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Method, System and Application for 3D Molecular Diffusion Tensor Measurement and Structural Imaging (2020-022)

The first biologically relevant 3D FRAP microscope

Market Overview

Fluorescence recovery after photobleaching (FRAP) is a versatile and widely used technique for measuring molecular diffusion properties within solutions, cells, tissues, biomaterials and the food and pharmaceutical industries. While it is a standard tool in biomedical and environmental research, all existing FRAP systems can only measure 2D diffusion, providing only diffusion measurement in limited directions. The long-standing goal to create a 3D diffusion tensor has not yet been achieved. The global Light Sheet Microscopy market segment was valued at $101.2 million in 2020 at a CAGR of 10.3% and is projected to grow to $181.9 million in 2026. This can be associated with application for a 3D FRAP microscope in the Biomaterials market segment, which was valued at $105.18 billion in 2019 at a CAGR of 14.5%. Clemson University researchers have implemented the first 3D FRAP microscope in the world by innovatively combining the 3D spatial Fourier transform FRAP method with high speed volumetric imaging and high-resolution structural imaging, calling it Light-sheet imaging-based Fourier transform FRAP (LiFT-FRAP).

Technical Summary

This technology incorporates high-speed 3D two-photon scanned light-sheet microscopy with the 3D Fourier transform FRAP method and achieves noninvasive, in-situ measurement of 3D diffusion tensors with diffusivities up to 51 μm2/s. This sensitivity is within the diffusion range of most molecules in biological systems, making FRAP a practical tool for 3D diffusion analysis in broad biomedical applications. A customized control software is written to run the microscope for performing the 3D FRAP experiment; included data analysis package provides a seamless process of acquired images for calculation of 3D diffusion tensors.

Application

FRAP, 3D Diffusion Tensor, Light-sheet Microscopy

Development Stage

Prototype

Advantages

- LiFT-FRAP allows for quantification in any direction in a 3D space
- The microscope provides for a much higher volumetric imaging speed than the current available approach for FRAP, therefore LiFT-FRAP can measure a wide range of molecular diffusivities
- This approach avoids the previously necessary tissue sectioning, plus all of the structural integrity problems and material property changes

App Type	Country	Serial No.	Patent No.	CURF Ref. No.	Inventors
Patent	United States	63/052,726	NA	2020-022	Dr. Hai Yao Dr. Tong Ye

About the Inventors

Dr. Hai Yao

Professor of Bioengineering at Clemson University

Dr. Hai Yao received his Ph.D. in Biomedical Engineering from the University of Miami in 2004. Along with being a professor, Dr. Yao is the Ernest R. Norville Endowed Chair and Associate Chair for the CU-MUSC Bioengineering Program. Dr. Yao's research interests include musculoskeletal biomechanics, multiscale modeling, biotrasport, and tissue engineering.

Dr. Tong Ye

Associate Professor of Bioengineering at Clemson University

Dr. Tong Ye received his Ph.D. in Optics from Chinese Academy of Sciences in 1995. Dr. Ye is the principal investigator of the Nano and Functional Imaging Lab at Clemson University. His research interests include optical imaging, functional imaging, and light-biomaterial interaction.

For more information on this technology contact:

A. Chris Gesswein
Director of Licensing for Technology Transfer
E: agesswe@clemson.edu
P: (864) 656-0797