Nano-antennas excitation with visible light and their observed response with a Confocal

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19th ISOT
CANCÚN · 2018 · MÉXICO
International Symposium on Optomechatronic Technology

Abstract

A confocal microscope was used to study the electromagnetic field produced from a cluster of nanoantennas excited by means of visible light. The experimental results shows the dynamic behavior of iron oxide nanoparticles deposited over a nanoantennas cluster, this as result of the magnetic field produced thought the excitation of said nanoantennas.

Methodology

We used iron oxide Fe_3O_4 nanoparticles (Np) with a size of 50-100 nm scattered in an immersion fluid (no polar fluid) with the help of an ultrasonic bath. Then, 20 µl of the immersion fluid with the dispersed Np were deposited over the substratum of the THz nanoantennas (Na). The Np were forced to get close to the substratum with two neodymium magnets, this with the aim to increase the density of Np in the Na vicinity, given that the electromagnetic field produced by the Na affects only the Np that are located a few micrometers from said Na. After the magnets were removed, the substratum was irradiated with two wavelengths one for observation (λ_o =543 nm) and one for excitation (λ_e=1000 nm). Images of the process were captured with the help of a confocal microscope.

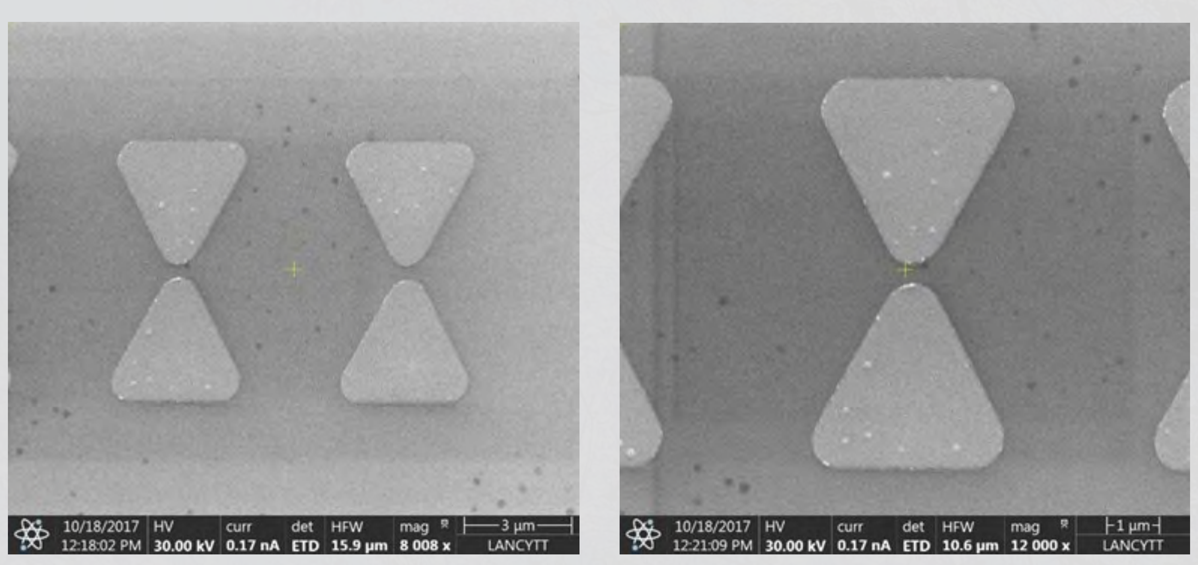

Fig. 1. Na of the discrete type.

