Numerical Analysis Of Star-shaped Nanostructures As Optical Detectors

R. Diaz de Leon-Zapata[1], A.B. De la Rosa-Zapata, E. Flores-Garcia, F.J. Gonzalez[2], J. Sanchez[2] and J.V. Gonzalez-Fernandez[1]

1. Tecnologico Nacional de Mexico/Instituto Tecnologico de SLP, San Luis Potosi, Mexico
2. Universidad Autonoma de San Luis Potosi, S. L. P., Mexico

INTRODUCTION: Star shaped nanostructures obtained by self-assembled growth [1] has peculiar geometry that suggests their use as optical detector. A full characterization is needed to comprehend their behavior. Numerical simulation becomes a very useful technique due the dimensions and pre and post nanostructures processing.

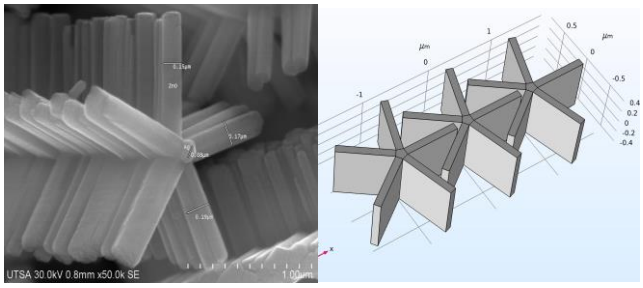

Figure 1. Star-shaped nanostructure and its COMSOL geometry model

COMPUTATIONAL METHODS: Applying the Wave Optics and the LiveLink for MatLab Modules, a resonance frequency was observed around 135 THz when the gold cover reaches 770 nm thick (figure 3), this frequency is presented due to its particular interest in telecommunication applications at Tbits per second (Tb/s) frequencies. It is worth mentioning that the particular combination of these two modules allows us to perform the study that covers several thicknesses, wave polarizations and the response of the electric field in the presence of the stellar geometry structure at a fixed frequency and varying the thickness of the gold layer. A very brief summary of the applied studies is depicted in figure 2.

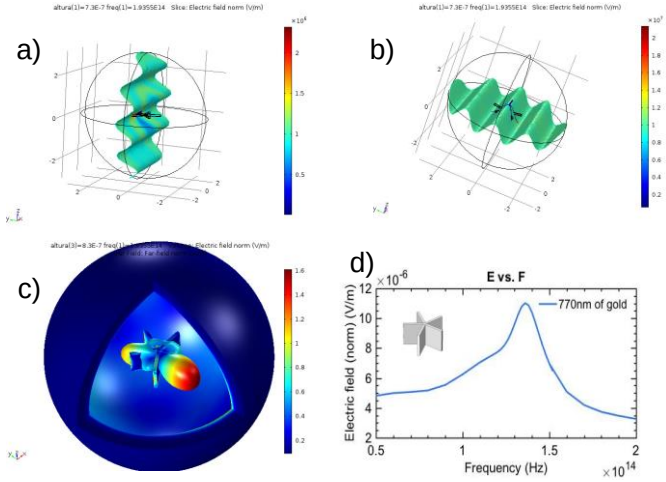

Figure 2. Wave polarization applied for the study: a) vertical, b) horizontal. c) Far-field electric field study. d) Resonance response discovered by simulation

RESULTS: The results allow us to suggest (among others) an application (work in progress) for the detection of dielectric and/or conductive particles with specific shapes (due to the star geometry), by applying a modified arrangement for the microreflectance difference spectrometer based on a charge coupled device camera [2] and its respective algorithm.

The ability to detect particles of certain dimensions and/or shapes is useful in fields such as medicine (diseases diagnosis), ecology (contaminant detection) chemistry (identification of specific molecules) and so on [3].

Figure 3 resumes the study of the structure as a sensor/detector.

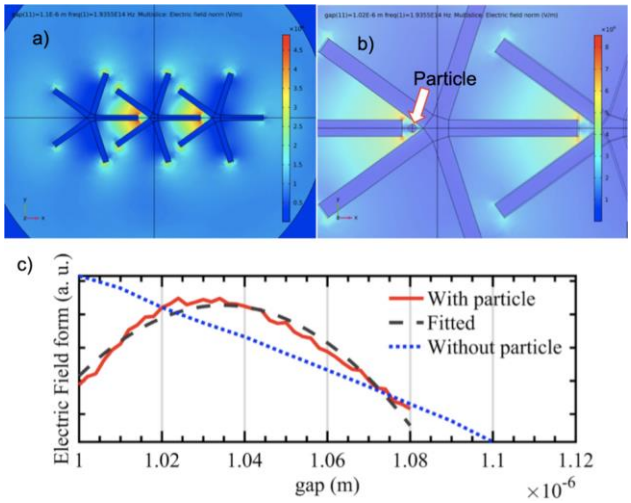

Figure 3. Electromagnetic response simulation. a) Nanostructure array without particle to detect. b) Distortion of electric field caused by a particle presence. c) Structure response as a particle detector.

CONCLUSIONS: As a result of few experiments, a star-shaped nanostructure could be grown. Applications could be imagined but the time and resources to demonstrate its practical functionality would have been impossible unless numerical simulation was applied.

Furthermore, new or unknown features were obtained thanks to the interactions between specialized software as can be done with COMSOL and LiveLink for Matlab, allowing to propose more applications for these structures.

REFERENCES:

1. J. E. Sanchez et al., "Resonance properties of Ag-ZnO nanostructures at terahertz frequencies", Optics Express, vol. 23, no. 19, (2015)
2. L. F. Lastras-Martínez et al., "Microreflectance difference spectrometer based on a charge coupled device camera", Applied Optics, vol. 48, no. 30, (2009)
3. K. S. Anuj, P. Ankit Kumar, and K. Baljinder "A Review of advancements (2007–2017) in plasmonics-based optical fiber sensors", Optical Fiber Technology, vol. 43, (2018)