The interaction of gold nanostructures with different laser polarizations in COMSOL simulation

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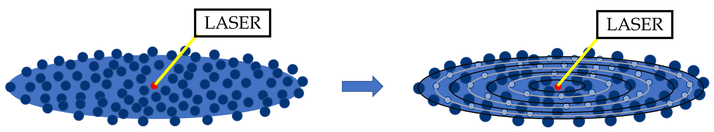
Plasmonics : Study and Application of Plasmons



In a conductive metal, free electrons behave as a fluid. Under laser illumination, these electrons begin to oscillate collectively, causing ripples like water. This collective motion is called a *plasmon*. The resonant coupling between the incident light and the conduction electrons is called *surface plasmon resonance* (SPR).

In nanoparticles, localized surface plasmon resonance (LSPR) can cause large enhancements in the electric field[1]. Stained glass is one everyday example of LSPR[2].

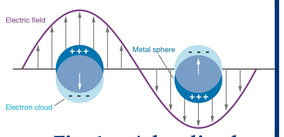


Fig. 1. : A localized surface plasmon[1]

This electric field enhancement is used for surface-enhanced Raman spectroscopy (SERS) and other techniques to measure the dynamics of a single molecule [3].

San Fernando Cathedral

Plasmons can also travel along the interface of the metal and dielectric. This type of plasmon is called *surface plasmon polariton* (SPP).

Rice Memorial Chapel

In our previous researches, we demonstrated the electronic detection of SPP in gold nanostructures with different laser polarizations.

Obejective

To simulate the thermoelectric detection of SPP in gold nanostructures

Approaches Used : Experimental and Simulation

Experimental

- We measured the photothermoelectric effect of gold nanostructures.
- We changed the linear laser polarization using a half-wave plate.

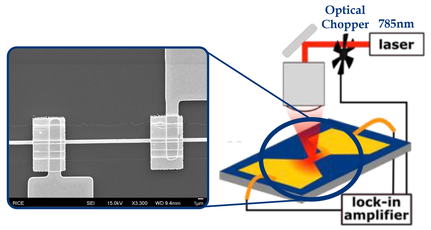


Fig. 2. Schematic of experiment[4]

- We used a chopped, linearly polarized laser as a heating source and external lock-in reference and measured the open circuit voltage as a function of laser position.
- Surprisingly, we detected different features in the measurement pads based on laser polarization. We wanted to know if this is from SPP excitation.

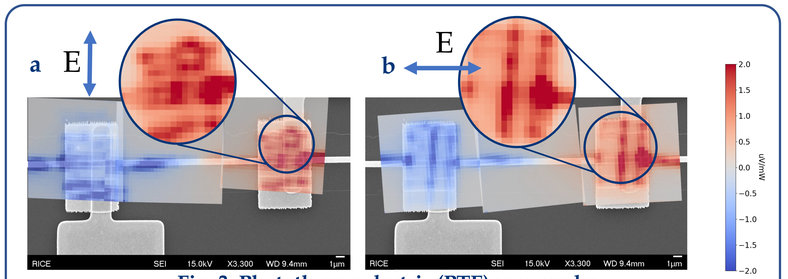
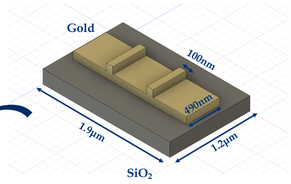


Fig. 3. Photothermoelectric (PTE) map under (a) 0° and (b) 90° laser polarization.

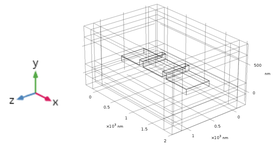
Simulation

COMSOL

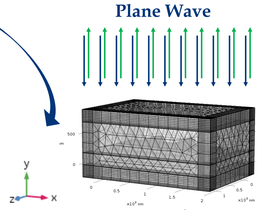
A cross-platform finite element analysis, solver and multiphysics simulation software



3D modeling of the sample with smooth edges



Perfectly Matched Layer (PML)



Mesh

Results & Discussion

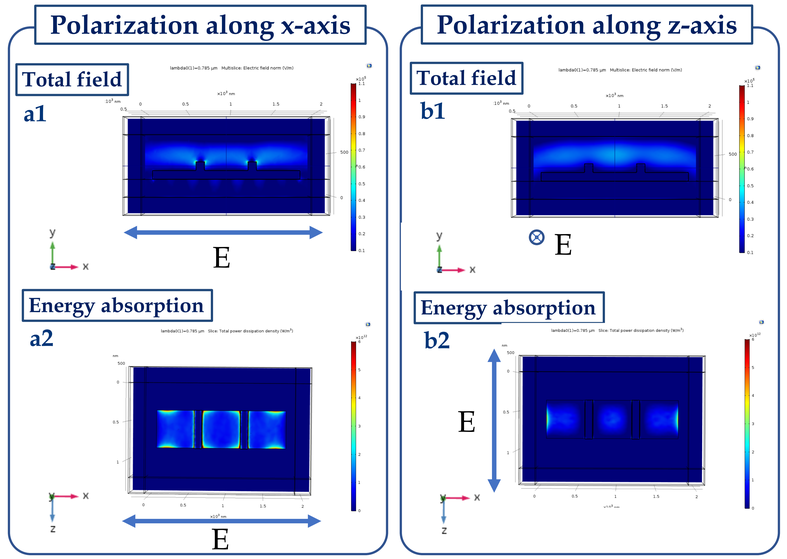


Fig. 4. Simulation results: Total field and energy absorption of the device under 0° polarization (a1, a2) and under 90° polarization (b1, b2), respectively

- Total field around the gold nanostructure with different laser polarizations (a1 and b1).

-Polarization along x-axis : greater enhancement of total field around the nanostructure

- The experimental results from open-circuit voltage were consistent with the simulation (Fig. 3a and Fig. 4a2).

-Polarization along x-axis, energy absorption was remarkable around nanostructure, which has agreement with PTE map.

→Suggests SPP excitation in experimental device!

→Next steps: simulate SPP detection using open circuit voltage

Acknowledgement

This research project was conducted as a part of the Nakatani Foundation's 2018 Nakatani RIES Fellowship for Japanese Students.

For more information, visit http://nakatani-ries.rice.edu .

Special thanks to the members of the Natelson Group for their research mentorship and support and to Prof. Junichiro Kono, Sarah Phillips, Kenji Ogawa, and Aki Shimada.

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