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Absorption Measurement in Gold Nanostructure

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Abstract: *In this paper we investigate the absorption in gold rod nanostructure on glass substrate. The gold nanostructure unit cell is composed of two gold rods of unequal lengths. The simulation results show absorption peaks at resonance wavelengths of 803.6 nm for the superradiant and 1089.3nm for the subradiant modes respectively. The experimental measurements show absorption peaks at the resonance wavelength of 781.2 nm and 1083.3nm respectively. The measured experimental absorption peaks in the fabricated structure atresonance is found to be in agreement with the results from simulation.*
Keywords: *Absorption, nanostructure, resonance*

I. Introduction

The nature of the resonance in nanostructures can be affected by the design geometry of the structure. This allows for interaction and coupling of the plasmon modes[1, 2, 3, 4, 5]. Resulting from the coupling are other effects such as electromagnetically induced transparency [6, 7, 8]. In metallic nanostructures, dark and bright transitions can be realized with the dark or subradiant modes showing a sharp profile compared to the bright or superradiant modes which has a broad profile [9, 10, 11, 12]. In this paper we present a nanostructure whose unit cell is composed of two gold rods of unequal lengths. The absorption for the broad profile and narrow profile resonances was simulated. Experimental measurements of absorption in the fabricated gold rod structure for the broad and narrow profile resonance showed good agreement with that from the simulation.

II. Geometry And Simulation

The geometry of the unit cell of the device to be measured is shown in Fig.1. The structure made up of gold rod G1 with dimensions of length Y1 of 170nm, a width X1 of 68nm and a thickness of 30nm. The second gold rod of the unit cell G2 has a length Y2 of 200nm, a width X2 of 68nm and a thickness of 30nm. The gold rods G1 and G2 are separated by a distance S of 50nm. The period of the unit cell along both the X and Y directions is 300nm. The refractive index of the glass substrate is taken to be 1.5. The gold is modeled in terms of the Drude model with plasma frequency and collision frequency of $1.37\times10^{16}s^{-1}$ and $1.2\times10^{14}s^{-1}$ respectively [13].

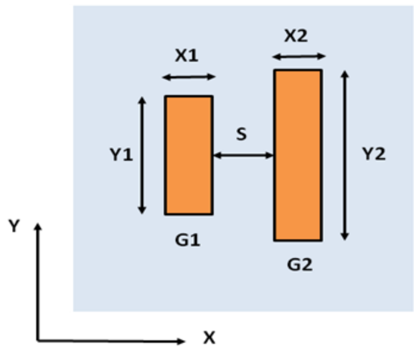

Fig.1 Geometry of the gold rods on glass substrate

With the properties of the structure shown in Fig.1, we performed an FDTD simulation of the structure, with the incident field normal to plane of the structure and with the electric field along the length of the gold rods or the Y axis of Fig.1. The result of the numerical simulation is shown in Fig.2.

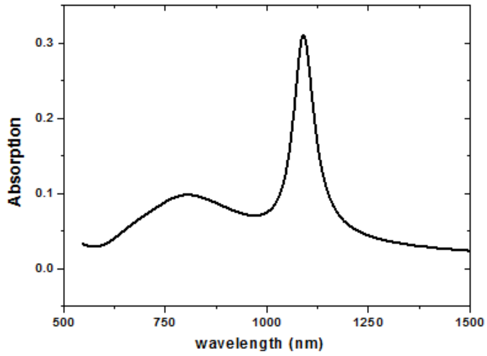

Fig.2 Absorption of the gold rods. Two absorption peaks can be observed at the resonance wavelengths of 803.6nm with peak of 10% and 1089.3nm with a peak of 31% respectively.

Fig. 2 shows the results of the simulation of absorption of the gold rods on glass substrates (Fig.1) from the reflection and transmission, given as $A = 1 - T - R$ [14,15]. From Fig. 2, the abruption of the gold rods over a range of wavelength show two abruption peaks at the wavelength of 803.6nm and 1089.3nm respectively. The lower wavelength of 803.6nm, which is a superradiant mode,shows a lower absorption peak compared to mode at the longer wavelength of 1089.3nm.The lower resonance at 803.6nm shows a broad prolife, having a high loss and low absorption peak. However at the longer wavelength of 1089.3nm the resonance mode which is a subradiant mode has a narrow profile, with a characteristic lower loss and a higher absorption peak compared to the resonance mode at 803.9nm. Thus, the quality factor of the resonance modes at the shorter wavelength of 803.6nm is smaller than that at the longer wavelength of 1089.3nm, as can be observed from the absorption results of Fig.2.

III. Experimental Results

In this section we discuss the experimental measurements on the fabricated structure shown in Fig.1. The experimental absorption measurement of the fabricated structure shows two resonances. The first resonance is at the shorter wavelength of about 781.2nm while the other resonance is at the longer wavelength of about 1083.3nm as shown in Fig.3. The resonance mode at the shorter wavelength of 781.2nm has a lower absorption peak with a broad bandwidth, characteristic of a high loss mode. This is in agreement with the result from the simulation as depicted in Fig.2. A second resonance mode of at the longer wavelength of 1083.3nm of Fig.3 has a larger peak than the shorter wavelength resonance peak. This absorption peak at 1083.3nm has a narrow bandwidth with a lower loss as shown in the experimental measurements of Fig.3. The experimental absorption measurements of Fig.3 show a good agreement with the results of absorption for simulation shown in Fig.2.

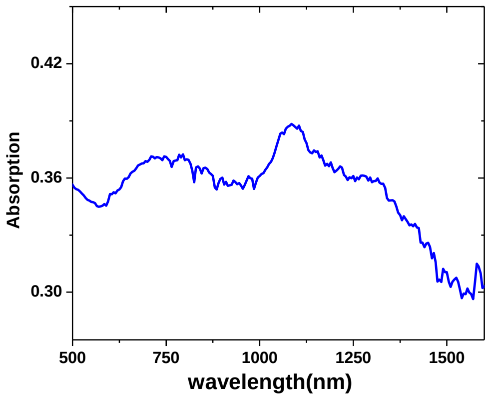

Fig.3.Measured experimental absorption spectra for the gold rods. Two absorption peaks can be observed indicating of the resonances at wavelengths of 781.2 nm with a peak of 37% and 1083.3nm with a peak of 39% respectively.

IV. Discussion And Conclusion

In the paper we have investigated the absorption at resonance for gold rod whose unit cell is composed of gold rods of unequal length. Simulations results of the absorption of the structure was presented indicating two absorption peaks. A smaller absorption peak having a broad profile at the shorter wavelength of 803.6nm and a larger absorption peak having a narrow profile at the longer wavelength of 1089.3nm. From the experimental absorption, a smaller absorption peak having a broad profile at a shorter wavelength of 781.2nm and a larger absorption peak with a narrow profile at the longer wavelength of 1083.3nm respectively were obtained. The experimental result of the absorption was shown to be in good agreement with the simulation results. The nature of the resonances of the structure allows for application in sensing.

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