Two-Photon Fluorescence for Detecting Hot Spots on Metallic Nanostructures

Application Note

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Introduction

Our research focuses on controlling the localization of light in metallic nanostructures. When the structures are illuminated with broadband femtosecond light pulses, the excitation energy concentrates at local sites called "hot spots," which can be visualized with the iXon DV885 JCS-VP EMCCD detector. By encoding different spectral phase patterns onto the pulse we can modify where on the structure the light ends up. To find the optimal spectral phase we employ an evolutionary algorithm that works in a feedback loop.

Figure 1: A random gold nanostructure imaged with the iXon DV885 JCS-VP.

Experimental details

We create random gold structures on glass slides using electron beam lithography (see Fig. 1). The gold islands have a thickness of 50 nm and a typical diameter of 200 nm. The structures are coated with a layer of quantum dots, which are used as reporters of the local field intensity. To get a good measure of the local (evanescent) field, this layer needs to be very thin (~50 nm).

In order to observe the effect of the spectral phase, a non-linear response is needed. This non-linearity is introduced by exciting the quantum dots with two photons from the excitation pulse. The combination of the thin layer and low two-photon absorption cross-section makes for low signal levels.

We detect spatially-resolved two-photon fluorescence by imaging the structure onto an iXon DV885 JCS-VP (1004 x 1002 pixels, 27 MHz) with an optical microscope (Olympus IX-71). By using the EMCCD camera we achieve high signal-to-noise without the need for long integration times. The increased acquisition speed allows us to run the experiment in a feedback loop and adaptively search for the optimal pulse shape.

Results

When we illuminate the gold structures we indeed observe that the light localizes in hot spots (see Fig. 2). This effect was already known for random structures, but here we show that the combination of a quantum dot overcoat and the use of a sensitive EMCCD camera is a good method to detect the local field intensity. We are currently doing experiments where we shape the spectral phase of the excitation pulses. Preliminary results show that a hot spot can be switched on or off by changing the phase of the pulse.

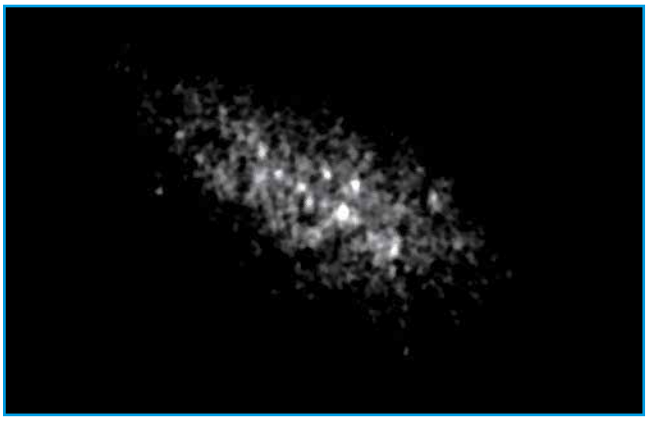

Figure 2: Hot spots on the structure detected by two-photon fluorescence.

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