【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project : Molecular imaging of living cells with metallic nanoparticles

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Research Project Number : 26000011　Researcher Number : 30144439
Research Area : Nanophotonics
Keyword : nanophotonics, plasmonics, nanoimaging, bioimaging

【Purpose and Background of the Research】

In various research fields, such as material science, bioscience, organic chemistry, and electrical devices, the demand for analytical imaging with nanometer-scale resolution has been steadily increasing over the past decade and has been the driving force behind recent advances in microscopy. For example, electron microscopy and probe microscopy have enabled us to observe atomic scale structures. However, their applications in the observation of living specimens are still limited.

To overcome the limitations of electron microscopy and probe microscopy, we have utilized optical light to develop optical microscopy techniques with nanometer resolution and have been leading this research field. Recently, we demonstrated a 4 nm spatial resolution to observe carbon nanotubes using near field optical microscopy, realizing the highest spatial resolution in optical microscopy. By combining near-field optical microscopy and surface-enhanced Raman scattering technique, we have further added the capability of material analysis and expanded its application into various other scientific research fields including cellular imaging, but the observation was still limited in the 2D plane. In this research, the research group aims to develop imaging techniques for observing the intracellular 3D space with capability for material and environmental analysis.

【Research Methods】

In this research, we develop a new optical microscope which can resolve intracellular structures in 3D with nanometer-scale resolution. Our approach is to introduce a metallic nanoparticle into a living cell and utilize it as a probe for imaging and analysis of intracellular molecules. The metallic nanoparticle explores the cell by being transported by cellular functions or diffusion while illuminating adjacent molecules through the light field localized by plasmon polariton. Since the illuminated molecules reveal their presence to us by scattering the localized light, the measurement of the scattering light and the particle position in the sample provides a precise position of the molecules. A time-sequential detection of Raman spectra and particle positions visualizes the molecule distribution of the nanoparticle pathways, finally revealing the intracellular structures in 3D.

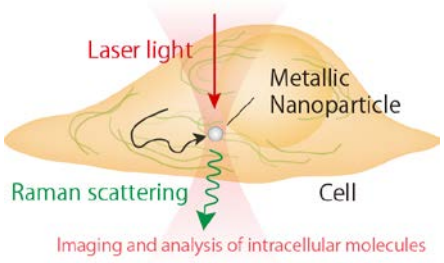

Figure 1　Molecular imaging of a living cell with metallic nanoparticles

【Expected Research Achievements and Scientific Significance】

In this research, we will develop a microscopy technique that allows us to observe biological samples with nanometer scale resolution in 3D space without labeling. The technique will provide distribution of molecular vibrations in the 3D space of a living cell, with which we can derive information about chemical environments and biomolecule responses to exogenous stimuli, such as pharmaceutical treatments.

【Publications Relevant to the Project】

・Yano et al., Nat. Commun., **4**, 2592 (2013).
・Palonpon et al., Nat. Protoc., **8**, 677 (2013).
・Okada et al., PNAS, **109**, 28 (2012).
・Ando et al., Nano Lett., **11**, 5344 (2011).
・Yano et al., Nat. Photon., **3**, 473 (2009).

【Term of Project】 FY2014-2018

【Budget Allocation】 401, 600 Thousand Yen

【Homepage Address and Other Contact Information】

http://lasie.ap.eng.osaka-u.ac.jp/