Western Nanofabrication Facility

Western Science

Localized surface plasmon resonance of nanometer-scale patterns

Renjie Hou
Western University,
Department of Chemistry,
Faculty of Science,
London, ON, Canada

Plasmon, a quantum of plasma oscillation, is a quasiparticle resulting from the quantization of plasma oscillations just as photons and phonons are quantizations of light and mechanical vibrations, respectively. And, for nanometer-sized structures, the collective oscillation of valence electrons in a solid stimulated by incident light is called localized surface plasmon resonance(LSPR). Large enhancement of electromagnetic field around the metallic surface can be observed when the frequency of the conduction electrons in the metal matches the frequency of incident photons. By changing the shape and size of the structures, the optical properties of the structures can be modified, in order to manipulate the frequency and intensity of the electromagnetic waves. This phenomenon can be applied to overcome the diffraction limit and to focus light on the nanometer scale to design extremely sensitive sensors.[1, 2]

In our research, samples are designed and made to be used in conjunction with surface enhanced Raman spectroscopy to detect the enhanced signal of low concentration system, such as monolayers or single molecules. In general, nano-scale noble metal structures are made by using electron beam lithography technique at The Western Nanofabrication Facility. First, glass cover-slips were cleaned and spin coated with ZEP 520A, a positive photoresist. After that, a thin chromium layer was deposited with a magnetron sputtering tool to prevent the electron scattering at the surface of glass. Meanwhile, the nano-scale structure was designed by CAD softwares. Then, the array was inscribed onto the cover-slips with photoresist using a LEO 1530 Field Emission scanning electron microscopy(SEM). After this, samples were etched by chromium etcher. Then, the underlying photoresist was developed, and Titanium and gold layers was deposited by e-beam evaporation. Finally, a lift off procedure was made to remove the remnant photoresist and to obtain the desirable patterns. This e-beam lithographic technique, which has a high reproducibility and excellent resolution, has a great advantage in making nano-scale particles or patterns with certain geometry.

These treated samples(Fig. a) can be used to study the optical properties such as plasmonics or Second-Harmonic Generation(SHG), etc. At the same time, to get a better understanding of the properties, computational simulations were performed by using finite difference time-domain (FDTD) method(Fig. b). Based on the simulation results, the electromagnetic wave intensity of certain polarization and wavelength can be significantly enhanced by a factor of 10^4 in some parts of the structure.

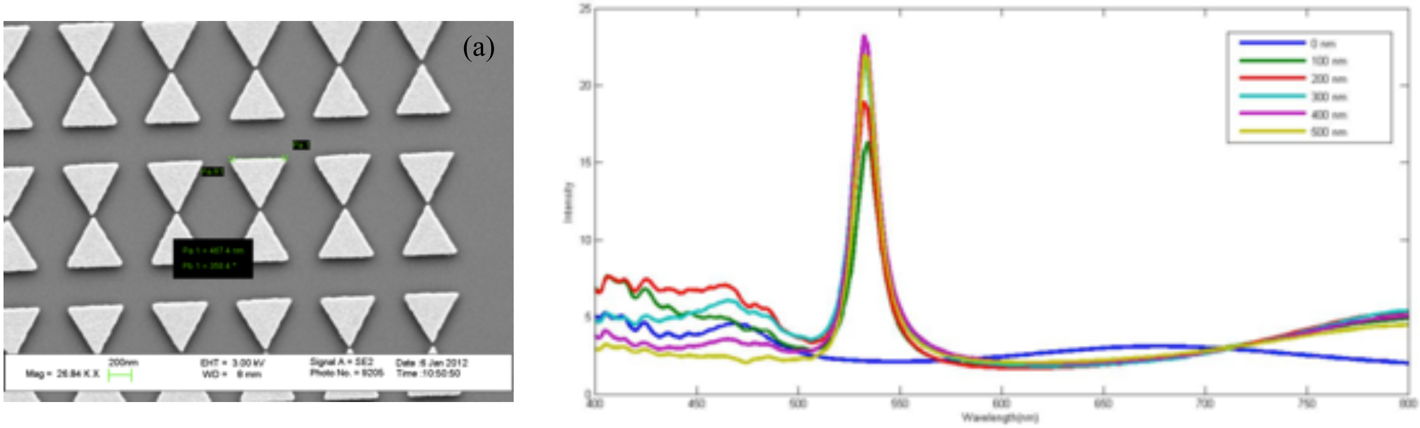

Figure: (a) Nanometer-scale structures made by electron beam lithography. The triangle is made of gold on glass cover-slips. The gap between two triangles is 20 nm width. (b) The transmission spectrum of simulation. An enhancement was observed between 500 nm- 550 nm wavelength.

1. Geldhauser, T., et al., Visualization of Near-Field Enhancements of Gold Triangles by Nonlinear Photopolymerization. Plasmonics, 2011. 6(2): p. 207-212.
2. Galarreta, B.C., et al., Plasmonic properties of Fischer's patterns: polarization effects. Physical Chemistry Chemical Physics, 2010. 12(25): p. 6810-6816

Renjie Hou, Ph.D. candidate, supervisor: Prof. François Lagugné-Labarthet, collaborator: Dr. Betty C Galarreta