Interfacial Contact with Noble Metal - Noble metal and Noble Metal – 2D Semiconductor Nanostructures Enhance Optical Activity

Student: Ricardo R. Romo Degree: MS, December 2019
Major Professor: Dr. Keith Roper

UNIVERSITY OF ARKANSAS
Graduate School & International Education
Microelectronics-Photonics

Photonics

Modeling and Simulation

Background/Relevance

- Nanoantenna-enhanced semiconductors exhibit extraordinary optical properties that allow nanoscale energy modulation (i.e. localized surface plasmon resonance (LSPR) and excitons.
- Applications such as optical switching, drug delivery, environmental sensors and photocatalysis can be derived from strong and weak coupling between plasmons and excitons in transition metal dichalcogenide (TMD)-heterostructures.

Innovation

- Distinguishing respective contributions of plasmonic heating and hot electron transfer in noble metal - TMD heterostructures via experimentally and computationally.

Approach

- Produce TMD nanoflakes.
- Scanning transmission electron microscope (STEM) of the TMD-heterostructures.
- Perform far- and near-field maps of the TMD-heterostructures via Discrete Dipole Approximation (DDA).
- Compare both computational and experimental optical feature enhancements.

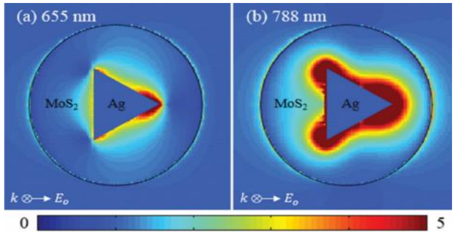
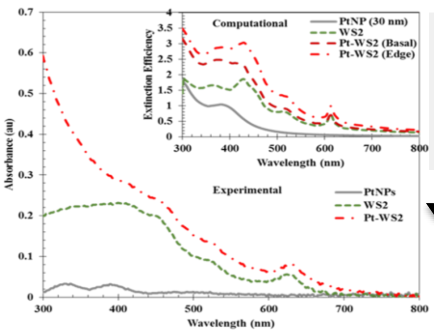


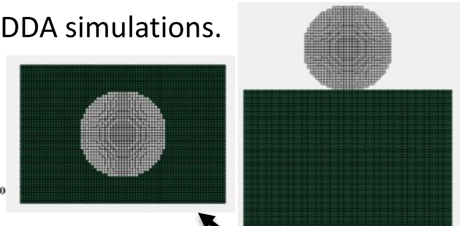
Figure 1. G. T. Forcherio, D.K. Roper. Advanced Optical Materials. **2016**, 4, 1288-1294

Key Results

- Mapped local electric fields and hot electron transfer in 2D materials in order to distinguish relative thermal and hot electron transfer dissipation from LSPR.
- Distinguished respective contributions of electron transfer and plasmonic heating from DDA simulations.



Experimental and computational spectra comparisons for Pt-WS_2



Pt-WS_2 heterostructures used for simulations.

Conclusions

- These tools allowed comparison between the metal nanoantenna and the DDA simulations to determine relative contributions of plasmonic heating and hot electron transport to increase LSPR-enhanced photocatalysis from the TMD-heterostructure.

Future Work

- Possible x-ray photoelectron spectroscopy (XPS), atomic force microscopy, and Raman spectroscopy to improve understanding of photoinduced doping of TMDs by metal nanoantennae.

This work was supported by Arkansas Biosciences Institute, the major research component of the Arkansas Tobacco Settlement Proceeds Act of 2000; College of Engineering Ralph E. Martin Department of Chemical Engineering University of Arkansas