Journal of Biomedical Optics

BiomedicalOptics.SPIEDigitalLibrary.org

Biomimetic and Bioinspired Materials for Applications in Biophotonics

Bahman Anvari
Pablo del Pino
Vikas Kundra
Wolfgang J. Parak

SPIE.

Biomimetic and Bioinspired Materials for Applications in Biophotonics

Bahman Anvari
University of California
Riverside, Department of Bioengineering
900 University Avenue
Riverside, California 92521
E-mail: anvarib@ucr.edu

Pablo del Pino
CIC biomaGUNE
Bioengineered Particles Laboratory
Paseo Miramon nº 182
20009 San Sebastian, Spain
E-mail: pdelpino@cicbiomagune.es

Vikas Kundra
University of Texas M.D. Anderson Cancer Center
Department of Radiology
Joint appointment: Department of Cancer Systems Imaging
Unit 1473, P.O. Box 301439
Houston, Texas 77230
E-mail: vkundra@mdanderson.org

Wolfgang J. Parak
Philipps Universität Marburg
Fachbereich Physik
Renthof 7, 35037 Marburg, Germany
and
CIS biomaGUNE
San Sebastain, Spain
E-mail: wolfgang.parak@physik.uni-marburg.de

Biomimetic and bioinspired materials present an emerging field in the areas of biomedicine, bioengineering, and biological sciences. One of the current trends is the production of biofunctional materials that are able to interact with light and thereby enable applications in therapy, biosensing, and bioimaging. The aim of this special section is to present some of the current state-of-the-art research activities on the use of such materials in relation to the field of biophotonics.

Two of the papers are review articles, which focus on the opportunities and current challenges of nanomaterial-based applications towards life sciences. Vázquez-González and Carrillo-Carrion present a review article on "bio-inspired" or "bio-mimetic" analytical platforms based on quantum dots (QDs) with great potential in the field of detection of heavy metal ions. They provide an overview on state-of-the-art strategies for surface modification of QDs, which together with the photophysical properties of QDs allow for highly sensitive assays. Three main analytical mechanisms based on the interaction of QDs and light are discussed: quenching and enhancement of the photoluminescence, and charge and energy transfer.

Del Pino provides a review article on the relevant parameters and some of the most promising applications resulting from the interactions between electromagnetic (EM) fields and nanoparticles. This review focuses on EM-active nanoparticles, which upon coupling with light or magnetic fields can provide highly useful responses, such as photoluminescence, nanoheating, energy or charge transfer, magnetic resonance, optoacoustic signal, etc. Several examples of bio-functional materials (that is, functionalized nanoparticles towards bio-applications) and corresponding applications in therapy, bioimaging, and biosensing are given. A significant part of this review discusses how current synthetic methods allow for tailoring the coupling and response of materials toward EM fields. Indeed, this topic connects very well with the report of Fujimoto et al. on the use of titanium oxide powder, localized on the tip of a quartz optical fiber, as a medium for transduction of optical energy emitted from a 980 nm semiconductor laser into heat. The authors propose high-power tip-functionalized semiconductor lasers with emission within the NIR window (also called biological window) as an alternative surgical tool for the clinic. By means of this interesting approach, extremely high temperatures can be produced at the tip of the fiber, which may find very useful applications in surgical procedures such as drilling holes in bone.

Maawy et al. present a study on the effectiveness of PEGylation of near-infrared dyes conjugated to a chimeric anti-carcinoembryonic antigen antibody, as an approach to enhance labeling of prostate tumor models. Their results suggest the potential for clinical applications of this optical probe in fluorescence-guided surgery. This work highlights two of the most relevant trends within the scope of this special section of JBO: first, materials with NIR features are highly useful for bioimaging purposes, as well as for therapeutic ones, due to the high penetration of NIR light in biological tissue; second, even the best performing photonics' materials typically require additional surface modifications such PEGylation to improve their biofunction capabilities.

Li and Schneider, using a combined multiphoton imaging-UV/Vis spectroscopic analysis, investigate the effect of gold nanoparticles diameter on their cellular uptake. The optical properties of gold nanoparticles, which extinction coefficients are orders of magnitude stronger than common organic dyes, allow for this quantitative study. Owing to the strong absorption of gold nanoparticles, the concentration of free gold nanoparticles that remained in the cell medium (therefore, not internalized by the cells) was quantified by absorption spectroscopy. On the other hand, multiphoton sources produce bright luminescence, as well as other processes such as second harmonic generation and light scattering, from gold nanoparticles and thereby allow for quantification of the cellular internalization of gold nanoparticles.

Cywinski et al. report on the engineering of nanoconjugates composed of cadmium selenide quantum dots, europium complexes, and biotin. These conjugates provide long-lived photoluminescence by the europium complexes, and may serve as useful platforms in diagnostic and imaging applications. This work highlights how tailoring the surface of nanoparticles—in this study, Europium onto polymer-coated QDs—can improve their “bio-performance” (e.g. long-lived photoluminescence emission).

Overall this special section provides an ample overview of current strategies for the functionalization of materials (mainly focused on inorganic nanomaterials), as well as their most relevant applications in biophotonics. We hope that this collection of papers will be of interest to the biophotonics community. We thank the investigators for their outstanding contributions.

Bahman Anvari received his BS in biophysics from UC Berkeley and PhD in bioengineering from Texas A&M University. He did postdoctoral work at Beckman Laser Institute at University of California, Irvine. He joined the Department of Bioengineering at Rice University in 1998 as an assistant professor and became an associate professor in 2003. He came to the Department of Bioengineering at University of California, Riverside, as a professor in 2006. He is a Fellow of AIMBE, AAAS, and SPIE.

Pablo del Pino graduated in physics from Universidad de Sevilla, Spain, in 2002 and obtained his PhD degree at Technische Universität München, Germany, in 2007. He then joined the group of Wolfgang Parak as a postdoctoral fellow at the Ludwig-Maximilians-Universität München, Munich, Germany. From 2009 to 2013, he was a scientist (first a postdoctoral researcher and in 2013, an independent ARAID junior researcher) at Institute of Nanoscience of Universidad de Zaragoza, Spain. In November 2013, he joined CIC biomaGUNE as a senior postdoc in the Biofunctional Nanomaterials unit.

Vikas Kundra, MD, PhD, is professor and director of molecular imaging in the Department of Radiology, University of Texas M.D. Anderson Cancer Center and has a joint appointment in the Department of Cancer Systems Imaging. He is a Fellow of the Society of Body Computed Tomography & Magnetic Resonance Imaging and a Distinguished Investigator of the Academy of Radiology Research. His translational research focuses on imaging of gene expression and therapy, imageable models of disease, and nanoparticles.

Wolfgang Parak studied physics at the Technische Universität München, Germany, and then received his PhD degree from the Ludwig Maximilians Universität München, Germany. After two years as a postdoc in Berkeley, he became an assistant professor in München, Germany. Currently, he is a full-time professor at the Philipps Universität Marburg, Germany. He is also associate editor of *ACS Nano*.