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Coupled Planar-Localized Surface Plasmon Resonance Device by Block-Copolymer and Nanoimprint Lithography Fabrication Methods

Peter Yang[1], Elaine Yang[1], Chip Steinhaus[1], Charlie Liu[2], Paul Nealey[2], Jack Skinner[1]
[1]*Sandia National Laboratories, Livermore, CA* and [2]*Department of Chemical and Biological Engineering, University of Wisconsin*

MOTIVATION

Surface plasmon resonances (SPRs) are excited when light is incident upon a metal-dielectric interface, resulting in electric field oscillations that propagate along the interface. These electric fields have been shown to enhance light absorption as well as increased emission from materials that reside within the oscillating field. This phenomenon is exploited in chemical and biological sensing, in applications such as fluorescence and Raman scattering. Furthermore, localized surface plasmon resonances (LSPRs) are localized oscillating electric fields resulting from light incident upon metal nanoparticles. These localized fields have an even greater and locally concentrated surface plasmon enhancement effect. This report investigates the effects of coupling surface plasmon resonances (SPRs) and localized surface plasmon resonances (LSPRs) on the same device.

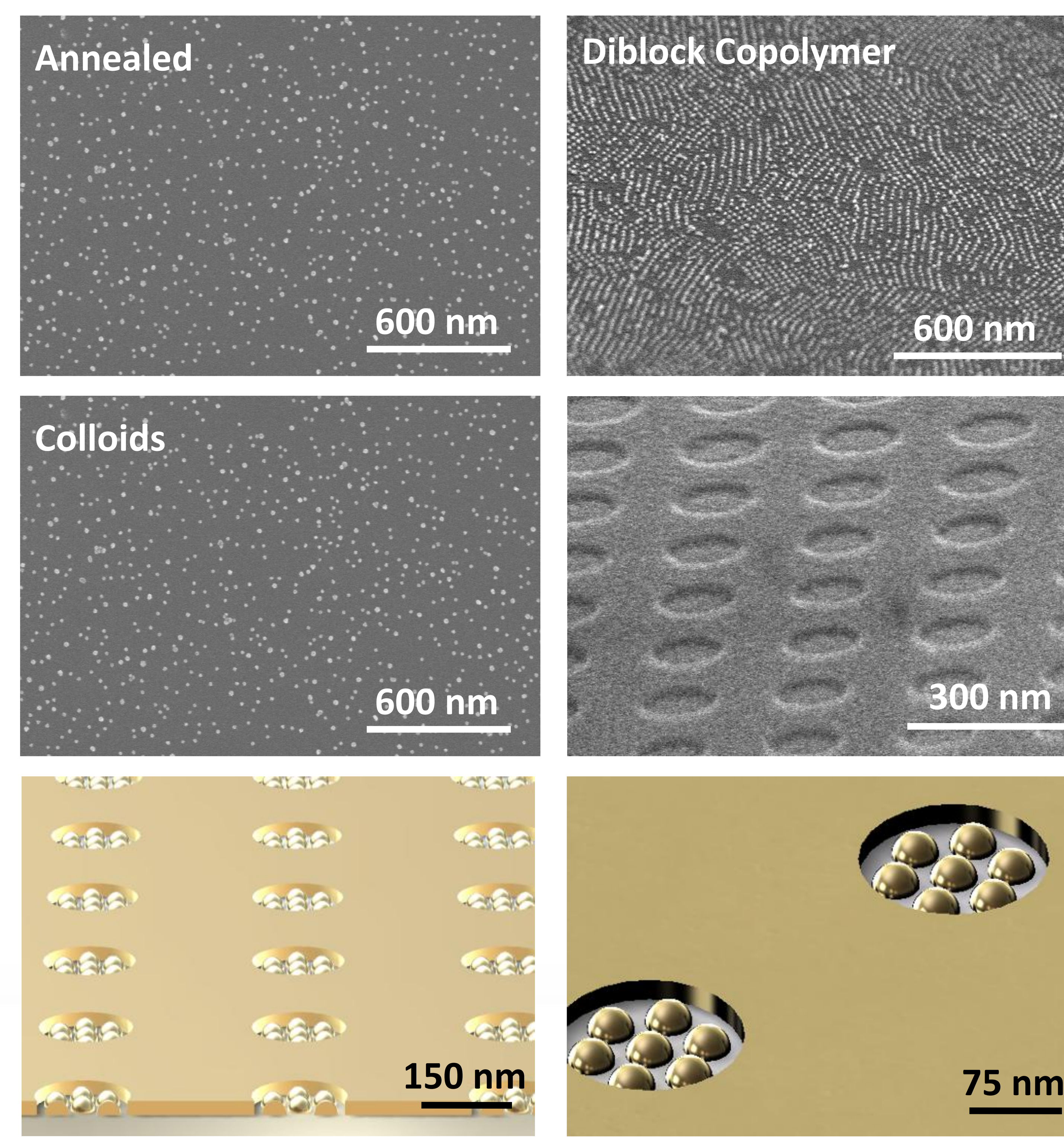
FABRICATION

Au nanoparticles of less than 50 nm in diameter were fabricated via three methods as a platform for LSPR. The three methods were fabricated in order to assess a comparison of plasmonic signature and intensity. Surface enhanced Raman spectroscopy was used as a tool to select the nanoscale platform to utilize as shown in the results section below.

