Light scattering from coupled plasmonic nanospheres on metallic thin film over a substrate*

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Abstract

Clustering effect of nanoparticles on a glass substrate by using a disk model [1] Here, we use a realistic model to describe close-packed naoparticles to calculate the light scattering spectra. We have investiaged optical scatteeing from clustering metallic nanoparticles on a metallic thin film over a substrate by using the spherical harmonics based Green's function method to obtain the ellipsometry parameters Ψ and Δ. First we focus on randomly distributed identical nanoparticles with geometry shown in Fig. 1(a) (top-view) and Fig. 1(b) (side view). We use Au nanoparticles (AuNPs), Au thin film and glass substrate. The calculated ellipsometric spectra for d=80nm and t=40nm is shown in Fig. 2. We attribute the dip in the Ψ spectrum to the strong coupling between AuNPs and Au thin film. Hence, the plasmonic peak splits into anti-symmetric and symmetric peaks. Furthermore, we have investigated light scattering from various arrangements of clustering nanoparticles as shown in Fig. 1(c) (top view).The calcutated results are shown in Fig. 3 and we find multiple plasmonic peaks caused by the Fano resonance effect. This phenomenon is due to the strong coupling between clusters and the metallic thin film. Finally, we include the nonlocal effect via using the random phase approximation (RPA) rather than semi-classical hydrodynamic model [2] to describe the dielectric function of both metallic nanoparticles and thin film. We believe our theoretical model calculations can be useful for determination of the distribution of coupled nanoparticles on or embedded in a multilayer structure, including biological samples.

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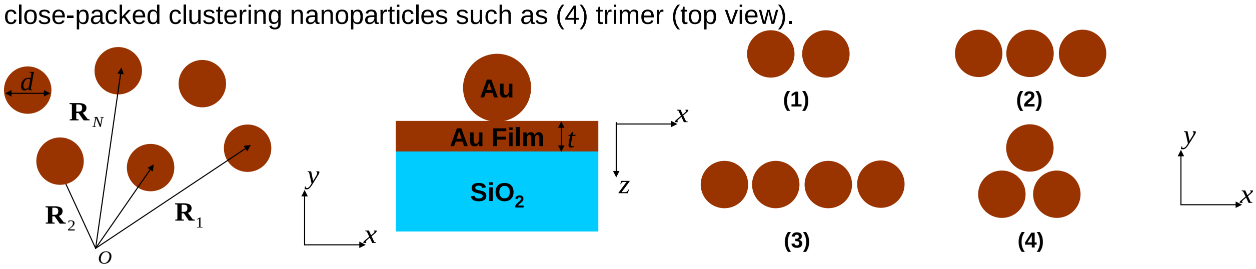
References

[1] H.-Y. Xie, Y.-C. Chang, G. Li, S.-H. Hsu, Opt. Express 21, 3091 (2013).
[2] C. Ciracì, R. T. Hill, J. J. Mock, Y. Urzhumov, A. I. Fernández-Domínguez, S. A. Maier, J. B. Pendry, A. Chilkoti and D. R. Smith, Science, 337, 1072 (2012).

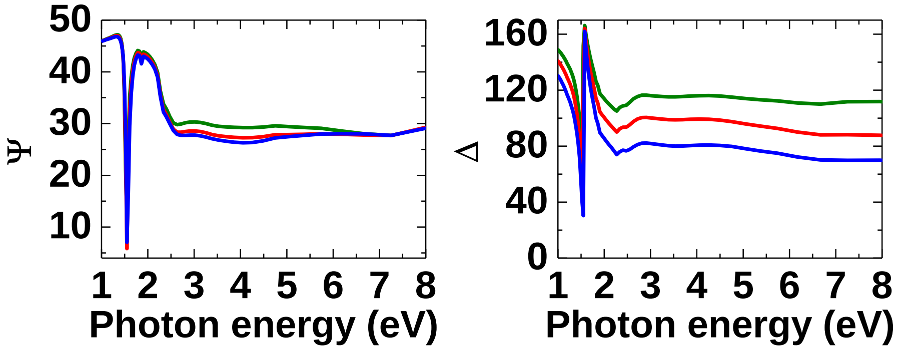
Figures

[1] (a) A picture describes randomly distributed identical nanoparticles with variable distances between the centers of particles R_i and the origin O (top view, x-y plane) and the diameter is d; (b) A geometry shows the coupled structure between AuNPs and Au thin film (the thinkness is t) on the SiO_2 substrate; (c) Schematic drawing of a chain of nanoparticles with particle number (1) 2, (2) 3, (3) 4 (top view) and close-packed clustering nanoparticles such as (4) trimer (top view).

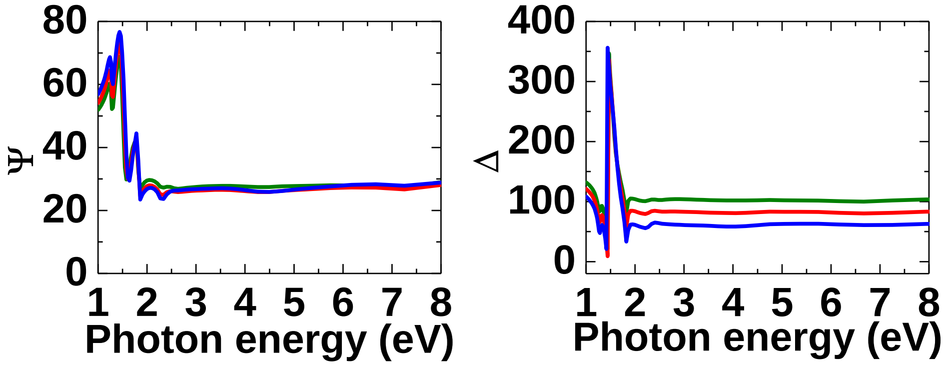


(a) (b) (c)

[2] Calculated ellipsometric spectra for a random distribution of nanoparticles coupled with Au thin film on glass substrate with d=80nm and t=40nm for incident angles of 55°(green), 60°(red), and 65°(blue).

