Coherent broadband light source for parallel optical coherence tomography

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Optical coherence tomography (OCT) is a recent technique for biomedical imaging. Tomographic images with micrometer resolution can be generated using fiber interferometers with broadband light sources. The longitudinal resolution of such instruments is inversely proportional to the optical bandwidth of the light source. Femtosecond Ti:sapphire lasers have, therefore, been used as large-bandwidth, high-brightness light sources, and sub-cellular imaging with longitudinal resolution of ~1 μm has been demonstrated in this way. Unfortunately, these systems are expensive and complex, limiting their widespread use.

Broadband luminescence from Ti:sapphire with luminescence gain bandwidths ranging from 670-1100 nm can also significantly improve the longitudinal resolution to <2 μm, while avoiding the complexity of femtosecond light sources. Ultrahigh-resolution OCT imaging in tissue was performed with such a light source at low speed on an African frog (*Xenopus laevis*) tadpole *in vivo* [1]. The brightness of such broadband light sources was improved by luminescence guiding in channel waveguides fabricated by pulsed laser deposition and subsequent reactive ion etching or Ar ion milling through a patterned photolithographic mask, and transverse fundamental-mode luminescence output of several hundreds of μW was achieved [2].

We have parallelized such a Ti:sapphire channel-waveguide emitter by structuring parallel ribs into a planar waveguide and pumping these ribs simultaneously by an Ar^+-laser line focus coupled into the parallel waveguides through a cylindrical lens (active in the vertical direction) and a cylindrical microlens array (active in the horizontal direction), see Fig. 1, thus creating single-mode broadband luminescence output from parallel channels, see Fig. 2. We demonstrate fully parallel OCT by launching such a light source into a free-space Michelson interferometer combined with a CMOS detector array where each pixel performs amplitude demodulation [3]. Only one depth scan is needed to acquire a whole cross-section image, thus allowing high-speed imaging [4]. Use of the present parallel light source allows to decrease optical cross-talk that would occur in standard parallel OCT using a wide-field illumination of the sample [5]. Experimental results obtained with this parallel system will be reported at the conference.

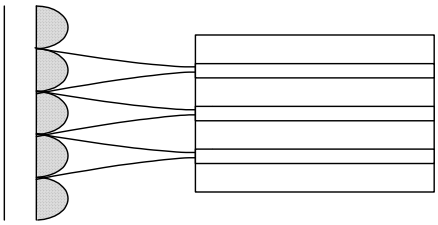

Fig. 1. Schematic of the parallel-waveguide light source. The line focus of an Ar-ion laser is coupled into the channel waveguides through a microlens array.

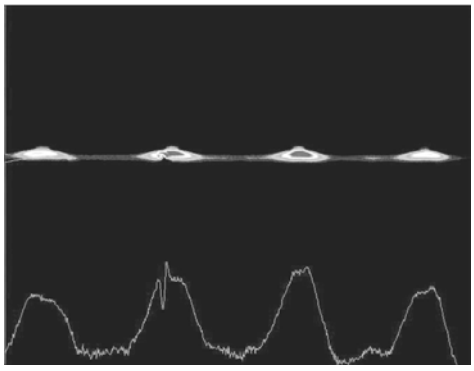

Fig. 2. Broadband Ti^{3+} luminescence centered near 760 nm outcoupled from parallel channels of the waveguide array.

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