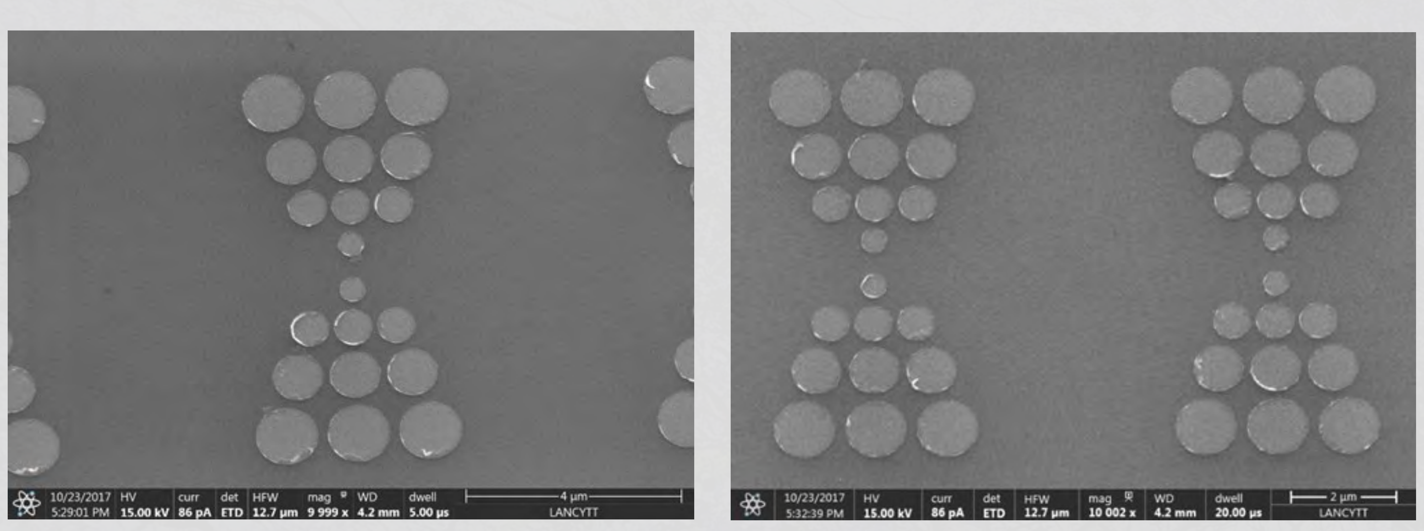

Fig. 2. Na of the un-discrete type.

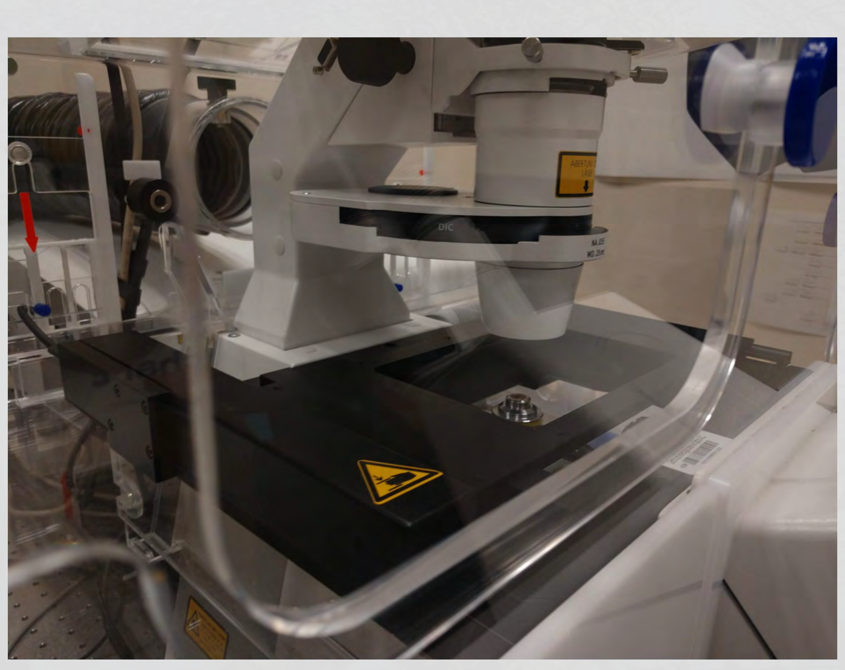

Fig. 3. Confocal microscope used in the capture.

