(SD2023-232) Multi-Dimensional Widefield Infrared-encoding Spontaneous Emission Microscopy

Tech ID: 33369 / UC Case 2021-Z08-1

BACKGROUND

Hyperspectral imaging (HSI) is an emerging imaging modality for medical applications, especially in disease diagnosis and image-guided surgery. HSI acquires a three-dimensional dataset called hypercube, with two spatial dimensions and one spectral dimension. Spatially resolved spectral imaging obtained by HSI provides diagnostic information about the tissue physiology, morphology, and composition.

Researchers from UC San Diego developed a new method using a pair of femtosecond mid-infrared and visible excitation pulses to distinguish chromophores, including molecules and quantum dots, that possess nearly identical emission spectra using multiplexed conditions in a three-dimensional space.

TECHNOLOGY DESCRIPTION

Photoluminescence (PL) imaging has broad application in visualizing biological activities, detecting chemical species, and characterizing materials. Though the spontaneous emission of PL signals can be detected with high sensitivity, it lacks the information on the identity and environment of chromophores. The broad PL bands in the visible wavelength region also limits the total number of simultaneously monitored chemical species. Nonlinear optical microscopies using molecular chromophores have been demonstrated to encode additional information into PL signals. However, such microscopies often operate under the tightly focused confocal configuration due to the high intensity required for nonlinear optical interactions.

Researchers from UC San Diego demonstrate a multiplexed widefield imaging method, Multi-Dimensional Widefield Infrared-encoding Spontaneous Emission (MD-WISE) microscopy. Using a pair of femtosecond mid-infrared and visible excitation pulses, MD-WISE can distinguish chromophores, including molecules and quantum dots, that possess nearly identical emission spectra using multiplexed conditions in a three-dimensional space.

The space is defined by three independent variables: the temporal delay between the infrared and the visible

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OTHER INFORMATION

KEYWORDS
medical hyperspectral imaging, tissue optics, quantitative imaging, image-guided surgery, image analysis and classification, widefield imaging, multiplexing imaging, therapeutics, ultrafast laser

CATEGORIZED AS
- **Optics and Photonics**
  - All Optics and Photonics
- **Imaging**
  - Medical
  - Molecular
- **Medical**
  - Imaging

RELATED CASES
2021-Z08-1

pulses, and the optical frequencies of the two pulses. The PL emissions from molecules with various functional groups can be distinguished by tuning the infrared pulse to specific vibrational frequencies of functional groups. Quantum dots and molecules can be distinguished in PL images by varying solely the temporal delay.

APPLICATIONS

By demonstrating the capacity of registering multi-dimensional information into widefield PL images, MD-WISE microscopy has the potential of expanding the number of species and processes that can be simultaneously tracked in high-speed chemical imaging applications.

