Enhanced optical scattering of Au nanoparticle by surface plasmon polariton coupling

T. S. Lee[1], W. M. Kim[1], S. J. Byun[2], D. Lee[2], K. S. Lee[1]

[1]Korea Institute of Science and Technology, Thin Film Materials Research Center, Seoul, 136-791, Korea
[2]INSIDEOPTICS CO., LTD, Seoul Technopark R&D building 172, Seoul, 139-743, Korea
email: tslee@kist.re.kr

Summary

Optical scattering of Au nanoparticle and its enhancement by surface plasmon polariton coupling were numerically calculated in the Kretschmann geometry using a finite difference time domain method. The coupling of SPR field to the LSPR of Au nanoparticles was confirmed to provide very effective means for light scattering.

Introduction

Evanescent field coupling has been widely used to excite localized surface plasmon of metal nanoparticles in the total internal reflection (TIR) spectroscopy for bio-chemical sensing and imaging application [1,2]. In this paper, further enhancement in the scattering intensity from the metal nanoparticles was tested in the geometry of a particle on metal surface where the surface plasmon polariton can be generated and coupled to excite the localized surface plasmon of metal nanoparticle.

As a model system, Au nanoparticle on Au film in the Kretschmann geometry was considered and its optical field distribution was calculated using 2-dimensional finite difference time domain (FDTD) method [3]. The model geometry used for simulation is schematically illustrated in Fig. 1. The diameter of Au particle is 100 nm and the thickness of Au film was varied from 40 to 70 nm. The refractive index of prism was set to 1.5. Plane waves with a wavelength ranging from 400 to 900 nm are assumed incident on the prism base at an angle of 45^{o}. The intensities of scattered light accompanied by the excitation of localized surface plasmon of Au nanoparticle were monitored by a detector positioned above the particle. Detecting angle covers 130^{o}, which corresponds to the measurement through objective lens with a numerical aperture (NA) of 0.9.

Simulation results & Discussion

Figure 2 summarizes the results of FDTD calculation for the model system shown in Fig. 1. As shown in Fig. 2, the intensity of scattered light of Au nanoparticle changes depending on the thickness of the underneath Au film. It is observed that, as the Au film become thinner to 40 nm, the scattering intensity is noticeably enhanced compared with that of conventional TIR geometry without metal layer. It is related with the optimal thickness condition for the generation of surface plasmon. At this optimal thickness, the local field in the metal/dielectric interface is greatly enhanced, and coupled to the localized surface plasmon of Au nanoparticle, thus increasing the

light scattering.

For the thickness of Au film over 60 nm, the off-resonance condition for SPR suppresses the light scattering. Interestingly, the resonance peak of optical scattering of Au nanoparticle is observed in the longer wavelength than that without underneath Au film, which may be ascribed to the interaction between the Au particle and metal surface and interpreted in the frame of plasmonic Anderson model [4].

Conclusion

From the above simulation results, we could confirm that the LSPR of Au nanoparticles coupled to SPR field was very effective for the enhancement of scattering intensity. Also, the red-shift of the resonance peak was observed due to the interaction of LSPR and SPR.

Acknowledgement

This research was supported by a grant(code #: M108KO010019-08K1501-01910) from 'Center for Nanostructured Materials Technology' under '21st Century Frontier R&D Programs' of the Ministry of Education, Science and Technology, Korea.

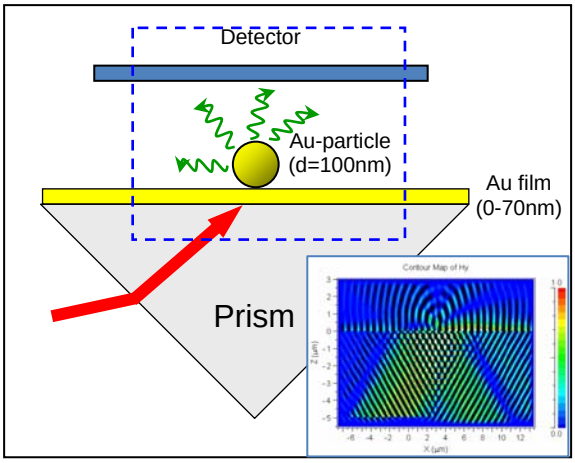

Fig.1. Schematic diagram of the simulation structure and calculated field (insert).

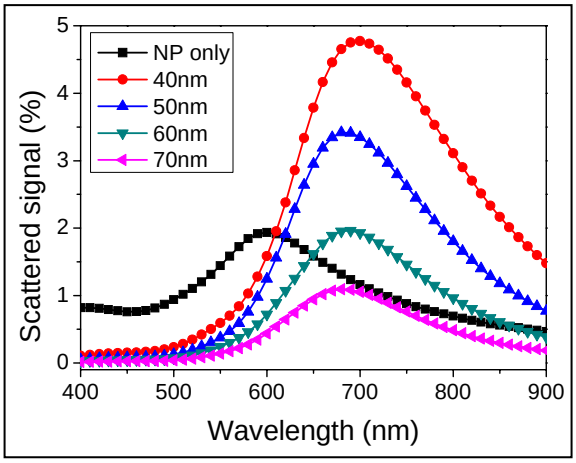

Fig.2. Calculated scattered intensity.

References

[1] C. Sonnichsen *et al*., Appl. Phys. Lett., 77, 2949, 2000
[2] R. Van Duyne *et al*., Nanoscape, 2, 35, 2005
[3] RayWiz-FDTD^{TM}, Insideoptics Co., Ltd.
[4] H. Wang *et al.*, Acc. Chem. Res., 40, 53, 2007