Program

International workshop on coupled plasmonic nanostructures and their applications to chemical sensing/reactions

Date: 6th August 2018

Place: Meeting Room (RIES bldg. 1F)

9:20-9:25 Opening Remarks Hiroaki Misawa

9:25-10:10 Stephan Link (Rice Univ.)
Carrier Dynamics in Plasmonic Nanostructures

10:10-10:30 Kosei Ueno, Quan Sun, Hiroaki Misawa (Hokkaido Univ., National Chiao Tung Univ.)
Spectral properties of plasmonic strong coupling systems

10:30-11:05 Kuang-Li Lee (Academia Sinica)
Fano resonances in capped metallic nanoslits for highly sensitive plasmonic sensors

11:05-11:15 Break

11:15-12:00 Christy F. Landes (Rice Univ.)
Towards predictive separations, one protein at a time

12:00-12:20 Xu Shi, Kosei Ueno, Tomoya Oshikiri, Quan Sun, Keiji Sasaki, Hiroaki Misawa (Hokkaido Univ., National Chiao Tung Univ.)
Enhanced plasmon-induced water splitting under modal strong coupling conditions

12:20-12:25 Closing Remarks Hiroaki Misawa

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Abstract

Carrier Dynamics in Plasmonic Nanostructures

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Aluminum nanostructures support tunable surface plasmon resonances and have become an alternative to gold nanoparticles. While gold is the most-studied plasmonic material, aluminum has the advantage of high earth abundance and hence low cost. In addition to understanding the size and shape tunability of the plasmon resonance, the fundamental relaxation processes after photo-excitation must be understood to take full advantage of aluminum nanostructures in various applications including photocatalysis and photodetection. In this work, we investigate the energy relaxation after ultrafast pulsed excitation and the launching of acoustic vibrations in individual aluminum nanodisks with varying diameters using single-particle transient extinction spectroscopy. We compare the results to individual and coupled gold nanostructures that are studied through a combination of various single particle techniques: pump-probe transient extinction spectroscopy, photothermal imaging, and emission spectroscopy.

Spectral properties of plasmonic strong coupling systems

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Nanoparticles of metals such as silver and gold show very intense color which is derived from localized surface plasmon resonances (LSPRs). LSPRs which are collective oscillations of conduction electrons give rise to the enhancement of electromagnetic field in the vicinity of metallic nanostructure. Especially, closely-spaced metallic nanostructures which are called as coupled plasmonic systems inducing plasmon hybridization or electromagnetically-induced transparency show strong enhancement of electromagnetic field due to localization of electromagnetic field at nanogap or suppression of light scattering due to a quadrupole mode excitation based on near-field interactions. In this presentation, spectral properties of coupled plasmonic systems based on plasmon hybridization and Fano resonance will be presented. Near-field spectrum measurements are crucial to distinguish strong and weak couplings. Besides, the spectral properties of vibrational strong coupling systems will be introduced for the study elucidating whether the vibrational states are really modulated or not by Raman scattering spectroscopy.

Fano resonances in capped metallic nanoslits for highly sensitive plasmonic sensors

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Surface plasmon resonance (SPR) sensing enables real-time and label-free measurements of biomolecular binding affinity and is beneficial to some applications including food safety, environmental monitoring and medical diagnostics. Common SPR sensor utilizes an optical prism to induce the propagation of surface plasmon polaritons on thin metallic films. The SPR can also be

excited using metallic nanostructures. Compared to the prism-based SPR sensors, nanostructured-based SPR sensors have some benefits, including no need of prism, simple measurement, small detection volume, and ease of multiple detections. Thought nanostructure-based plasmonic sensors have many advantages, improving their surface sensitivities is still an important issue. In this talk, different methods will be introduced to improve the sensing capability of nanoslit-based SPR sensors, such as spectral integration analysis, thermal-annealing nanoimprint methods, Fano couplings, oblique-angle-induced Fano resonances and nearly guided wave SPR sensors.

Towards predictive separations, one protein at a time

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Understanding nanoscale protein dynamics at interfaces is crucial for topics ranging from disease inception and drug delivery to separations science. Recent efforts by our group and others have shown the promise of applying single molecule methods to link mechanistic detail about protein adsorptions to macroscale observables. When we study one molecule at a time, we eliminate ensemble averaging, thereby accessing any underlying complexity. However, we must develop new methods to increase information content in the resulting low density and low signal-to-noise data and to improve space and time resolution. I will highlight recent advances in super-resolution microscopy for quantifying the physics and chemistry that occur between target proteins and stationary phase supports during chromatographic separations. My discussion will concentrate on the newfound ability of super-resolved single protein spectroscopy to inform theoretical parameters via quantification of adsorption-desorption dynamics, protein unfolding, and nanoconfined transport.

Enhanced plasmon-induced water splitting under modal strong coupling conditions

Xu Shi[1], Kosei Ueno[1], Tomoya Oshikiri[1], Quan Sun[1,] Keiji Sasaki[1], and Hiroaki Misawa[1,2]

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Plasmon-induced charge separation between metallic nanoparticles and semiconductor has received much attention as a novel strategy for the solar energy conversion. However, for the monolayer of metallic nanoparticles on the semiconductor, the insufficient absorption limited its solar energy conversion efficiency. Aiming at the enhancement of the light absorption, in this study, we apply the principle of modal strong coupling to plasmonic water splitting induced by plasmon-excited electrons transferring into semiconductors on the Au nanoparticles (Au-NPs)/TiO_2/Au-film (ATA) photoelectrode. The absorption as well as external quantum efficiency of the water oxidation of ATA is extraordinarily enhanced as much as 11 times than those of the conventional Au-NPs/TiO_2 photoelectrode without Au-film. Most importantly, in this strong coupling system, the internal quantum efficiency of the water oxidation is also enhanced at the strong coupling wavelengths, which is not based on the absorption enhancement but on the promotion of electron-hole pair generation. We also explored the plasmon-induced water splitting under strong coupling conditions using a two-electrode system, and the details are presented in the presentation.