An optimized hybrid nanostructure for tunable radiation and filter characteristics in optical circuits

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Abstract

A hybrid nanostructure using gold nanoparticles encapsulated in a dielectric shell has been proposed. The proposed nanostructure offers radiation and filtering characteristics in visible wavelength range. First, the design has been optimized then two variations of the optimized design have been analyzed. Dielectric shell index values are kept less than 2 to keep the electric and magnetic scattering efficiencies under control. First design is the array of structure with constant shell index and varying shell surrounding conditions which offers narrowband filtering in visible spectrum. In this design, both the operational filter bandwidth and the radiation wavelength red shifts with increment in shell index values. Design with shell index 1.5 offers a 3-dB filter bandwidth of 87 nm which increases to 155 nm for shell index 1.95. Contrary to filtering, radiation resonance remains approximately constant with change in 3 dB radiation spectrum. The shell surrounding index is also critical

in deciding the filter bandwidth as the offered filter bandwidth increases significantly with the surrounding index values greater than 1.3. Variation in the number of array elements causes no change in the power extinction and radiation characteristics, although it affects the far filed radiation pattern. Array with larger number produces more elliptical radiation pattern. Further, keeping the surrounding index constant and selecting different shell indices in the design offer wider 3-dB filter bandwidths and wideband radiation characteristics, and this forms the second proposed design. A wide 3-dB filtration band of 210 nm covering filtering bands offered by all the individual elements was achieved. Similarly, radiation pattern observes a wider spectrum covering spectrums of all the array elements. Analyzing the losses offered by dielectric shell, less than 20% of normalize shell loss are observed at 0.52 um with lowest shell index, whereas it increases to more than 90% of the normalized loss values with highest index contrast at around 0.41 um, which is sufficiently apart from the power extinction range of gold nanoparticle. All the simulations have been carried out using finite difference time domain method (FDTD).

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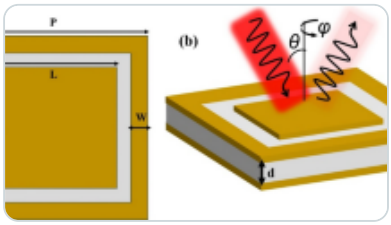

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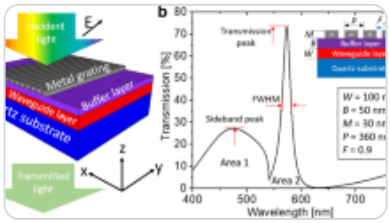

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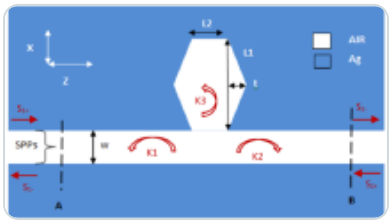

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Data availability

The manuscript does not contain any third party material.

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Contributions

VK As a first author, developed the concept, finalize the tool for simulation, simulate the design, and draft the manuscript. RZ has contributed in performing the formal analysis of the simulation result, verification of the data from the literature survey and drafting the manuscript. PKJ has assisted for obtaining the result with the aid of software. He also reviewed and edited the manuscript. VJ has contributed in analysis of simulation work. He has also handled the review and final editing of the manuscript.

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Ethics declarations

Conflict of interests

Authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work.

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