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Hybrid Plasmonic-Photonic Structures To Realize Localized Surface Plasmon Resonance Excitement

Nassibeh Ebadi
Assistant Professor of electrical engineering department
Roshdiyeh Higher education Institute
Tabriz, Iran
Ns-ebadi@tabrizu.ac.ir

***Abstract*— In this work, to realize localized surface Plasmon polariton excitement, hybrid plasmonic-photonic structures are studied theoretically. The considered hybrid structures are the integration of silicon dielectric material and gold as plasmonic part. 3D-FDTD based simulation results demonstrate that the radiated optical field exciting the Plasmon resonance of the metallic substructure is concentrated within the interface of the gold plasmonic particle and dielectric materials.**

The enhanced confined optical field can be applied in a wide range of applications based on optical field localization including optical nonlinearity, data storage, nanolasers, power supply, … .

***Keywords*- hybrid, plasmon resonance, photonic, field enhancement**

1. Main text

Plasmonic-photonic hybrid structures due to the combined capability of concentrating and enhancing the optical field within sub wavelength spaces have attracted much attentions of scientific community during last decades [1] to [2]. The hybrid systems constructed of plasmonic and dielectric parts, concentrate the incident optical field within the structure in the interface of the metallic and dielectric materials. The excited surface plasmons of the plasmonic substructure localized in the interface medium between the metal and semiconductor material result in the resonance and improvement of the confined optical field [3] to [4].

The enhanced optical field concentrated within micro or nano meter regions can be applied in significant potential applications including nonlinear optics, data storage in sub wavelength spaces, nanolasers, antennas, and etc. Various integrated plasmonic-photonic structures have been introduced by different research groups [5].

In this research work, the optical field concentration and enhancing within hybrid structures composed of gold and silicon materials is investigated. Numerical simulations have been performed applying FDTD technique. Results are presented in the paper.

1.1. Structure design and simulation results

Figure 1 illustrates the hybrid structure composed of dielectric silicon substrate and gold patch placed on the substrate. X-polarized electric dipole illuminates the structure from substrate side. The perfectly matched layer boundary condition is employed in 3D calculations.

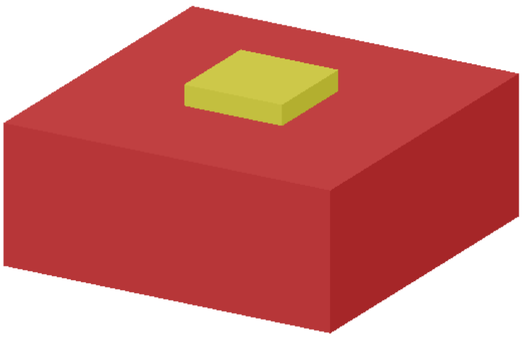

Figure 1. Hybrid structure of silicon substrate and gold patch

The input optical field excites the surface plasmons of the gold in the interface of the gold and silicon substrate. Consequently, the localized surface plasmons lead to confining and improving the incident optical field within the nanometer size interface of metal and dielectric in the four sharp angles of the gold rectangular piece. The calculated improved optical field distribution is depicted in Figure 2.

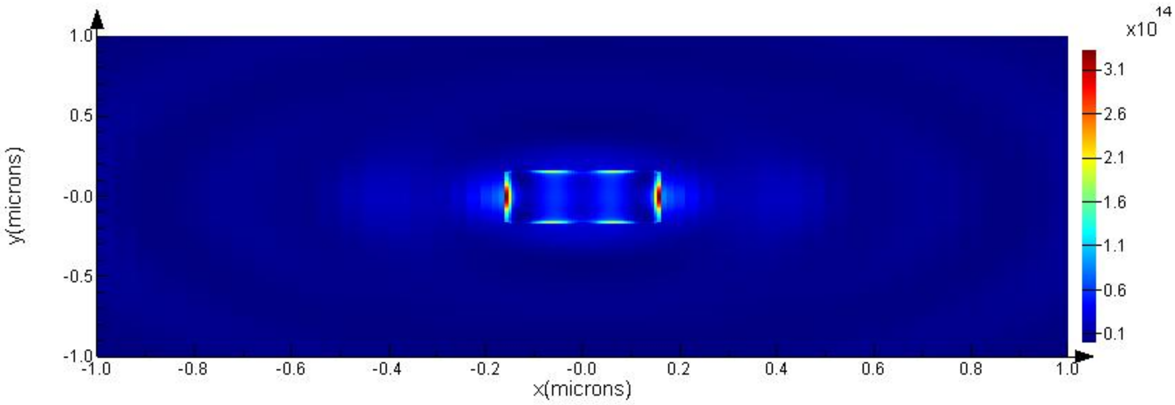

Figure 2. Enhanced optical field distribution within hybrid structure of silicon substrate and gold patch

The other combined structure constructed of gold substrate and dielectric silicon rectangular patch located on the plasmonic substrate shown in Figure 3.

