Optik 160 (2018) 259–266

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Original research article

Surface distortion compensation in nano particle by using the graphene layer to obtain reconfigurable absorber

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ARTICLE INFO

Article history:
Received 19 November 2017
Received in revised form 29 January 2018
Accepted 1 February 2018

Keywords:
Nano particle
Plasmonic
Graphene
Sub wavelength

ABSTRACT

Distortion in the fabrication of the nanoparticle in the process of the lithography affects the absorption of a nano antenna. In this paper, we have used the graphene as a part of the substrate for compensating the effect of these distortions. In this study, we have investigated rectangular nano particle as our basic nano particle which are placed over a SiN substrate as a spacer. We have utilized the graphene layer with thickness of 2 nm under the nano particle and then various distortions is modeled and applied by small spherical array. In optical domain, we have studied the effect of distortions on the nano particle reflection. We have checked the graphene effect for compensation the frequency shift that made by the distortions. We also replaced the graphene layer with SiN to show that how much the graphene is affected on reflection controlling. Furthermore the distortion volume has been considered and compared to the rectangular element. The result shows that the relaxation time and temperature have less effect on the absorbency and chemical potential is the main parameter for compensation. This method can be considered for calibration the nano antenna and the optical absorber.

1. Introduction

Nanotechnology is a type of applied science and technology that covers a wide range of topics in the optical spectrum. The main issue is contained materials or devices with dimensions of less than one micrometer, usually about 1–100 nm [1]. In fact, nanotechnology describes and employs new properties of the materials and systems in this dimension, that new physical effects exhibit mainly influenced by the dominance of the quantum properties of classical physic attributes [2].

This new technology is plasmonic that made by the surface plasmons [3]. The interaction between light and the electrons in the boundary of the metal and dielectric surface make the plasmons [4]. Surface plasmonic excitation is made at a certain wavelength of an incident beam result in an increase in electromagnetic fields in the vicinity of a thin metal film or metal nano particles, nano structure of a layer [5,6].

In addition, the surface plasmons in metallic nano particles or nanostructures on the stimulated substrates are used for controlling the scattering and absorbing the factors of the cross section associated with these structures. In studies, attention has been paid to the optical properties of plasmonic structures [7,8].

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https://doi.org/10.1016/j.ijleo.2018.02.004
0030-4026/

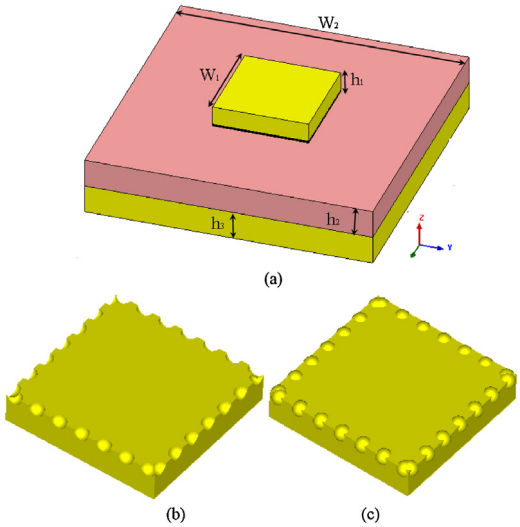

Fig. 1. The geometry of the nano antenna (a) the 3D view of the unit cell as nano antenna (b) the nano particle defected by subtracting (c) the nano particle defected by adding.

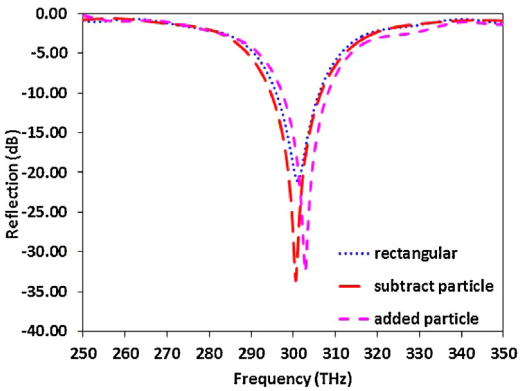

Fig. 2. The reflection of the nano particle in three cases.

This plasmonic structure can be used in many measurement systems as well as in chemical and biological measurements of molecules [9]. Moreover, as the electromagnetic field enhancement in the regions between the nano particles and the plasmonic film can be noticed for the Surface Enhanced Raman Spectroscopy (SERS) [10].

Nano-antennas have been considered in order to strengthen the field in solar cells and electrical absorbers. By using the nano sized antenna, the electrical charge is increased at the antenna and the substrate and so the absorption at the surface of the antenna is enhanced [11], and the current is produced at the surface of the solar cell that increased respectively, as an example of this structure is carried out with bowtie nano antennas [12].

Graphene is a kind of carbon with an atom thickness (monolayer), where the carbon atoms are placed in a honeycomb lattice (hexagonal). Graphene has become a unique substance due to its excellent properties in electrical conductivity and thermal conductivity, high density and mobility of load carriers, optical conductivity, and mechanical properties and graphene have been noticed for various applications such as nano antenna and absorbers [13,14].

In the field of optical nano particles, gold and silver particles with a plasmonic property are considered, and in this spectrum, changes in the physical structure result in changes in the frequency of resonance [15]. It is important to compensate for this effect in nano-antenna lithography.

Considering the effect of nano size dimensions and distortion on working frequency resonance, we can use graphene as a compensator, due to the variability of graphene properties [16].

Recently, the graphene is considered as a hybrid structure with metal like (Au) for controlling the Fano resonance [17], monolayer graphene as the Nano-spacer of Metal Film–Metal Nanoparticle coupling system [18] or plasmonic sandwich system based on graphene/copper film and its application in SERS [19].

In this paper, at first we have simulated a structure without distortion and then with distortion implementation. Initially, we consider a nanoparticle with a certain profile on a layer of graphene, and we show that if there is distortion in the production of nano particles, we will change the frequency resonances. “We propose that graphene be used as a compensator in the