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BIOPHOTONICS

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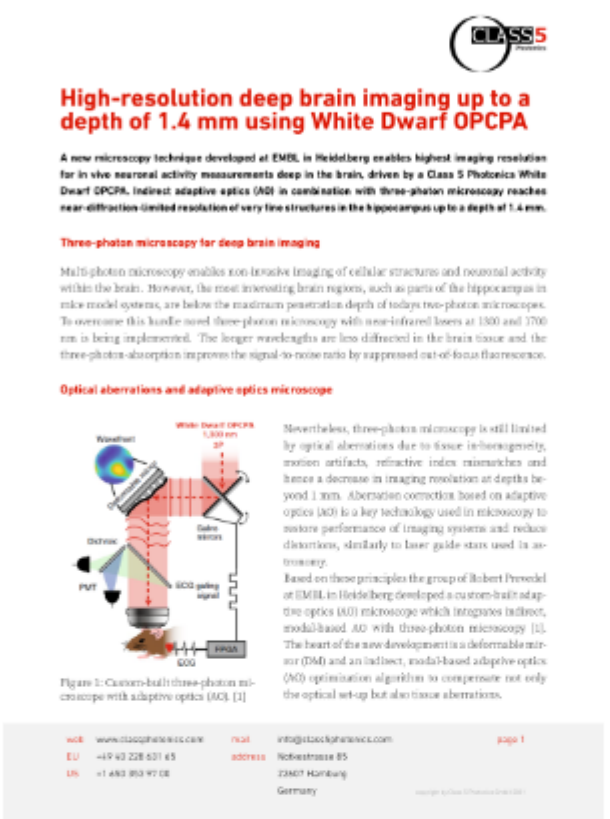

CLASS 5

High-resolution deep brain imaging up to a depth of 1.4 mm using White Dwarf OPCPA

A new microscopy technique developed at EMBL in Heidelberg enables highest imaging resolution for in vivo neuronal activity measurements deep in the brain, driven by a Class 5 Photonics White Dwarf OPCPA. Indirect adaptive optics (AO) in combination with three-photon microscopy reaches near-diffraction-limited resolution of very fine structures in the hippocampus up to a depth of 1.4 mm.

Three-photon microscopy for deep brain imaging

Multi-photon microscopy enables non-invasive imaging of cellular structures and neuronal activity within the brain. However, the most interesting brain regions, such as parts of the hippocampus in mice model systems, are below the maximum penetration depth of todays two-photon microscopes. To overcome this hurdle novel three-photon microscopy with near-infrared lasers at 1300 and 1700 nm is being implemented. The longer wavelengths are less diffracted in the brain tissue and the three-photon-absorption improves the signal-to-noise ratio by suppressed out-of-focus fluorescence.

Optical aberrations and adaptive optics microscope

Figure 1: Custom-built three-photon microscope with adaptive optics (AO). [1]

Nevertheless, three-photon microscopy is still limited by optical aberrations due to tissue inhomogeneity, motion artifacts, refractive index mismatches and hence a decrease in imaging resolution at depths beyond 1 mm. Aberration correction based on adaptive optics (AO) is a key technology used in microscopy to restore performance of imaging systems and reduce distortions, similarly to laser guide stars used in astronomy.

Based on these principles the group of Robert Prevedel at EMBL in Heidelberg developed a custom-built adaptive optics (AO) microscope which integrates indirect, modal-based AO with three-photon microscopy [1]. The heart of the new development is a deformable mirror (DM) and an indirect, modal-based adaptive optics (AO) optimization algorithm to compensate not only the optical set-up but also tissue aberrations.

web www.classphotonics.com mail info@classphotonics.com page 1
EU +49 40 228 601 65 address Notkestrasse 85
US +1 480 950 97 08 22607 Hamburg
Germany

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A new microscopy technique developed at EMBL in Heidelberg enables highest imaging resolution for in vivo neuronal activity measurements deep in the brain, driven by a Class 5 Photonics White Dwarf OPCPA. Indirect adaptive optics (AO) in combination with three-photon microscopy reaches near-diffraction-limited resolution of very fine structures in the hippocampus up to a depth of 1.4 mm. The results published in Nature methods have been achieved during a demo roadshow of the White Dwarf OPCPA. Hence, the great success motivates us to our next demo roadshow in 2022. Achieve immediate, new scientific results in Neuroscience with the White Dwarf by testing and trying out our high performance laser system specially designed for 3-photon microscopy at 1300 and 1700 nm.

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