Spectroscopic Investigation of the Plasmonic Coupling of a Nanoparticle and a Thin Metallic Film

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Raman spectroscopy is useful for chemosensor and biosensor applications, but signal levels are extremely small, which makes single molecule sensitivity challenging. Interest in surface-enhanced Raman spectroscopy (SERS) has increased based on recent observations of plasmon-enhanced single-molecule detection. Our research aims to provide more sensitive Raman detection using cavity enhancement, which is a nanoparticle spaced by a dielectric over a thin metallic film. Past studies have focused on gold nanoparticles over thin gold films. In this work, we investigate the Raman enhancement of aluminum and silver films coupled with a gold nanoparticle or a gold wire. We used UV-Vis and Raman spectroscopy on these samples to measure the dependence on metal film composition, sizes of nanoparticles, and cavity geometry. Specifically, we intend to develop a thorough understanding of where the film-nanoparticle coupled plasmon peak resides spectrally, as well as optimize SERS conditions for detecting specific molecules.
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1. Introduction

Raman spectroscopy is useful for chemosensor and biosensor applications, but signal levels are extremely small, which makes single molecule sensitivity challenging. Interest in surface-enhanced Raman spectroscopy (SERS) has increased based on recent observations of plasmon-enhanced single-molecule detection. So before now, a great variety of metal shapes and structures were studied. For example, Gold Nanoshells, Gold Nanorods and Gold film-Gold nanoparticle system.

3. Sample fabrication

- **a. EB evaporator**
  - The silver layer were prepared on a 20 nm by electron beam evaporation on glass.
  - Silver thin film
  - Glass substrate

- **b. SAM layer**
  - The SAMs were prepared on a 3 nm thick gold film deposited
  - SAM Layer
  - Silver thin film
  - Glass substrate
  - SAM layer is made by 4-aminophenol and ethanol.

- **c. Gold nanoparticle**
  - The substrates were immersed in the aqueous solution of the gold nanospheres for 2.5 h.
  - Gold nanoparticle
  - Silver thin film
  - Glass substrate

5. Simulation Results

UV-vis-NIR extinction spectra of Au nanoparticles with radius of 80 nm deposited over a silver film of 20 nm thickness with a ~3 nm space layer. 2 graphs are shown because of repeatability.

At wavelength 360, 800 nm we can see the resonances. In next step, we investigate what occur in this system using electromagnetic waves simulation.

6. Conclusion

Optical transmission spectra of the nanoparticle-thin film system are shown. Spectra are taken using a Cary 5000 spectrometer.

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