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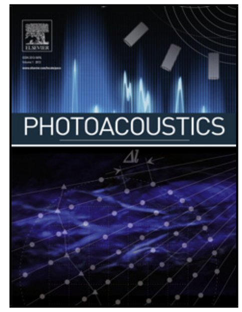

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Multispectral photoacoustic microscopy and optical coherence tomography using a single supercontinuum source

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Abstract

We report on the use of a single supercontinuum (SC) source for multimodal imaging. The 2-octave bandwidth (475-2300 nm) makes the SC source suitable for optical coherence tomography (OCT) as well as for multispectral photoacoustic microscopy (MPAM). The IR band centered at 1310 nm is chosen for OCT to penetrate deeper into tissue with 8 mW average power on the sample. The 500-840 nm band is used for MPAM. The source has the ability to select the central wavelength as well as the spectral bandwidth. An energy of more than 35 nJ within a less than 50 nm bandwidth is achieved on the sample for wavelengths longer than 500 nm. In the present paper, we demonstrate the capabilities of such a multimodality imaging instrument based on a single optical source. *In-vitro* mouse ear B-scan images are presented.

Keywords: multimodal imaging, multispectral imaging, photoacoustic, optical coherence tomography, supercontinuum

1. Introduction

Optical coherence tomography (OCT) and photoacoustic microscopy (PAM) provide complementary contrasts, which can be combined to benefit biomedical research and preclinical studies. OCT allows structure reconstruction via backscattered signal due to the scattering properties of the sample being investigated. PAM is based on tissue absorption properties by optical excitation and ultrasonic detection. Both techniques offer real-time and non-invasive imaging. Combined OCT-PAM systems have already been reported for a wide range of applications such as dermal or retinal imaging [1–5].

In most of the previous work carried out on bimodal OCT-PAM, two different light sources are used to accommodate the requirements of each modality. OCT employs broadband light sources, the most common of these being super-luminescent diodes (SLD). Recent developments of low noise supercontinuum sources (NKT Photonics A/S) made such sources attractive to ultra-high resolution OCT [6] as well as visible OCT [7, 8] since they offer a spectral range from 475 nm to 2300 nm. No other light source can cover such a wide bandwidth. PAM typically requires a light source with a pulse duration of a few nanoseconds because of thermal and stress confinement of the excitation beam in the sample. PAM commonly uses single-wavelength lasers as the excitation source, such as Nd:YAG lasers at 1064 nm [9] or its frequency-doubled counterpart at 532 nm [10], or dye lasers [11]. In order to perform multispectral PAM (MPAM), one can use multiple lasers [12], optical parametric oscillators [13] (at the cost of price and speed), stimulated Raman scattering fiber lasers [14, 15] (discrete wavelengths with limited choice) or supercontinuum sources [5, 16, 17] (wide wavelength range with limited energy). Previously reported supercontinuum sources for MPAM delivered too little energy per pulse to image biological samples [16, 17], more than 50 nJ within a bandwidth of less than 50 nm is typically required. Preliminary work targeting the enhancement in the pulse energy of supercontinuum sources (> 100 nJ) has been reported [18, 19].

Here a commercial supercontinuum source from NKT Photonics A/S (SuperK Compact) that offers more than 35 nJ per bandwidth of less than 50 nm over a broad wavelength range extending from 500 nm to 800 nm is used. The source is cost effective, compact and reliable. In addition, such a source can be used for OCT and can offer high resolution due to the large optical bandwidth available. To our knowledge, this is the first report on a combined OCT-MPAM system that offers fast volumetric imaging as well as spectroscopic measurements within a wide range of wavelengths covering the visible and extending from 500 nm to 840 nm with comparable energy to those of single wavelength lasers. This paper is an extension and continuation of the preliminary OCT images and spectroscopic photoacoustic measurements presented in our previous work [20]. Visible light is used in this paper because we intend to target hemoglobin, which absorbs mainly between 500 nm and 600 nm. This is the most imaged absorber for PAM, reported for MPAM alone [17] or combined with the structural information of OCT [1–5].

After some primary work to illustrate the system capabilities, we present in Section 3.3 *in-vitro* images of a mouse ear.

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