

Enhanced transmission through opaque ocular media and deeper penetration into the choroid of high speed optical coherence tomography at 1050nm

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Abstract: High speed optical coherence tomography (OCT), based on the frequency domain (FD) acquisition scheme enables scanning speeds of multiple thousand depth scans per second for investigation of the human retina in vivo. Ophthalmic FD-OCT systems are commonly designed to operate at 800 nm. Though being able to resolve all major retinal layers, this wavelength has shown to be strongly affected by opaque obstacles in the beam path, like cataracts, that are common in elderly patients. 1050 nm has already proven to be a wavelength range that allows deeper penetration beneath the retinal pigment epithelium into the choroid and enables to investigate choroido-vascular disorders like neovascularisation, because of lower scattering inside tissue. With the presented a spectrometer based FD-OCT system, the deeper penetration could be demonstrated also for high speed, volume acquisition in patients. Additionally the lower scattering at this wavelength improves the transparency of cataracts, thereby significantly widening the applicability of OCT.

Key words: optical coherence tomography, retinal imaging, choroid, penetration, scattering, infrared

Biography: Boris Považay received his Masters degree in Technical Physics in 1990 at the Vienna University of Technology, Austria, in the field of laser physics. Until 2006 he was associated to the Medical University of Vienna, Austria to conclude his studies in the field of OCT in association with the Vienna University of Technology where he earned a PhD in Electrical Engineering. Currently, he holds a lecturer position at the School of Optometry and Vision Sciences at Cardiff University, Wales, United Kingdom.

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In the last years the method of high speed frequency domain optical coherence tomography^{[1][2]} (FD-OCT) became available for ophthalmic *in vivo* imaging, increasing the acquisition speed from several hundred depth-scans per second by two orders of magnitude, without sacrificing sensitivity^[3]. This increase was caused by the simultaneous measurement of the full depth scan with a line-array detector in an imaging spectrometer. The availability of high speed line-arrays however was limited to the wavelength range below 1000 nm, due to silicon based sensing equipment and high speed, high resolution OCT was restricted to the 750-850 nm range, where multiple light sources were available. Recently new light sources, centred at 1050 nm with bandwidths above 50 nm were introduced. With slowly scanning time-domain OCT systems it could be shown^[4] that this wavelength allows for signal extraction from layers beneath the retinal pigment epithelium (RPE), necessary for investigation of the choriocapillaris and choroidal vascular system. With state-of-the-art high speed InGaAs, 512 pixel line array camera (Sensors Unlimited, Inc.) we were able to build a FD-OCT system, operating at 1050 nm with a bandwidth of 70 nm (NP-Photonics, Inc). Connected with an OCT-2 patient module (Zeiss Meditec), modified for operation at 1050 nm, this

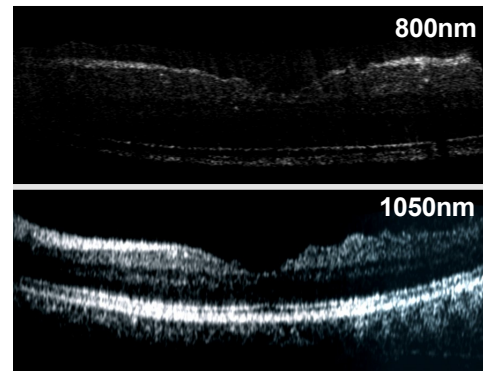


fig. 1: Comparison of signal intensity in an cataract-eye at 800 and 1050nm FD-OCT (OS CAT-III: NO1.5 NC1.5 C2.2 P3.0) – both at 70% of allowed corneal exposure. $\Delta\lambda=140\text{nm}@800\text{nm}\rightarrow\Delta z<3\mu\text{m}$ (best cross section of 60 frame set!); $\Delta\lambda>70\text{nm}@1050\text{nm}\rightarrow\Delta z$ (axial res.) $\sim 6\mu\text{m}$.

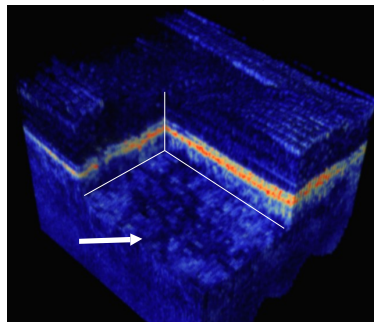


fig. 2: Rendering illustrating the deeper penetration at 1050nm, despite a cataract that reduces the overall signal quality. Arrow depicts choroidal vessel system.

device was used to investigate the usability in case of cataracts or to monitor vascularisation and overall performance for imaging retinal and choroidal morphology. In preliminary tests it could be shown that FD-OCT at 8 kHz line rate and 1050 nm central wavelength significantly improves penetration through scattering media that are usually intransparent for the commonly used 800 nm illumination (see fig. 1), additionally to the higher penetration into the choroid (compare fig. 2).

1050 nm OCT technology improves clinical usability of OCT, especially for the wide range of patients with less transparent media where common 800 nm systems currently cannot be used.

References

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