Journal of Innovative Optical Health Sciences
Vol. 10, No. 5 (2017) 1702002 (3 pages)

DOI: 10.1142/S1793545817020023

Editorial: Introduction to the special issue on bio-photonics in neuroscience and brain diseases

Published 29 September 2017

Photons with a great many tunable physical properties have been profoundly engaged in research of brain science in all aspects for more than a hundred years. Taking advantage of highly developed incoherent light sources, coherent lasers and short-pulse lasers, innovative optical tools including both instrumentations and strategies have significantly boosted comprehensive research on neural science within a very short period. Right before China launches its Brain Project (Chinese version of BRAIN — Brain Research through Advancing Innovative Neurotechnologies) by the end of this year (2017), we are delighted to introduce to our readers a special issue on applications of bio-photonics in neuroscience and brain diseases.

This special issue is intended to introduce 11 original research papers and review papers that cover applications including optogentics, Raman spectroscopy, stimulated Raman scattering microscopy, light sheet, laser speckle contrast imaging, super-resolution and other areas of brain research innovated by advanced optical tools.

The blood-brain barrier (BBB) is a persistent challenge for brain drug delivery. Many physical, chemical and biological methods are able to open BBB, but all of them have their limitations. Eketerina Borisova *et al.* successfully developed an optical approach based on photodynamic therapy (PDT) to break this physical barrier to access the central nervous system of brain.[1] In the other paper from Alexey and his colleagues, the researchers applied laser speckle contrast imaging (LSCI) and multi-scale entropy (MSE) to image the blood flow dynamics in a label-free manner.[2] This optical tool also exhibited excellent capabilities in evaluating the dynamics of permeability of BBB as opened by sound exposure.

Biological tissues are highly scattering for photons. In contrast to X-ray, MRI, and PET, interrogating photons or treatment light wave cannot travel very deep into the tissue, especially for brain tissues that contain largely lipids. The short penetration depth is a long-standing issue for optical brain imaging, photodynamic therapy, and other clinical applications. Ting Li *et al.* simulated light penetration by tuning the laser wavelength, beam shape and beam diameter through innovative high-realistic 3D Monte Carlo modeling.[3] Long-wavelength infrared laser and near infrared laser ($> 800\,\mathrm{nm}$) are typically chosen to study most of the tissue samples. The research team at Tsinghua University applied a 465-nm laser to invoke optical compound action potentials (OCAPs) successfully by manipulating laser pulse energy and pulse duration.[4] To obtain complete 3D structure of whole mouse brain, Prof. Peng Fei and his team at Huazhong University of Science and Technology combined chemical tissue clearance and light-sheet fluorescent microscopy (LSFM) for high-speed imaging.[5] With much reduced tissue scattering, the LSFM achieved four times better spatial resolution as well as superior imaging quality. Despite the difficulties of 3D volume imaging, the astrocyte and pyramidal neurons together with detailed fiber connections have been clearly visualized in their work.

Chemical specification and chemical imaging are essential and desired for brain science. In this special issue, Raman spectroscopy and label-free stimulated Raman imaging are highlighted as increasingly important optical imaging platforms. Dr. Piyush Kumar at Amity University reviewed Raman spectroscopy applied to brain cancer detection.[6] Wang's group at Northwest University in China implemented confocal Raman microspectroscopy to investigate the biochemical specificity of spinal cord tissue.[7] Further, Jiaqi Wang and Ping Qiu introduced a time-lens based coherent Raman scattering microscopy for chemical imaging.[8] Yifan Yang and colleagues in Professor Minbiao Ji's group at Fudan University reviewed recent progress in stimulated Raman scattering (SRS) microscopy for brain tumor histology and broad applications in clinical diagnosis.[9] SRS is capable of differentiating a broad range of brain tissue types, such as grey matter, white matter, and different grades of glioma/meningioma tumors with chemical specification.

All in all, bio-photonics in brain science will eventually push the limits in all the following directions: Photons are able to travel much deeper, above centimeters, in the tissue; they can break the diffraction limit and achieve super-resolution imaging in clinical tissue samples[10]; they can bring much success in *in vivo* and invasive imaging of human brain and diagnosis of brain diseases.[11]

At the end of this editorial, we would like to thank the contributions and efforts from all the authors, reviewers and the editorial office, who bring here this special issue.

Feature Editor

Ping Wang
Britton Chance Center for Biomedical Photonics
Wuhan National Laboratory for Optoelectronics (WNLO)
Huazhong University of Science and Technology
Wuhan 430074, P. R. China
p_wang@hust.edu.cn

References

1. O. Semyachkina-Glushkovskaya, E. Borisova, A. Abdurashitov, A. Shirokov, N. Navolokin, E. Saranceva, "Blood-brain barrier and laser technologies for drug brain delivery," *J. Innov. Opt. Health Sci.* **10**, 1730011 (2017).
2. A. N. Pavlov, A. S. Abdurashitov, O. N. Pavlova, M. V. Ulanova, A. A. Bodrova, N. A. Shushunova, A. P. Khorovodov, O. V. Semyachkina-Glushkovskaya, "Characterization of cerebral blood flow dynamics with multiscale entropy," *J. Innov. Opt. Health Sci.* **10**, 1743005 (2017).
3. T. Li, C. Xue, P. Wang, Y. Li, L. Wu, "Photon penetration depth in human brain for light stimulation and treatment: A realistic Monte Carlo simulation study," *J. Innov. Opt. Health Sci.* **10**, 1743002 (2017).
4. T. Guan, M. Yang, Y. He, "*In vivo* auditory nerve stimulation with visible light," *J. Innov. Opt. Health Sci.* **10**, 1743004 (2017).
5. S. Liu, J. Nie, Y. Li, T. Yu, D. Zhu, P. Fei, "Three-dimensional, isotropic imaging of mouse brain using multi-view deconvolution light sheet microscopy," *J. Innov. Opt. Health Sci.* **10**, 1743006 (2017).
6. P. Kumar, "Raman spectroscopy as a promising noninvasive tool in brain cancer detection," *J. Innov. Opt. Health Sci.* **10**, 1730012 (2017).
7. Y. Gong, Z. Liang, Y. Yin, J. Song, X. Hu, K. Wang, Q. He, Z. Wang, J. Bai, S. Wang, "Interpreting the biochemical specificity of mouse spinal cord by confocal Raman microspectral imaging," *J. Innov. Opt. Health Sci.* **10**, 1743007 (2017).
8. J. Wang, P. Qiu, "Photodetection-induced relative timing jitter in synchronized time-lens source for coherent Raman scattering microscopy," *J. Innov. Opt. Health Sci.* **10**, 1743003 (2017).
9. Y. Yang, L. Chen, M. Ji, "Stimulated Raman scattering microscopy for rapid brain tumor histology," *J. Innov. Opt. Health Sci.* **10**, 1730010 (2017).

10. X. Wang, J. Wang, X. Zhu, Y. Zheng, K. Si, W. Gong, "Super-resolution microscopy and its applications in neuroscience," *J. Innov. Opt. Health Sci.* **10**, 1730001 (2017).
11. L. Li, Y. Tang, L. Sun, K. Rahman, K. Huang, W. Xu, J. Yu, J. Dai, G. Cao, "*In vivo* fiber photometry of neural activity in response to optogenetically manipulated inputs in freely moving mice," *J. Innov. Opt. Health Sci.* **10**, 1743001 (2017).