- Silicon templates (made from diblock copolymer patterns) were used to imprint nanohole arrays into which Au was evaporated
- Au nanoparticles from a colloid solution were spin-casted onto a substrate
- Au thin film (3 nm) was evaporated and annealed to form nanoparticles

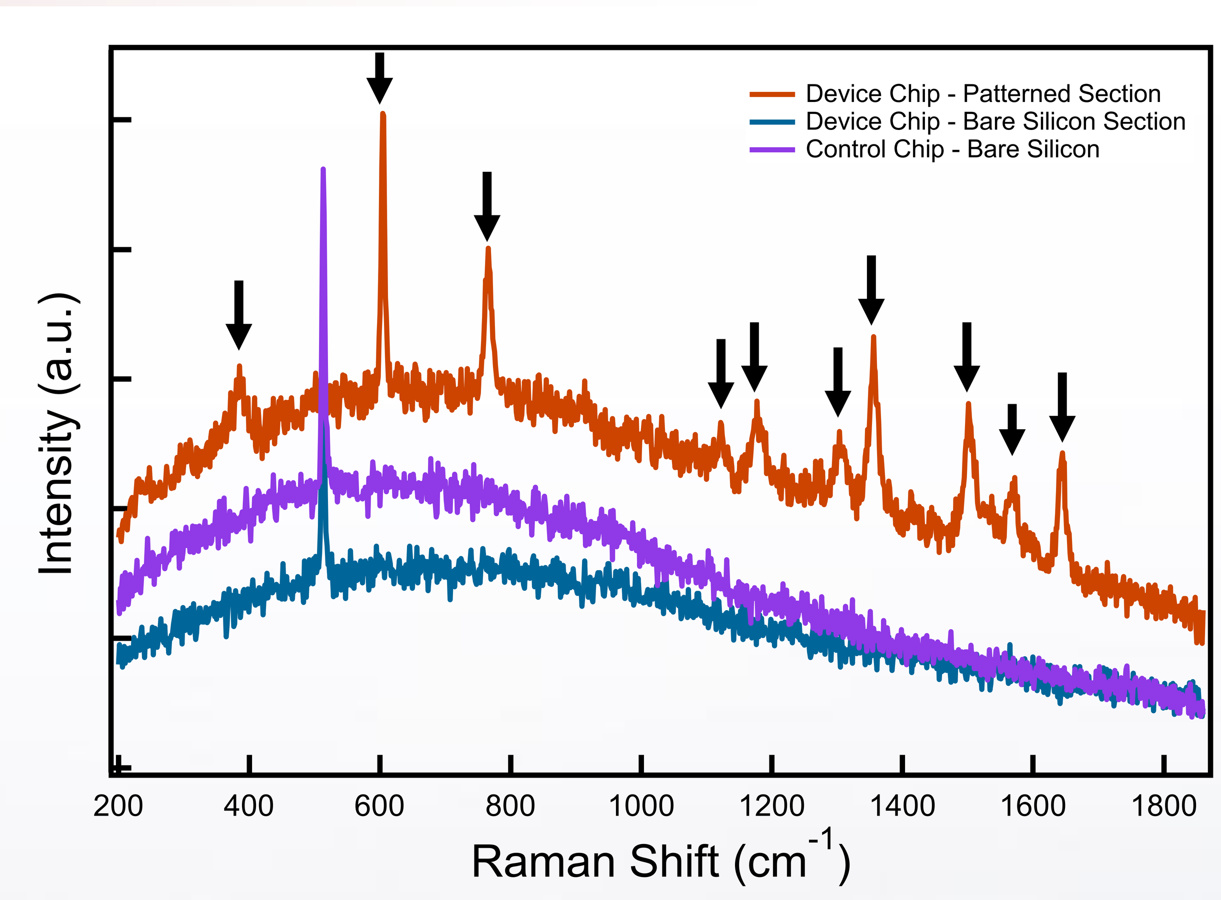
To achieve planar surface plasmons, an Al submicron grating with 150 nm holes at 500 nm pitch was created via nanoimprint lithography. The SPR grating layer was 50-60 nm in thickness.

