transparent conductive oxide (TCO) particles with different shapes embedded within high electric permittivity medium topped with an antireflective layer.

Localized Surface Plasmon Resonance (LSPR) on plasmonic particles ensures high field localization around and directly beneath the particles translating into high density of optical energy within the photodetector active area [1]. We investigate the possibilities to modify the particle shape end size in order to maximize the photodetector optical energy intake i.e. to maximize photodetector external quantum efficiency. We perform ab initio simulation of the optical response of the whole system utilizing the finite element method, starting with spherical particles [2] and then extending our approach to include spheroids and sub-micrometric plates.

As an illustrative example, we analyze a mercury cadmium telluride infrared detector with an ultrathin active epitaxial active layer. An increase in external quantum efficiency can be used to offset a decrease in the optical path/internal quantum efficiency. Plasmonic localization is extremely beneficial for this approach since optical energy density is strongly localized close to the illuminated surface, thus ensuring a large decrease of the total photodetector volume and therefore suppressing the total generation-recombination noise levels that are proportional to the device volume.

Our results show that it is possible to realize an uncooled semiconductor detector for midd-wavelength infrared range with its specific detectivity strongly increased compared to the conventional photodetectors.

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Field localization control in aperture-based plasmonics by Boolean superposition of primitive forms at deep subwavelength scale

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Aperture-based nanoplasmonics deals with an important class of structures using surface plasmons polaritons at subwavelength hole arrays to control propagation and localization of electromagnetic fields [1]. Such structures include extraordinary optical transmission arrays [2], fishnet-based metamaterials [3] as well as different other metasurface with applicability in sensing and detection, waveguiding, etc. [4].

The electromagnetic field localization in aperture-based plasmonic structures can be controled by modifying of the structure geometry at the deep subwavelength scale [5-6]. In this contribution we define subwavelength primitive objects that are combined in Boolean manner by applying logical operations like AND or OR to them to generate complex-shaped apertures and thus modify the subwavelength unit cell geometry. Generally, any arbitrary shape may be presented as superposition of a number of primitive forms (corresponding to a series expansion).

The approach can be used to generate field hotspots in a controled manner and redistribute field within a unit cell. Boolean operations applied to aperture shapes not only ensure “fine tuning” of scattering characteristics, but also the redesign of spectral characteristics of nanohole-based metasurfaces, owing to control over field concentration and the appearance of strong field nonlocalities.

We designed our designer (spoof) plasmon structures [7] with deep subwavelength modifications, simulated their scattering parameters by the finite element method and fabricated the experimental samples for the mid-wavelength infrared range using the conventional silicon-based planar technologies with silver as plasmonic material. The shapes were obtained by overlapping (Boolean OR) square primitive objects.

We show that one can use a set of primitive shapes readily produced by the existing lithographic equipment to generate strong field nonlocalities without increasing the complexity of the system or requiring finer resolutions. Actually the simplest situation would be to simply shift the same photolithographic mask and repeat the already used pattern. Owing to the redistribution of spectral characteristics and their structural tuning, the present approach can be used for multispectral operation of plasmonic chemical or biological sensors.

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