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Large-area Tunable Al Plasmonic Substrate for Infrared Spectroscopy

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1. Introduction

Surface-enhanced infrared absorption (SEIRA) spectroscopy employs noble metal nanoparticles or nanostructures to enhance the characteristic absorption spectra of certain molecules. These plasmonic nanoparticles or nanostructures act like antennas and demonstrate great potentials for single molecule or monolayer biosensing[1-4]. Here in this study we fabricated large-area aluminum (Al) plasmonic substrates based on nanosphere lithography (NSL) and applied them for infrared molecular sensing.

2. Results and Discussions

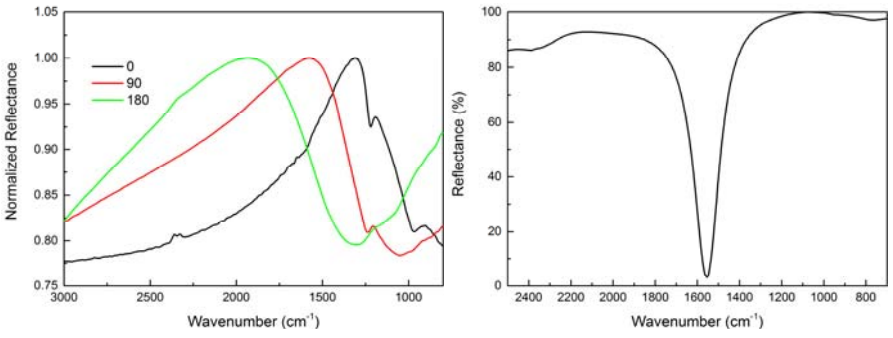
Al nanotriangle

Here Al nanotriangles were fabricated directly by NSL with 4.5 μm size (diameter) microspheres on a Si substrate. The plasmon resonances can be tuned by using microspheres with different diameters. In addition, as we show here, the resonances can be tuned by dry etching of the Si substrate. By controlling the etching time, we can determine the etching depth of Si and thus adjust the effective refractive index of the surrounding media. Figure 1a shows that the resonance displays a continuous blue-shift as the etching time increase.

Perfect absorber based on Al disks

Metamaterial perfect absorbers can also be fabricated by NSL. We fabricated Al-Al_2O_3-Al multilayer films on a Si substrate. The reflectance is minimized through impedance matching to that of free space and the transmittance is totally blocked by the bottom metal layer leading to total absorption of the incoming light at certain wavelength. As shown in Figure 1b, near perfect absorption ~97% was achieved at 1553 cm^{-1}.

The plasmonic substrates demonstrated here are easy to fabricate since they do not require any complicated lithographic tools. In addition, the properties of Al plasmonic nanoparticles for infrared spectroscopic sensing are not explored yet. Our Al plasmonic substrates would provide an excellent platform for the SEIRA studies.



(a) (b)

Figure 1 (a) Spectra from Al nanotriangles with different etching time; (b) Representative reflectance of a perfect absorber structure.

3. Conclusions

We demonstrated fabrication and characterization of large-area Al plasmonic substrates with great resonance tunability. The fabrication of these substrates is based on nanosphere lithography combined with dry etching. These plasmonic substrates are promising for novel and ultrasensitive infrared molecular sensing applications.

References

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