The materials Al and Au were chosen because it is well known that they both exhibit strong plasmonic resonances in the visible region. The strongest coupling should occur when the surface plasmon resonance of the grating and the localized surface plasmon resonance of the nanodots match or are in close proximity to one another.

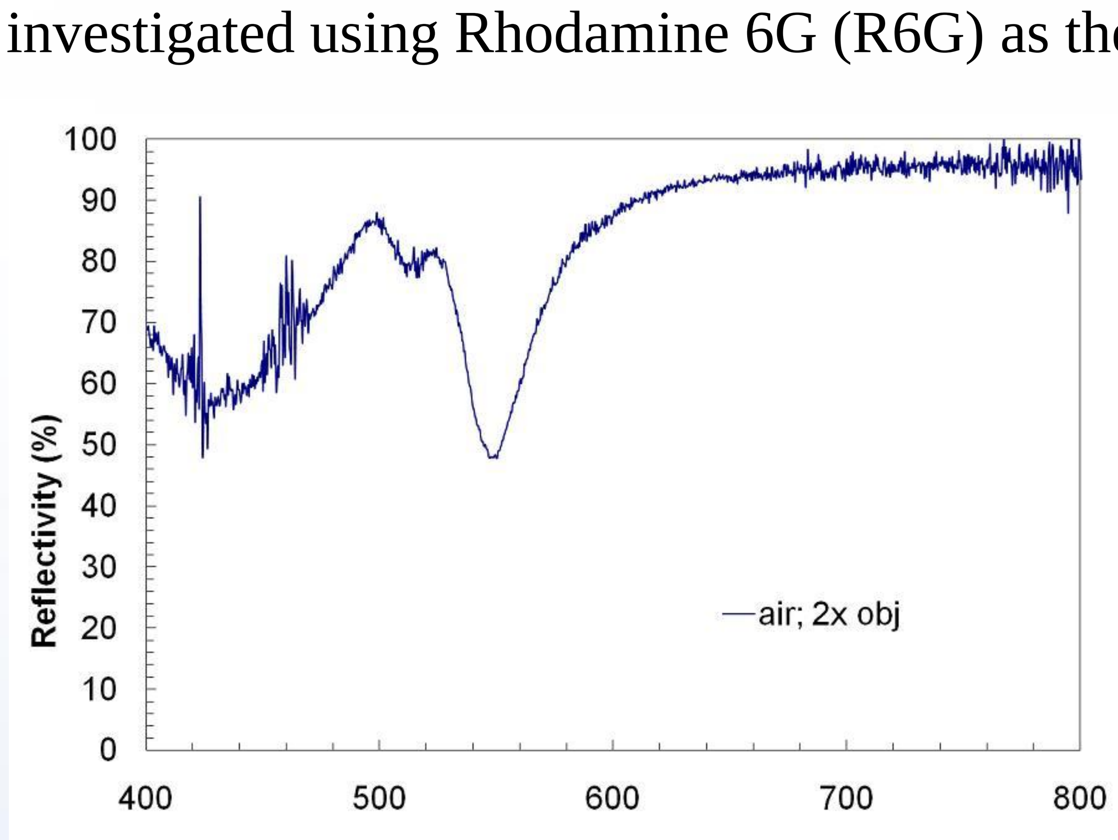


EXPERIMENTAL RESULTS

The surface-enhanced Raman scattering (SERS) nature of the resulting nanodots was investigated using Rhodamine 6G (R6G) as the interrogation molecule. A solution of 10^{-5} M R6G was dropcasted onto the three substrates with nanodots. The substrates were excited by the 532 line of a Nd:YAG laser and the resulting scattering plot is shown to the right.



The colloid method was chosen as the platform for the coupled nanodot/grating device. Reflectance spectra of the grating alone and coupled nanodot/grating device is shown in the figure to the left. The plasmonic signature of the coupled nanodot/grating device as compared to the grating alone can be seen.



SUMMARY AND CONCLUSIONS

The coupled SPR and LSPR device was predicted to exhibit SERS spectral peaks greater than either the SPR or LSPR device alone. As indicated in the reflectance spectra, there is a clear distinction between the coupled device and the grating alone. In conclusion, we have fabricated Au nanodots using three techniques: imprint by diblock copolymer pattern, annealing, and colloid dropcasting and also fabricated coupled nanodot/grating devices using a nanoimprint submicron grating. We have found that the coupled nanodot/grating device does exhibit a reflectance spectra distinct from the grating alone and deduce that this is due to the coupling of the surface plasmon resonance and localized surface plasmon resonance.

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