Plasmon Enhanced Optical Response of Metal-2D TMDC Hybrids for Nanophotonic Devices

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Abstract :

Tunable light-matter couplings in dissimilar constituents (metal & semiconductors) play a leading role in the development of two-dimensional (2D) transition metal dichalcogenides (TMDCs) based quantum hybrids along with their applications in Si-compatible photonics. We shall present the superior broadband photodetection characteristics of few-layer MoS_2 and black phosphorus (BP) nanosheets integrated with metal nanoparticles (Au & Ag NPs) using vertical heterojunctions on Si platform. The hybrid Ag-NP:BP sample exhibits broadband absorption with a strong plasmonic peak around ~425 nm due to the localized surface plasmon resonance (LSPR) of Ag-NPs of average size ~6.0 nm. The quenching of photoluminescence intensity in plasmonic hybrid compared to the pristine sample ascertains the energy transfer from black phosphorus nanoflakes to Ag-NPs. The size-dependent optical response of BP nanostructure/Si state-of-art broadband (300–1600) photodiodes have been studied extensively. The tunable spectral responsivity with a peak value of ~3.2 A/W (@ ~440 nm, –5 V) for the Ag-BP/Si heterojunction device demonstrates the potential of plasmonic BPs hybrid for future nanophotonic devices [1]. On the other hand, the ultrafast time-domain results reveal a three hundred-fold enhancement in the lifetime of inter-band hot-electrons for Au/MoS_2 nanohybrids, over the pristine one. The real-time investigation of double Fano lineshapes is also demonstrated in Au nanodisk-MoS_2 hybrids. The time-domain double Fano build-up shown in Fig.1 starts at ~ 1.0 ps timescale, which sustains up to 5.0 ns [2]. The diverse ultrafast light-matter couplings for layered TMDCs and their plasmonic hybrids are attractive for next generation quantum photonic devices.

References

[1] S. Jana, S. Mukherjee, S. B.N. Bhaktha and S. K. Ray, ACS Appl. Mater. Interfaces, 14 (2022), 1699

[2] R. K Chowdhury, S.Mukherjee, S.N B Bhaktha and S.K.Ray, Physical Review B, 101 (2020), 245442

Figures

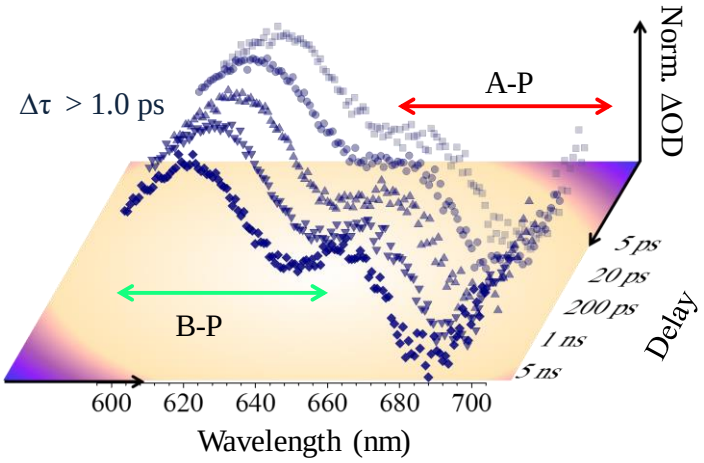

Figure 1: Normalized double Fano spectra of excitons for Δτ > 1.0 ps probe delay in Au-MoS_2 hybrids