Mapping Plasmonic Response of Nanostructures via Multiphoton Absorption in Poly(methyl methacrylate)

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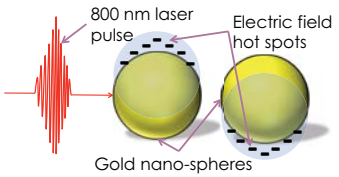
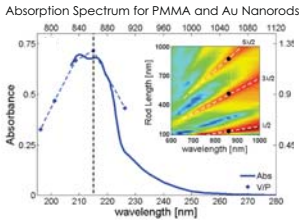
Introduction

- Localized surface plasmons (LSPs) result from electron-photon coupling in sub-wavelength nanoparticles (NPs)
- Simple LSP near-field structures have been observed.
- However, current methods perturb complex systems making their results unreliable.
- Four-photon absorption in poly(methyl methacrylate) (PMMA) is a non-perturbative way to characterize these complex resonance modes.
- When exposed, the damaged PMMA surrounding the NPs can be mapped, creating an electric near-field intensity profile, without absorbing the fundamental.



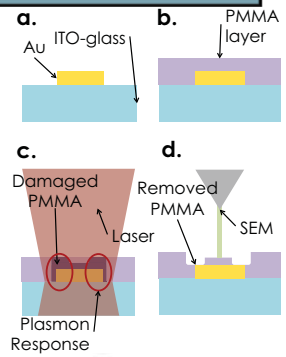


Objectives

- To confirm and optimize the use of PMMA scission at areas of high electric field as a method to map and characterize plasmon resonance.
- To experimentally verify computationally predicted resonance modes of complex, asymmetric NPs.

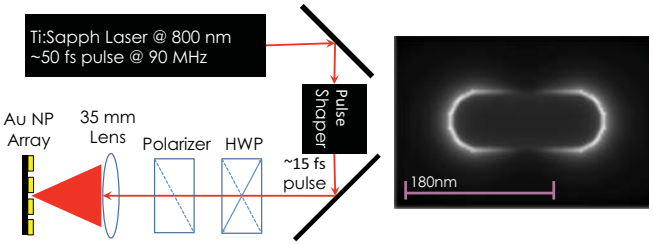
Methods

a. Au NPs were made with e-beam lithography on ITO-glass at a height of 20 nm.
b. NPs are then spin-coated with 40nm of 950 PMMA .
c. Arrays are exposed to a Ti:sapphire laser with a range of powers and exposure times
d. IMBK was used to remove damaged polymer.
The missing PMMA was then imaged with a scanning electron microscopy (SEM).



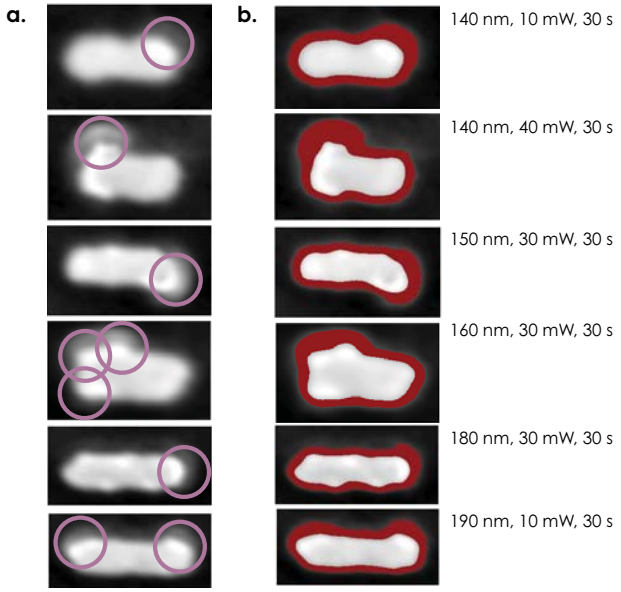
Methods cont.

- Optics set-up used for exposing PMMA-coated arrays.
- Near-field resonance modes were simulated to predict plasmon responses on the developed PMMA.



Results

a. Images were processed with adjusted contrast using analysis software. Circles are added to show hot-spot areas of high electric near-field.
b. Detected areas where PMMA is damaged (overlaid in red), which corresponds to a local near-field map.

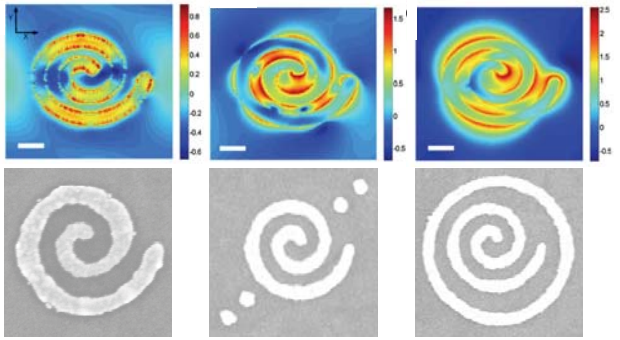


Discussion

This method and accompanying image analysis techniques have proven successful in observing electric near-field hot-spots in developed PMMA, and has laid the foundation for refining the technique for structures with higher orders of complexity.

Future Work

- This method will later be used to map complex NPs including the 3 modes present in the Archimedean nanospiral and ensemble structures.
- Creating and observing these complex resonances is necessary for furthering the frontier of plasmonics knowledge and application.



References

- Giorgio Volpe *et al.*, "Near-field mapping of plasmonic antennas by multiphoton absorption in poly(methyl methacrylate)," Nano letters 12 (9), 4864-4868 (2012).
- Jed I. Ziegler and Richard F. Haglund Jr, "Complex Polarization Response in Plasmonic Nanospirals," Plasmonics 8 (2), 571-579 (2013).

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