Enhancement of the nonlinear optical response at multiple wavelengths in metal nanoparticle multilayers

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Application Note

Introduction

Nonlinear optical (NLO) compounds are widely used in applications and there is an ongoing effort to find efficient materials throughout a wide wavelength range. Materials exhibiting efficient nonlinear optical responses at multiple input and emission wavelengths are desired for applications like simultaneous frequency doubling and tripling or for improving sensor design, but they remain scarce. To synthesize such a material, we combine gold, silver and iron oxide nanoparticles, which show large nonlinear optical responses at specific wavelengths, into a homogeneous, partially transparent and polymer-free nanoparticle multilayer material on glass substrates by a layer-by-layer method. The integration of multiple metal nanoparticles allows enhancement of frequency doubling and tripling as well as multiphoton luminescence at different wavelengths simultaneously, associated with plasmon bands of the respective particles as well as coupled plasmons. By varying the used materials, engineering of the nonlinear optical resonance becomes possible.

Experiments

To investigate the potential of these new NLO materials for different input/emission wavelengths we need i) a broadband tunable laser source of high intensity ii) sensitive spectral detection over a broad wavelength range. A Spectra-Physics Insight DeepSee ultrafast femtosecond pulsed laser, tunable from 690 nm to 1300 nm, was used as light source. The emitted light, originating from different NLO processes, was detected by a combination of a Bruker spectrograph (SureSpectrum 500is-sm) and an Andor iXon Ultra 897 EMCCD camera (DU897 DCS-EX). Within the Andor Solis software it is possible to connect to a wide range of spectrometers of different manufacturers, while the step and glue function automates taking spectra over the whole wavelength range of the spectrometer. A typical spectrum at multiple input wavelengths is shown in Figure 1. The high sensitivity of the detector allowed reducing the input power while keeping the integration time short, eliminating the occurrence of sample degradation for our samples.

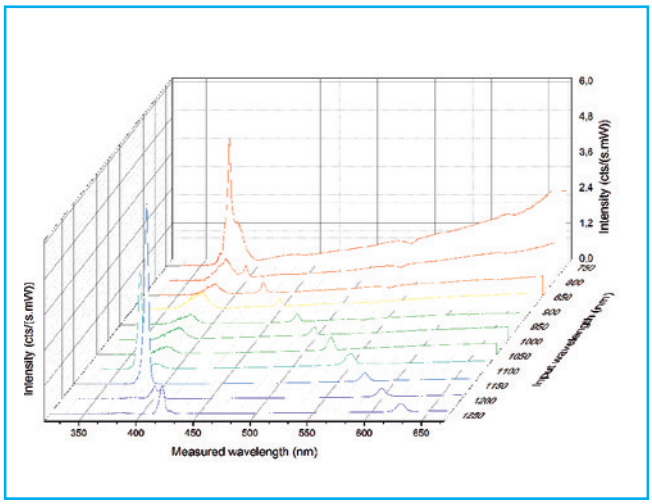

Figure 1. The spectral nonlinear optical response of metal nanoparticle multilayers at multiple input wavelengths showing simultaneous SHG, THG and multiphoton luminescence.

References

1. T. Verbiest, K. Clays, and V. Rodriguez, Second-order Nonlinear Optical Characterization Techniques: An Introduction, 2009.
2. R. W. Boyd, Nonlinear optics, Academic press, 2003.
3. W. Brullot, T. Swusten, and T. Verbiest, Adv. Mater., 2015, 27, 2485–8.
4. W. Brullot, R. Strobbe, M. Bynens, M. Bloemen, P.-J. Demeyer, W. Vanderlinden, S. De Feyter, V. K. Valev, and T. Verbiest, Mater. Lett., 2014, 118, 99–102.

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