami and associates present their work on rapid bacterial counting method based on the photothermal assembling (PTA). They demonstrate that this new and faster technique only shows a difference of 10% from the conventional cultivation method. With a maximum measuring time of 90 seconds the PTA based counting method is a viable candidate for fast measurement for medical and food safety applications [22].

Fixler and associates present a new method for coating gold nanorods (GNRs) with poly(3,4-ethylenedioxythiophene) (PEDOT) and Monte Carlo simulations of the resulting nanocomposites. They demonstrate the potential role of such nanocomposites as contrast agents in molecular imaging [23]. He et. al. present  $\text{Yb}^{3+}$  containing silica UCNPs for simultaneous cell imaging and photothermal cell imaging. They successfully demonstrate drug release in UCNPs triggered by a laser operating in the biological transparency window [24]. The gas sensing application of microfiber knot resonators with graphene oxide functionalization is demonstrated by Chen et.al. This is achieved by optically detecting the refractive index change in graphene oxide brought about by the adsorption of gases [25]. Chiroptical responses of polyfluorene–phenylene (PFP) films were studied by Choi et. al. They demonstrate influence of temperature on the structure of the PFP film and the resulting chirality studied by circular dichroism [26]. Genina et al. describe their work on *in vivo* optical monitoring of transcutaneous delivery of carbonate microcontainers in *Biomedical Optics Express* [27].

We hope that this issue serves to highlight the importance of biophotonic materials to a wider audience, and puts into context the many approaches contributing to its continuing evolution as a science of 21st century. We appreciate to all of the authors and reviewers for their contributions. We are also thankful to Dr. Prem Prabhakaran for his assistance with this feature issue. Thanks also for the valuable contribution of the OSA staff for their support in the review and production process.