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# Large area multi-channel plasmonic absorber based on the touching triangular dimers fabricated by angle controlled colloidal nanolithography

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ABSTRACT

Here we introduce large area plasmonic touching triangular dimers by angle controlled colloidal nanolithography to use them as an efficient multi channel absorber and also high figure of merit sensors. For this purpose, we coated gold thin films onto nanometric and also micrometric polystyrene hexagonal closed packed masks in different deposition angles and also diverse substrate polar angles. Our prepared samples, after remove masks, show large area touching triangular pattern with different inter particle distances in greater polar angles. To get more sense about optical response of the samples such as transmittance and also electric field distribution, we use finite difference time domain method in simulation part. The transmittance plot shows one narrow or multi-channel adjustable deep depend on inter-particle distances which can be controlled by azimuthally angle in nano lithography process. Also, due to the isoelliptical points in the transmittance spectra; we can see the bright and dark plasmon modes coupling and thus the Fano like resonance takes place in the optical spectral region which is very useful for refractive index measurement.

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## 1. Introduction

The ability to design and fabrication of multi-channel plasmonic structures like absorber and sensors by controlled geometrical nano patterned structures has been the subject of intense during recent years [1–3]. Design of plasmonic sensors can be achieved by Fano resonance due to symmetry breaking [4–6], fabricating multiple metallic elements [7] and also via change in the incidence angle and light polarization. Symmetry breaking allow directly excitation of higher order plasmonic modes with normal incidence light [8] and thus reached to the Fano resonance to use as a good chemical sensors. Such Fano resonance has been reported in a variety of metallic nanostructures [9–11], oligomers [12], septamers [13], ring disk nanocavities [14], core shell nanostructures [6] and also multilayer nanoshells [15,16] via expensive and completive procedure.

Because the above mentioned procedure can lead to the rise of the resulted sensors' price, researches drift to replace the cheaper methods like that nanosphere lithography (NSL). The NSL method is one of the accessible methods to achieve designed and perforated nanostructures in spite of its lower cover areas [17,18]. In order to break symmetry in the structures and efficient excitation of Fano resonance due to strong interaction of the involved plasmonic modes, septamers and oligomers take the attention to themselves which may be achieved by angle controlled NSL processes [19].

On the other hand, thinks about multi-wavelength devices drift researchers to design newer optical devises based on nanophotonic area like as multi defect photonic crystals [20], core shell nanoparticles [16] and so on.

In this paper, plasmonic nano and micro antenna as a dimer touching triangular plasmonic structure has been designed and fabricated via nanosphere multistep lithography and then the multi wavelength absorber due to the Fano resonance has been characterized in the large area fabricated samples.

## 2. Experimental procedure

To prepare our plasmonic structures, at a first step, we get ready a monolayer of hexagonally close-packed polystyrene 800 and

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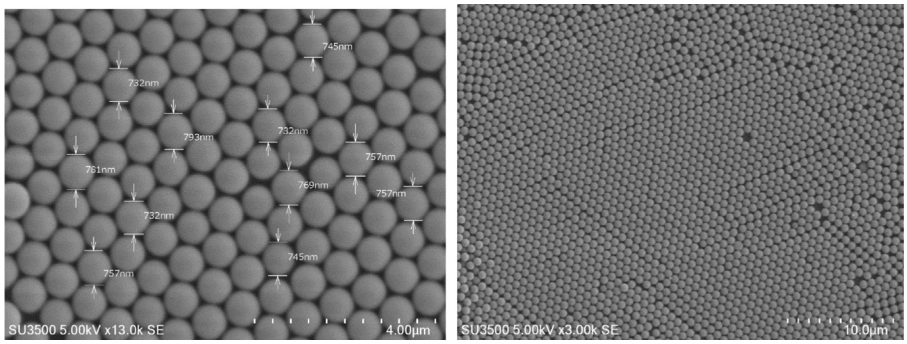


