NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE
School of Electrical and Electronic Engineering

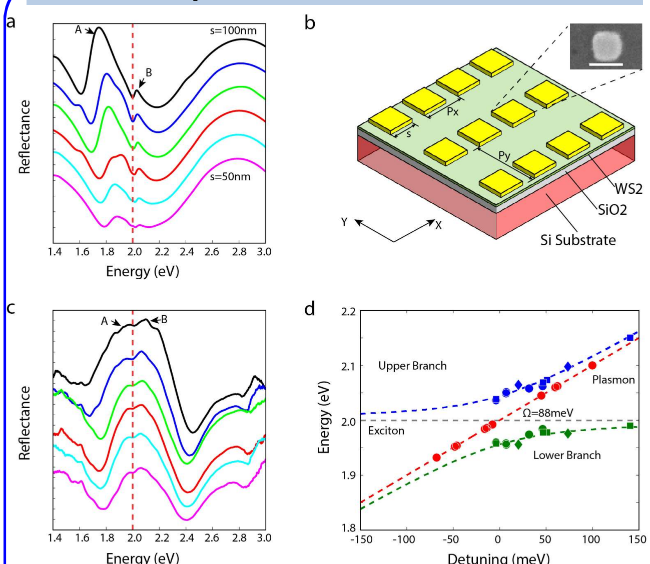
COEB PHOTONICS
COEB - Centre for OptoElectronics and Biophotonics

Strong Light-matter Interaction in Monolayer WS2 Coupled with Nanoantenna Arrays

Background Motivation

-Realizing strong plasmon-exciton coupling is essential for nonlinear optics in single photon level and applications in quantum information.
-Monolayer TMDs have be discovered to have direct band gap and very large exciton binding energies, pave a promising way to realize strong coupling at room temperature.

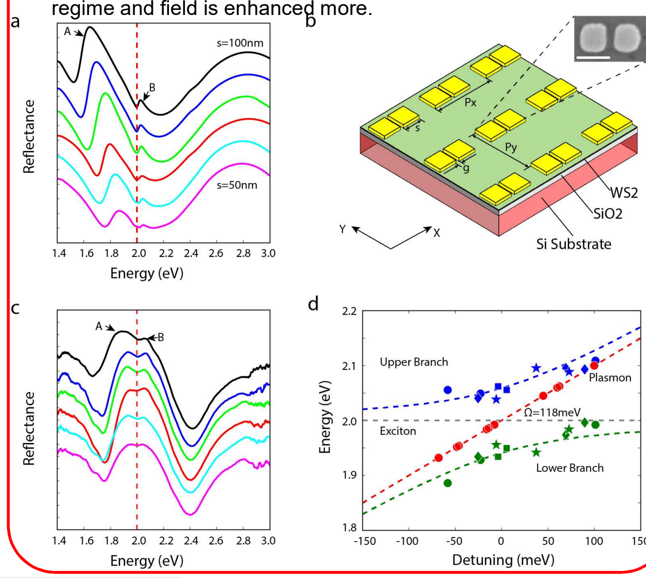
WS2 Coupled with Disk Nanoantennae



(a) Reflectance from Au disk nanoantennae-WS_2 structures using FDTD simulation method. The period of the nanoantenna array in x direction is two times the side length of each disk, and in y direction is four times. The red dashed line displays monolayer WS2 exciton peak at 2eV. When varying the side length from 50nm to 100nm, the plasmon resonance has a red shift.
(b) Schematic diagram.
(c) Experiment results of reflectance from Au disk nanoantennae-WS_2 structures.
(d) Anti-crossing behavior of Au disk nanoantennae-WS_2 structures. When detuning is zero, which corresponds to that the plasmon resonance frequency is equal to WS_2 exciton resonance frequency, the Rabi splitting energy is 88meV.

WS2 Coupled with Dimer Nanoantennae

(a) Reflectance from Au dimer nanoantennae-WS_2 structures using FDTD simulation method. The period of the nanoantenna array in x and y direction is four times of side length, gap size is fixed at 20nm. The side length is tuned from 50nm to 100nm.
(b) Schematic diagram.
(c) Experiment results of reflectance from Au dimer nanoantennae-WS_2 structures.
(d) Anti-crossing behavior of Au dimer nanoantennae-WS_2 structures. Both side length and gap size are changed to tune the plasmon resonance frequency in experiment. The Rabi splitting energy is 118meV larger than the 88meV splitting in disk structure, which indicates that the coupling strength of dimer structure is higher than disk. In dimer nanoantenna, the small gap between two disk structure help to confine light in this regime and field is enhanced more.



Conclusions

-We for the first time compared different gold nanoantennae strong coupling with WS_2 at room temperature. An 88meV Rabi splitting of disk structure and 118meV Rabi splitting from dimer nanoantennae coupled with WS_2 are observed.
-By engineering the geometry of nanoantenna arrays, the coupling strength can be effectively adjusted, opening up a way for realizing tunable two-dimensional plasmonic devices operating at room temperature.

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