In this case, the x-polarized electric dipole illuminates the hybrid structure from dielectric material side, upside of the structure. Once again, the input optical field excites the plasmon resonance of the gold substrate results in concentrating the optical field in the nano meter size interface between the gold and silicon. The improved optical field intensity distribution profile of the above-mentioned structure is displayed in Figure 4.

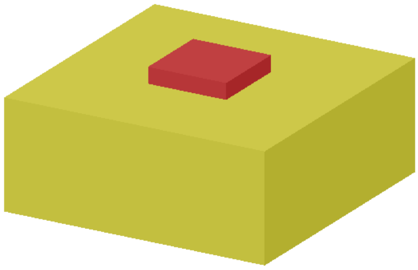

Figure 3. Hybrid structure of gold substrate and silicon patch

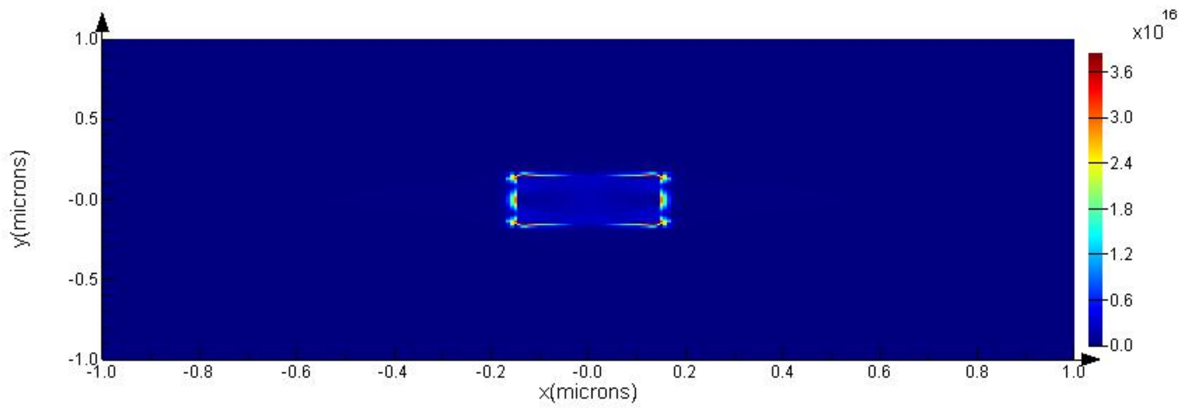

Figure 4. Enhanced optical field distribution within hybrid structure of gold substrate and silicon patch

It is observed in Fig. 4 that the radiated optical field is confined in the four angles of the silicon patch within the interface between gold substrate and silicon patch.

Comparing the achieved localized optical field profiles for two considered different hybrid structures, in Fig. 2 and 4 demonstrates that the incident optical field is enhanced more strongly within the combined design of gold substrate and silicon rectangular patch.

2. Conclusion

Optical field localization and enhancement resulted through plasmon resonance excitation is investigated for two different hybrid plasmonic-photonic structures composed of gold and silicon bulk materials as substrate and patch and vice versa. Numerical simulation results illustrates that both combined structures hugely improves the concentrated optical field at sharp angles of the plasmonic/dielectric resonator within nanometer size interface medium. According to the calculations, the ultrahigh confined optical field is achieved within the integrated gold substrate and silicon patch resonator.

References

[1] Ebadi, N., Yadipour, R., Baghban, H. (2017). High intensity gap light coupling of nano-antenna to high Purcell factor photonic crystal nanocavity. Journal of Optoelectronics and Advanced Materials, vol. 19, no. 7, p. 454-458.

[2] Ebadi, N., Yadipour, R., Baghban, H. (2018). Ultrahuge light intensity in the gap region of a bowtie nanoantenna coupled to a low mode volume photonic crystal nanocavity. Current Optics and Photonics, vol. 2, no. 1, p. 85-89.

[3] Zhang, T., Callard, S., Jamois, C., Chevalier, C., Feng, D., Belarouci, A. (2014). Plasmonic-photonic crystal coupled nanolaser. Nanotechnology, vol. 25, p. 315201.

[4] Belarouci, A., Benyattou, T., Letartre, X., Viktorovitch, P. (2010). 3D light harnessing based on coupling engineering between 1D-2D photonic crystal membranes and metallic nanoantennas. Optics Express, vol. 18, p. A381-A394.

[5] *El Eter, A., Grosjean, T., Viktorovitch, P., Letartre, X.,. Benyattou, T., Baida, F. I. (2014). Huge light enhancement by coupling a bowtie nanoantenna's plasmonic resonance to a photonic crystal mode.* Optics Express*, vol. 22, p. 14464-14472.*