Towards Easily Tunable Mid-infrared Surface Plasmon Resonance with Gold Nano-crescent Structures

F. Liu[1]

[1]St. Mary's Ryken High School, Leonardtown, MD, USA

Abstract

Mid-infrared, which interacts with most of the chemicals and creates spectra with functional group and fingerprint information, is widely used as a chemical sensing method for a variety of applications, including biomedical testing, quality control in electronics manufacturing and food production, leakage monitoring in oil and gas pipelines, etc. Although extremely useful, the applications of mid-infrared have been limited by the technical difficulties in making pertinent equipment, especially mid-infrared detectors. Researchers have shown that the sensitivity of detectors for visible light can be improved by gold nanoparticles, due to the enhanced optical response from the collective oscillation of conductive electrons, also known as surface plasmon resonance(SPR). Gold nanoparticles with SPR in the mid-infrared range can therefore be potentially helpful in making mid-infrared detectors.
Gold nano-crescent, due to its large aspect ratio and strong tip enhancement effect, has significant SPR effect in the mid-infrared range. Previously, the tuning of SPR was done by changing the size of the gold nanocrescent, which involves changing the templates for the complex fabrication process. In this study, the control of the SPR was proposed to be achieved by gold-silver alloy, which can be much more convenient because it only requires changing the ratio between gold and silver in the deposition process. With such easy control of the SPR, enhanced optical response throughout a broad range of spectrum can be potentially realized by the combination of different gold-silver alloy nanocrescents, which can therefore be helpful for making sensitive mid-infrared detectors.
In Comsol Multiphysics® , in the RF module, Electromagnetic waves, Frequency Domain was used to calculate the extinction cross-section at different wavelengths. The refractive indices for gold-silver alloys with different ratio was specified in the "material" section of the model. It is expected that the peak position of SPR can be shifted due to the different refractive indices of the gold-silver alloys. Broadband enhancement can then be potentially achieved by the gold-silver alloys of different ratios.

Figures used in the abstract

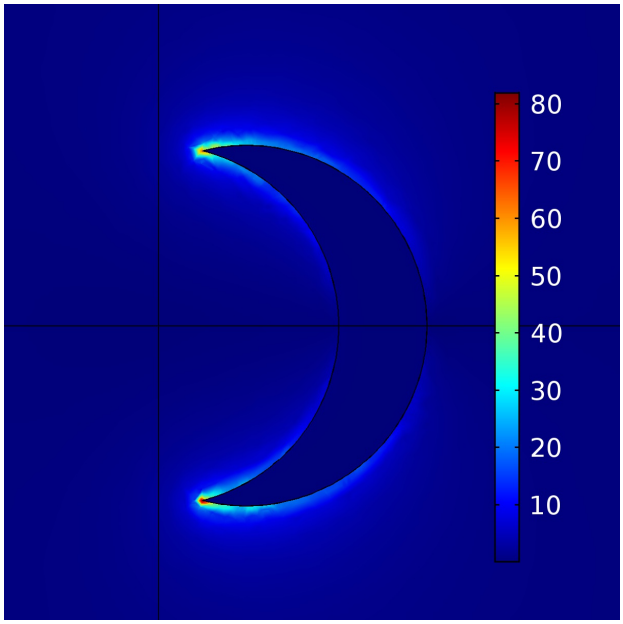

Figure 1: Electrical Field Distribution on a Nanocrescent (V/m). (Diameter: 0.96µm, Thickness: 50nm; Composition: gold; Wavelength: 6.7µm).