ADVANTAGES

STATE OF DEVELOPMENT

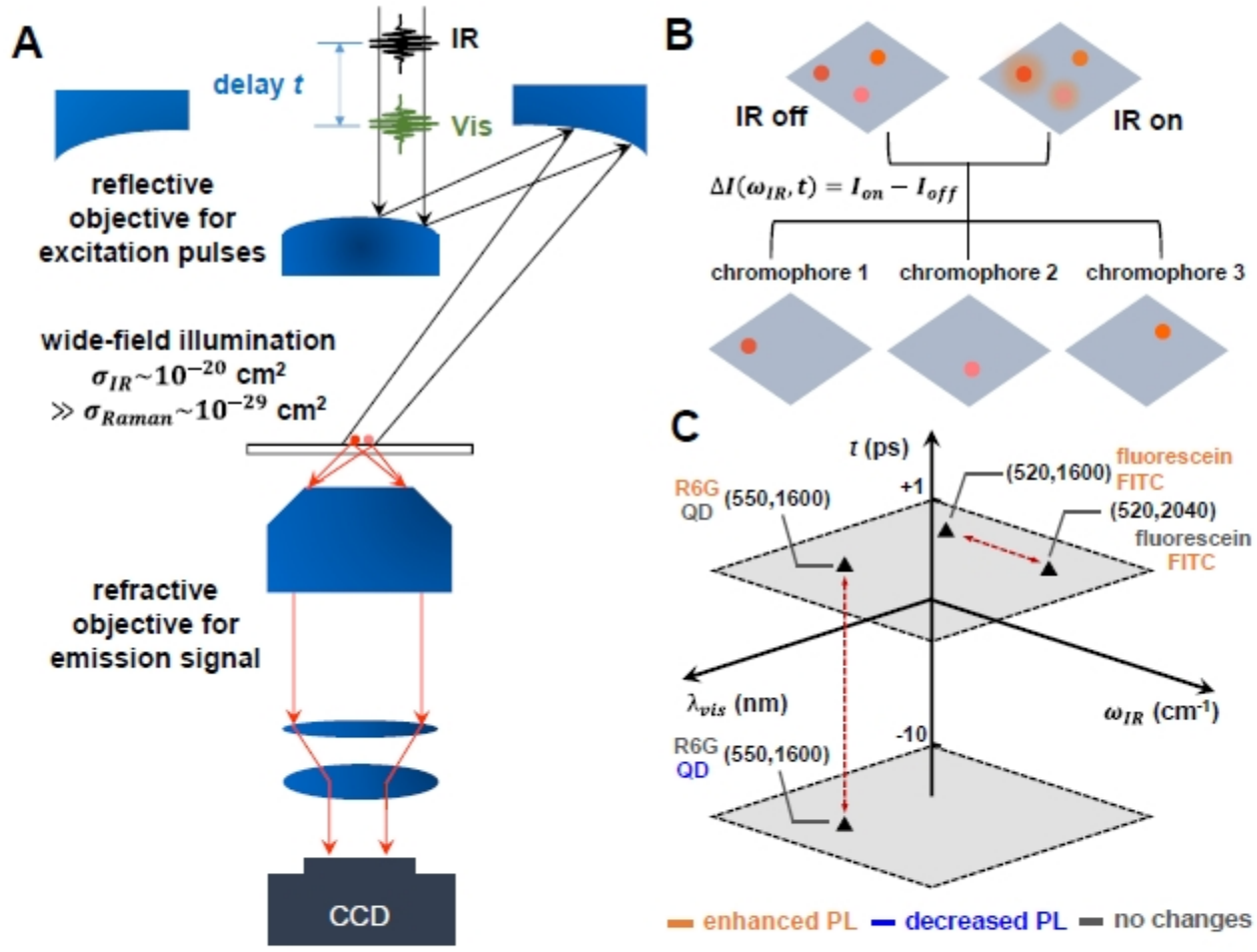


Fig. 1 **(A)** Schematic illustration for MD-WISE microscopy, positive delay of t denotes that the IR pulse arrives earlier than the visible pulse. **(B)** The intensity of PL signals generated following the visible excitation pulse can be encoded by the optical frequency of IR pulse or the delay t. By taking the difference images with or without IR pulse, various chromophores can be distinguished apart even if their emission spectra are nearly identical. **(C)** The change of a chromophore's PL induced by the IR pulse, either there is no change (gray), or increased PL (orange) or decreased PL (blue), is a function of independently tunable variables expressed as the three orthogonal axes: visible excitation wavelength λ_{vis} (nm), IR frequency ω_{IR} (cm^{-1}), and ultrafast delay t (ps). By choosing a condition (▲) in the three-dimensional space, pairs of chromophores with nearly identical PL spectra can be distinguished from each other, such as the pairs of QD versus R6G and FITC versus fluorescein. The two gray shaded planes are condition planes having the same delay, +1 or -10 ps, and the coordinates in brackets are expressed as (λ_{vis}, ω_{IR}).

INTELLECTUAL PROPERTY INFO

Patent rights are available for licensing for commercial deployment.

RELATED MATERIALS

- Wei Xiong, Chang, Yan and Chenglai Wang. 2023. Multi-dimensional widefield infrared-encoded spontaneous emission microscopy: distinguishing chromophores by ultrashort infrared pulses, at SPIE Photonics West 2023, at San Francisco. - 01/28/2024
- Multi-dimensional Widefield infrared-encoding spontaneous emission microscopy: distinguishing chromophores by ultrashort infrared pulses ACS Fall 2023 - Sessions, No. 3906214 - 08/16/2023

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