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Editorial — Introduction to the special issue on photoacoustic and microwave-thermoacoustic imaging

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Photoacoustic imaging and microwave-thermoacoustic imaging are innovative hybrid imaging techniques that have experienced rapid development in recent years. Photoacoustic imaging is based on the photoacoustic effect. When the laser pulses (the width of the laser pulse is usually several nanoseconds to tens of nanoseconds) irradiate the biological tissue, the absorbers in the tissue absorb the optical energy and then induce the instantaneous rise in temperature, and radiate the thermal energy in the form of mechanical energy, i.e. ultrasound signals. We can detect the ultrasound signals with ultrasound transducer and recover the absorption information of the absorbers in the tissue with different imaging algorithms. Photoacoustic imaging integrates the merit of high contrast of optical imaging and high imaging depth of ultrasound imaging. If the excitation source of the photoacoustic imaging is changed into the microwave (the width of the microwave pulse is usually from tens of nanoseconds to hundreds of nanoseconds), that is called thermoacoustic imaging, which can provide high-resolution imaging and imaging depth of more than ten centimeters. Meanwhile, photoacoustic imaging and thermoacoustic imaging have high molecular specificity and have already been widely used in the research of physics, chemistry, and biomedicine.

In the past decade, more and more studies have been made in the technology development and applications of photoacoustic and microwave-thermoacoustic imaging. This special issue is intended to present some of the recent progress mainly from China. Original research papers and reviews included here cover a broad range of topics: development of photoacoustic molecular imaging based on functional nanoparticles and photoacoustic viscoelasticity imaging, new photoacoustic imaging methods and applications, new data analysis and reconstructed method, and the progress of thermoacoustic technology and applications.

In China, Xing and his group are the pioneers in the field of photoacoustic and microwave-thermoacoustic imaging. Firstly, they introduced their pioneering work in photoacoustic viscoelasticity imaging.[1] They introduced the principle of this technique and the research progress of photoacoustic viscoelasticity imaging. Secondly, they summarized the development of photoacoustic molecular imaging based on functional nanoparticles, and discussed the current limitations about functional nanoparticles.[2] Some recent advances in contrast agent design, biochemistry and theranostic applications for photoacoustic imaging are listed. Indeed, the versatile optical probes are now increasingly active in numerous aspects: enhanced sensitivity and specificity, functional biosensing, activatable drug release/response, and imaging of tumor microenvironments. Next, they reviewed the development of combined all-optical photoacoustic imaging and optical coherence tomography.[3] As a new method of all-optical photoacoustic imaging, it shows merits such as noncontact and broad bandwidth. Moreover, they reviewed the progress of thermoacoustic technology and applications, including all kinds of excitation sources, data acquisition systems, and biomedical applications.[4] Meanwhile, they provided prospect of the developmental directions of thermoacoustic imaging, such as expanding the applications in cancer detection and functional imaging, as well as developing the multimodality imaging technology.

Jiang and his group in Chengdu, China presented the original work about *in vivo* imaging of rat brain using microwave-induced thermoacoustic tomography.[5] They found that the imaging contrast was highly dependent on the direction of the electric field polarization and that more tissue structures/compositions could be revealed when both X- and Y- electric field polarizations were used for thermoacoustic imaging. They also compared with MRI images and histological photographs to prove their results. These experimental results showed that thermoacoustic imaging has a great potential to be used in neuroscience studies and in noninvasive imaging of brain disorders.

Zeng and his colleagues in Nanchang, China focused on the low-cost photoacoustic imaging system with laser diode.[6] They reviewed the state-of-the-art developments of low-cost photoacoustic imaging system with laser diode and light-emitting diode excitation source, and highlighted a few representative studies. They also discussed some drawbacks about the laser diode and LEDs in the low-cost photoacoustic imaging system, and forwarded some improvement methods.

Biological tissue is high-scattering object; when the laser irradiates on the tissue, the laser energy decays exponentially along with the depth. In order to obtain the deep tissue imaging and quantify the optical absorption information, the fluence compensation is needed. Li and his colleagues in Beijing, China presented a fluence compensation method to improve the photoacoustic imaging quality of human breast with a handheld PA/US dual-modal imaging probe.[7] The results demonstrated that the fluence compensation indeed improved the imaging quality.

The last paper in this special issue is by Xiang and his co-worker from University of Oklahoma, USA.[8] They reviewed the photoacoustic imaging for prostate cancer detection and its potential in aiding prostate cancer therapy. They also proposed the future development of prostate photoacoustic imaging, including the *in vivo* studies, technology improvement, photoacoustic imaging–guided prostate cancer therapy, and PAI-guided drug delivery.

Finally, we greatly appreciate the efforts and contributions from all of the authors and the editors. We hope that this special issue could be helpful for readers to understand, at least partially, the research currently being investigated in photoacoustic and microwave-thermoacoustic imaging. We also hope that this special issue may assist in bringing advances and new insights to the development and maturation of photoacoustic and microwave-thermoacoustic imaging technology.

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