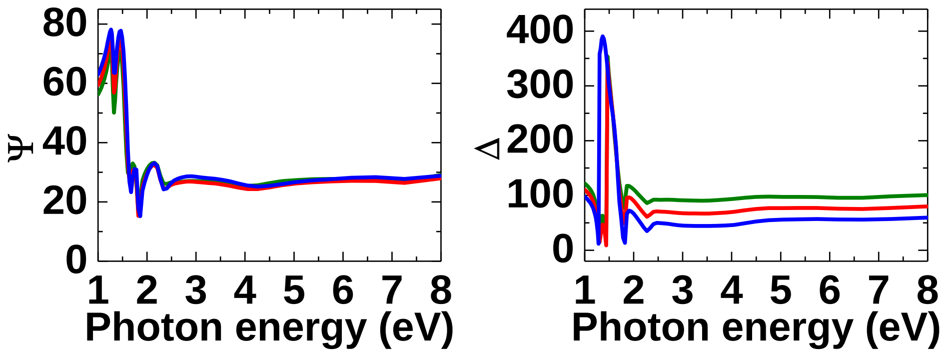


[3] Calculated ellipsometric spectra (Ψ and Δ) for isolated clusters of Au-NPs (with d=80nm and t=40nm) coupled with Au thin film on glass substrate with three different angles of incidence: 55^o (green), 60^o (red) and 65^o (blue) for four different arrangements: (a) a chain of two nanoparticles (2) a chain of three nanoparticles (3) a chain of four nanopatrticles and (4) a trimer. The gap used is 2nm.



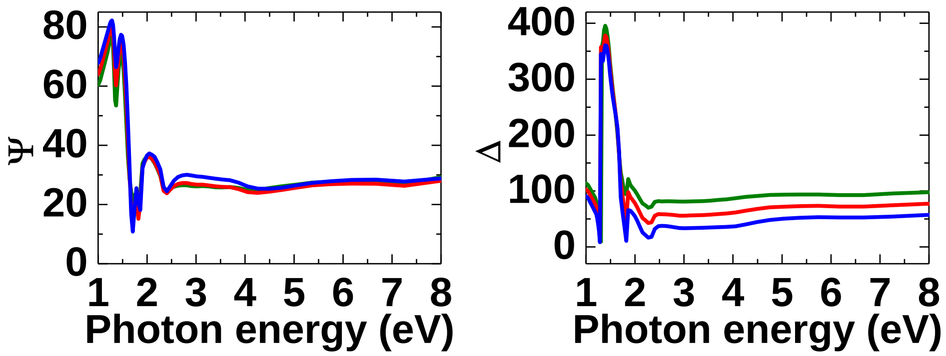
80
60
40
20
0
Ψ
1 2 3 4 5 6 7 8
Photon energy (eV)
400
300
200
100
0
Δ
1 2 3 4 5 6 7 8
Photon energy (eV)

(a)



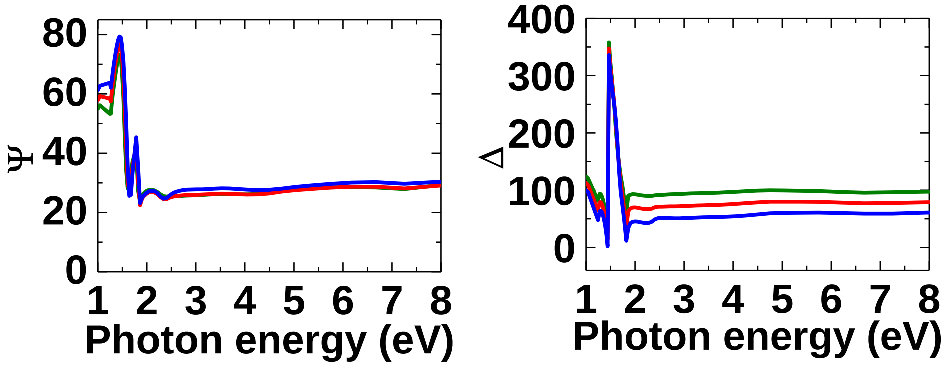
80
60
40
20
0
Ψ
1 2 3 4 5 6 7 8
Photon energy (eV)
400
300
200
100
0
Δ
1 2 3 4 5 6 7 8
Photon energy (eV)

(b)



80
60
40
20
0
Ψ
1 2 3 4 5 6 7 8
Photon energy (eV)
400
300
200
100
0
Δ
1 2 3 4 5 6 7 8
Photon energy (eV)

(c)



80
60
40
20
0
Ψ
1 2 3 4 5 6 7 8
Photon energy (eV)
400
300
200
100
0
Δ
1 2 3 4 5 6 7 8
Photon energy (eV)

(d)