

Improving time resolution of plasmonic spectra acquiring

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Application Note

Introduction

It is well known that noble metal nanoparticles are good sensors for refractive index changes in their immediate environment. The basic concept works in the following way: illuminating the nanoparticles with white light leads to a collective oscillation of the conduction electrons, called the plasmon. Because of this phenomenon, light corresponding to the resonance frequency is scattered strongly. This resonance frequency depends on several factors including size, material, shape, and refractive index of the local environment. We can monitor the resonance position of a single particle as an indicator for changes in the local environment, such as exchanging the solvent [1], or more interestingly, binding of a small particle or molecule [2-4].

As binding normally occurs on a short time scale, especially if we are dealing with reversible binding events, it is important to build a setup with maximal time resolution. Here we present our home-build setup and data concerning the quality at short time scales.

Experimental Setup

We have made two major improvements compared to common methods for acquiring spectra of single plasmonic particles. First, we use a white light laser for illumination to increase the number of photons at the sample and therefore the number of scattered photons. Furthermore, we use an EMCCD camera from Andor Technology for detection to improve the spectral resolution. In addition its 'crop mode' read out option allows read out rates for particle spectra in the 20 kHz regime.

Figure 1 shows the experimental scheme. The core of our device consists of an upright transmission microscope (Zeiss Axioskop). For illumination, we use a supercontinuum white light source (Koheras SuperK-Power). The light is directed to the sample via total internal reflection using a glass half cylinder situated directly under the sample holder. At the position of total internal reflection, the evanescent wave illuminates the sample. Light scattered from the sample is collected by a 40x air objective (CP-Achromat NA 0.65) and dispersed through a transmission spectrometer (Specim ImSpector V8). As detector we use an EMCCD camera (Andor iXon DV885-KCS-VP).

To successfully implement the 'crop mode' as read-out mode, it was necessary to introduce an additional slit at the position of the entrance slit of the spectrometer. Because the two slits are perpendicular to each other, only light from one particle is transmitted to the detector. Hence, no light can fall onto unwanted regions of the detector and contribute additional background.

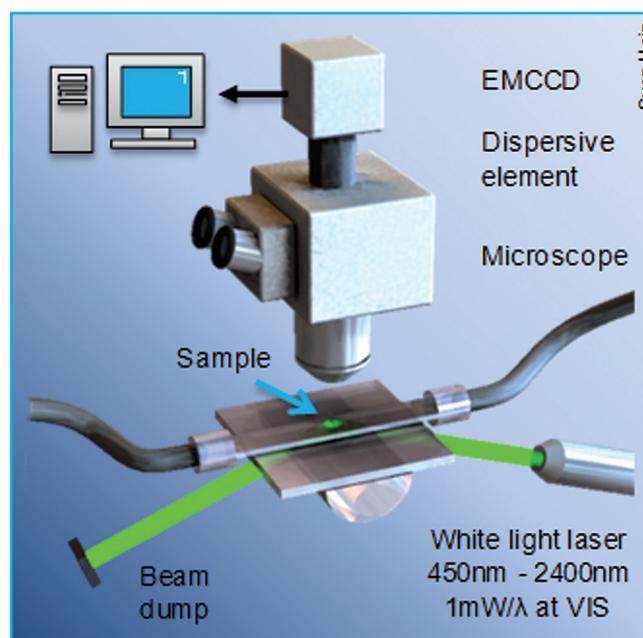


Figure 1: Experimental setup for time resolved spectral measurement of noble metal nanoparticles.

Example

To demonstrate the potential of this spectroscope for time resolved spectral acquisition, we measured the spectral resolution of differently shaped particles with different exposure times (Figure 2). Three different kinds of gold particles were immobilized on a cleaned microscope slide: spheres with a diameter of 60 nm, and two kinds of rods with the dimensions 35 x 78 nm and 50 x 107 nm. For each exposure time, the optimal gain condition was chosen. We then took the time trace of a particle spectrum until the camera gathered 10.000 spectra. As spectral noise, we used the standard deviation of the resonance wavelength of these spectra.



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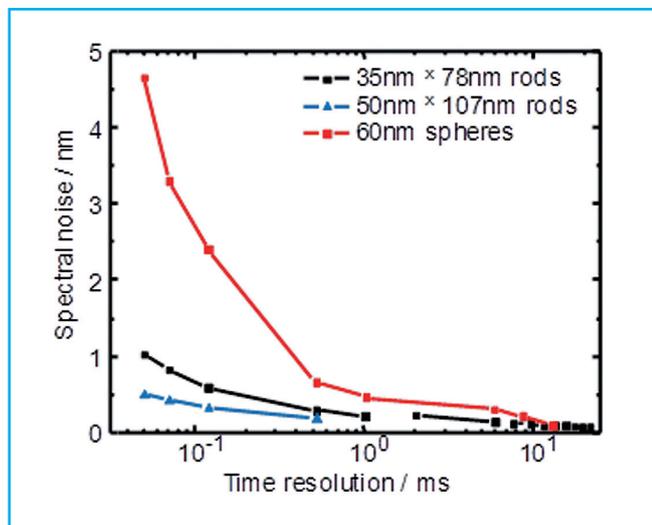


Figure 2: Spectral noise of a variety of Au nanoparticles illuminated for different exposure times. The spectral noise corresponds to the standard deviation of the resonance wavelength of 10.000 spectra

Conclusion

The "crop mode" of the Andor iXon DV885-KCS-VP camera in combination with a powerful supercontinuum white light source allows improving the time resolution of plasmonic resonance spectra acquisition into the 50 μ s regime. Furthermore, the sensitivity at the millisecond time scale is increased compared to prior instruments. These improvements allow us to observe interesting processes that were previously not resolvable, like the detection of the adsorption process of unlabeled single proteins to the sensor [4].

References

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