Swept source optical coherence tomography imaging by an MOEMS endomicroscopy probe with Mirau micro-interferometer and two-axis electrothermal micro-scanner using Lissajous curves scanning.

Przemysław Struk*[a], Sylwester Bargiel [b], Michał Józwik [c], Bartosz Mirecki [c], Maciej Wojtkowski [d,e], Huikai Xie[f,g], Christophe Gorecki [d,e]

[a] *Silesian University of Technology, Department of Optoelectronics, Faculty of Electrical Engineering, 2 Krzywoustego Str., 44-100 Gliwice, Poland.*
[b] *FEMTO-ST Institute (UMR CNRS 6714), UBFC, 15B Avenue des Montboucons, 25030 Besançon cedex, France.*
[c] *Warsaw University of Technology, Faculty of Mechatronics, Institute of Micromechanics and Photonics, 8 Sw. A. Boboli St., 02-525 Warsaw, Poland.*
[d] *International Center for Translational Eye Research (ICTER), ul. Skierniewicka 10a, 01-230 Warsaw, Poland.*
[e] *Institute of Physical Chemistry, Polish Academy of Sciences, ul. Kasprzaka 44/52, 01-224 Warsaw, Poland.*
[f] *School of Information and Electronics, Beijing Institute of Technology, Beijing 100081, China.*
[g] *University of Florida, P.O. Box 116200, Gainesville, FL 32611-6200, USA.*

[#]*corresponding author email: Przemyslaw.Struk@polsl.pl*
**Presenting author*

1. Main Text

This paper presents the results of a study focused on the development of an innovative integrated probe designed for modern endomicroscopic application. A new type of transverse scanning probe is presented, which was built using Mirau micro-interferometer fabricated in Micro-Opto-Electro-Mechanical Systems (MOEMS) technology, and a 2-axis electrothermal micro-scanner fabricated in Micro-Electro-Mechanical Systems (MEMS) technology, connected with a GRIN lens collimator and single mode fiber, which transmits the interferometric signal to the single point detector (photodiode) [1,2,3]. The Authors present a numerical analysis and an optimization of endomicroscopic probe optical properties and scanning properties, based on Lissajous trajectories. The 2D- and 3D-imaging of phantom structures visualized with an endomicroscopy probe is shown. The imaging was obtained by the Swept Source Optical Coherence Tomography technique (SS-OCT), using swept source laser which working at a central wavelength λ_c = 1,06 μm, a swept range $\Delta\lambda$ = 0,1 μm, an A-scan rate equal to f_A = 200 kHz, and the scanning of samples with the use of Lissajous curves. The presented results confirm the proper operation and functionality of the presented endomicroscopic probe, which allows scanning of structures with a relatively large scanning area at the level of 71 μm x 86 μm with the frame rate 10 fps or 110 μm x 110 μm with the frame rate 5 fps depending on the driving electric signal - voltage and frequencies delivered to 2-axis electrothermal actuator [1]. The endomicroscopic probe enables of scanning samples with a high axial resolution at the level of 5 μm and transverse resolution 14 μm [1,3]. The integration of the MOEMS Mirau micro-interferometer with a MEMS two-axis electrothermal actuator, and analyzing the scanning trajectory with Lissajous curves allows for precise and fast 2D as well as 3D imaging of the examined structures by SS-OCT techniques. The presented MOEMS endomicroscopy probe with its small geometric size (4.8 mm x 4.8 mm x 22 mm) and operating parameters such as: axial and lateral resolution, scanning speed and scanning area is an attractive solution for applications in medical endomicroscopic devices for 2D and 3D imaging of human upper digestive tract using the SS-OCT technique [1,2,3].

2. Acknowledgement

This work was supported by the Labex Action program ANR-11-LABX-0001-01, the project ROBOT ("Robotics and Optical Coherence Tomography (OCT) for BiOpsy in the digestive Tract "Project No: INSERM Robot 2017-0123, the French RENATECH network and its FEMTO-ST technological facility and by the Collegium SMYLE, the Silesian University of Technology Rector's pro-quality grant: 05/040/RGJ20/2003, National Science Center (2020/38/L/ST2/00556).

4. References

[1] Przemysław Struk, Sylwester Bargiel, Michal Józwik, Bartosz Mirecki, Maciej Wojtkowski, Huikai Xie and Christophe Gorecki, "Optical Coherence Tomography Imaging by a Fully Integrated MOEMS Endomicroscopy Probe With Mirau Microinterferometer and Two-Axis Electrothermal Microscanner Using Lissajous Trajectory Scanning," IEEE Sensors Journal, vol. 24, no. 9, pp. 13903-13913, 1 May1, 2024.

[2] Przemyslaw Struk, Sylwester Bargiel, Luc Froehly, Maciej Baranski, Nicolas Passilly, Jorge Albero, and Christophe Gorecki, Swept Source Optical Coherence Tomography Endomicroscope Based on Vertically Integrated Mirau Micro Interferometer: Concept and Technology, IEEE Sensors Journal, Vol. 15, no. 12, pp. 7061-7070, 2015.

[3] Przemysław Struk, Sylwester Bargiel, Quentin Tanguy, Q.A.A.; Fernando Garcia Ramirez, Nicolas passilly, Philippe Lutz, Olivier Gaiffe, Huikai Xie, Christophe Gorecki, "Swept-source optical coherence tomography microsystem with an integrated Mirau interferometer and electrothermal micro-scanner, Optics Letters, Vol. 43, Issue 19, pp. 4847-4850, 2018.