micro photonics

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Quantum Dots and Nanostructures

Abstract No. 48:

Ultrafast exciton dynamics and nonlinear response of few layer MoS2

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Transition metal di-chalcogenides (TMDCs) have become promising candidates for future nano-photonic systems owing to their novel optoelectronic properties, tunable direct bandgap as well as their scalability. Besides, they exhibit strong linear as well as nonlinear light-matter interactions throughout the visible range which makes them ideal for phonic applications. The photo-response of TMDCs is largely due to formation strongly bound electronhole pairs i.e excitons. The energetics and dynamics these excitons play a crucial role in determining the optical response of these materials. Therefore, a deeper understanding of the behavior of the charge carrier states and their relaxation pathways is vital in order to utilize TMDCs for various applications. Equally important is the nonlinear behavior, associated with large absorption and Pauli blocking, which makes these materials ideally suited for ultrabroad band and fast saturable absorbers.

Here we have investigated the spectral and temporal evolution of excitonic transitions in few layer MoS2 nanosheets at ultrafast time scales employing femtosecond pump-probe spectroscopy. We have synthesized high quality nanosheets by liquid phase exfoliation. A detailed kinetic analysis provides vital information about excited state carrier density and life time of the transient states. The steady state optical absorption shows excitonic resonances in MoS2 at 675 nm (A) and 605 nm (B) as a result of spin orbit splitting at K point. In our ultrafast studies, we observe short lived transient bleach near the A and B excitonic resonances (with time constants $\tau 1$=0.8 ps and $\tau 2$=6.6 ps), which can be attributed to photo-induced filling of the conduction band. This state filling inhibits further carrier transition because of Pauli Exclusion principle and results in a bleaching (reduction) in absorption of the delayed probe signal, in effect it appears as a negative signal in TA spectra. The photo-induced band filling and subpicosecond to picoseconds dynamics of charge carriers commensurates with the nonlinear measurements which show a broadband saturable absorption with a saturation intensity of 1.5 GW/cm-2 at 800 nm excitation. This unravels the role of excitons in TMDC optics which can facilitate the potential applications of TMDCs in optoelectronic devices.

Abstract No. 49:

Assessment of adipose tissue temperature using [NaYErYrF4] upconversion particles

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Nowadays, there is a strong interest in the development of new laser-based diagnostic and their application for treatment of obesity and cellulite. These techniques are based on the adipose tissue destruction. The achieved by artificial stimulation of hyperthermia and/or by selective photothermolysis. Application of these methods is limited by the lack of reliable methods of determining optimal exposure conditions. The one of the potentially promising methods for monitoring of the local temperature in tissue is

based on using of temperature-sensitive fluorescent upconversion particles (UCPs) as a recognition element of nanosensors for monitoring the real temperature inside a biological tissue. An alteration in the luminescent intensity occurs due to reduction of scattering of the heated adipose tissue that is similar to optical clearing. To determine a local temperature of biological tissue we have used the synthesized by us temperature-sensitive fluorescent [NaYErYrF4] upconversion nanoparticles (UCNPs). Interest in the use of UCNPs in comparison with other nanoparticles is on the rise due to their high photochemical stability, low toxicity, and stable narrow-band emission at excitation in biological tissue transparency window.

For the simultaneous monitoring of adipose tissue phase transition and the real temperature inside a biological tissue (adipose tissue) we have used [NaYErYrF4] upconversion nanoparticles. We have performed tests showing that the logarithm of the ratio of the fluorescence peaks at 551 and 521 nm of the UCNPs is linearly dependent on the inverse of temperature that making them promising for temperature measurements.

We showed that fluorescence of [NaYErYrF4] upconversion nanoparticles is sensitive to adipose tissue phase transition in vitro. The spectra of the UCNPs located in porcine adipose tissue at different temperatures were arranged into three groups, corresponding to the phase of fatty tissue at the given temperature. The phase transition leads to decrease in the fluorescence intensity from the nanoparticles inside the tissue due to changes in fat tissue scattering.