**Fig. 1.** SEM image of the prepared mask by 800 nm nanospheres in zoom and large area scales.

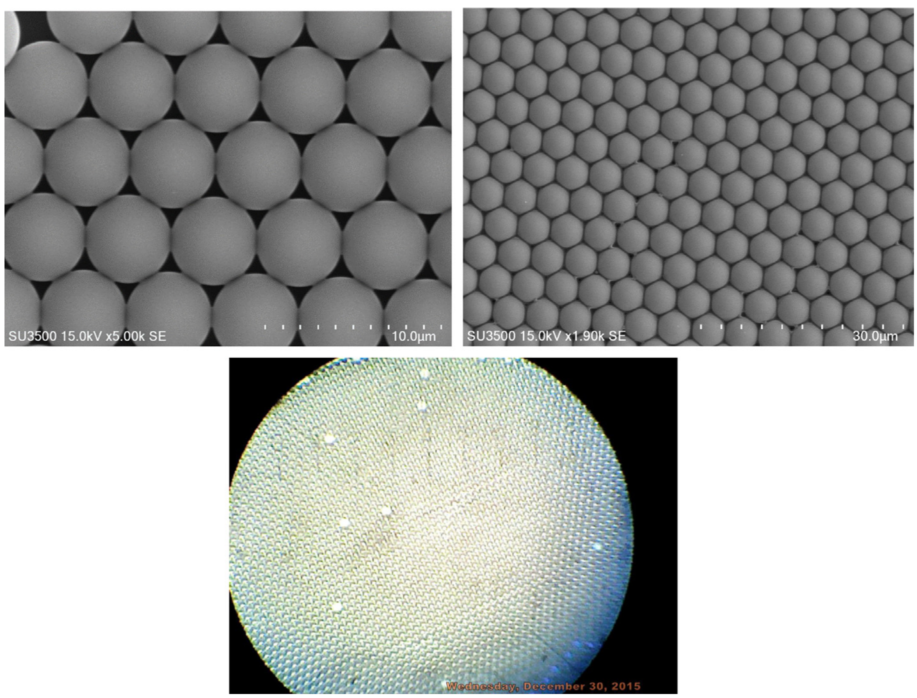


**Fig. 2.** SEM image of the prepared mask by 5000 nm nanospheres in zoom and large area scales and also optical microscopy of the large area coverage.

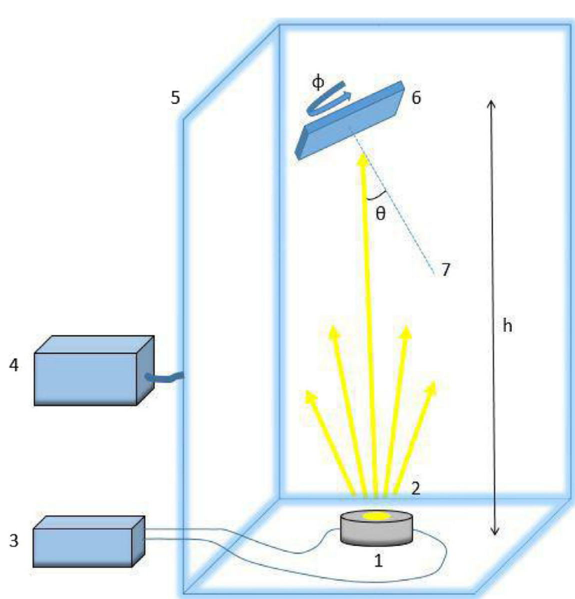


**Fig. 3.** A Schematic diagram of multistep deposition process.

**Table 1**
Change in the triangular size by deposition angle for each of nanospheres used as a mask.

| θ° | a (nm) with 800 nm mask | θ° | a (nm) with 1500 nm mask |
|---|---|---|---|
| 0 | 270 | 0 | 1700 |
| 10 | 260 | 15 | 1580 |
| 15 | 250 | 20 | 1488 |
| 20 | 235 | 22 | 1440 |
| 22 | 227 | 25 | 1350 |

**Table 2**
Change in the distance between two triangular by polar angles for each of nanospheres used as a mask.

| φ° | s (nm) with 800 nm mask | φ° | s (nm) with 1500 nm mask |
|---|---|---|---|
| 15 | 40 | 23 | 400 |
| 22 | 60 | 32 | 560 |
| 37 | 100 | 42 | 720 |

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