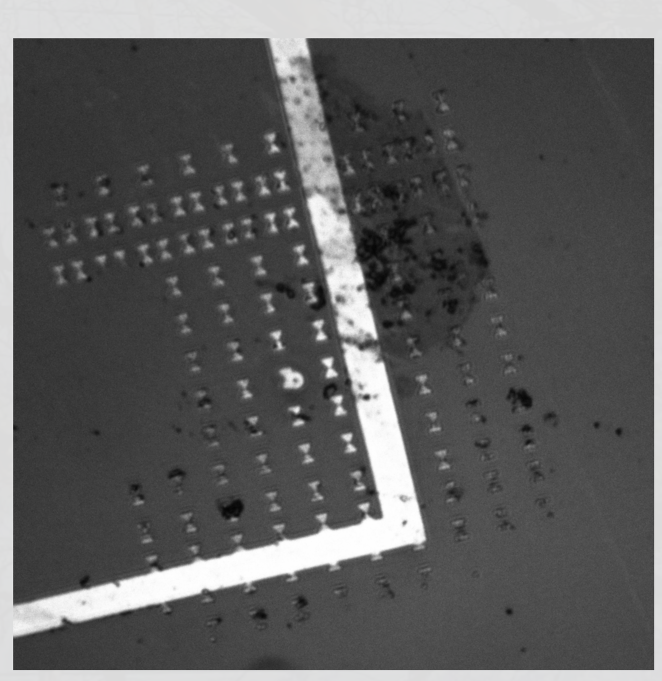

Fig. 4. Cluster of nano-antennas in confocal microscope.

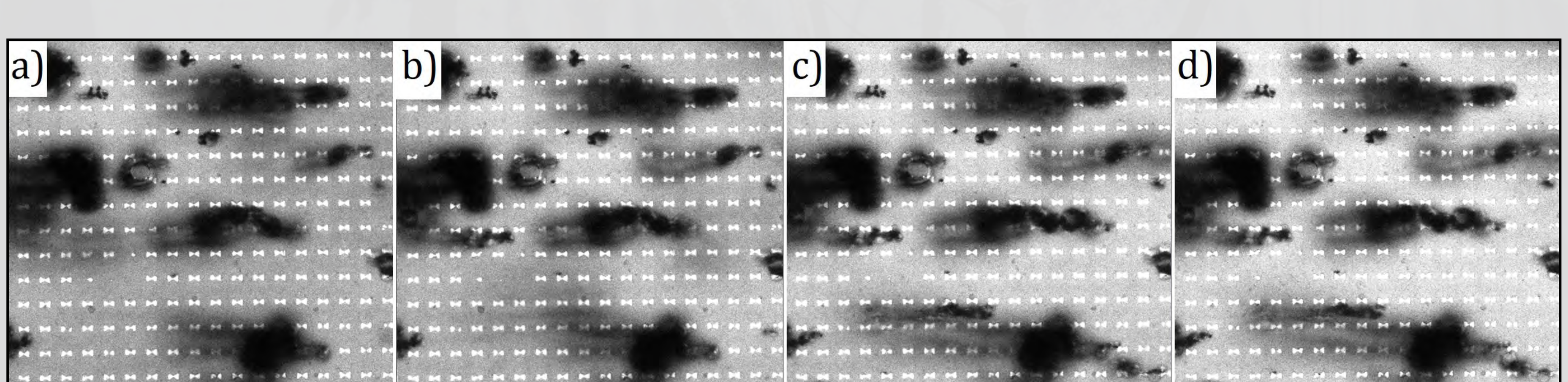

Fig. 5. Substratum of Na with Np deposited in immersion fluid and under magnetic stimulation by means of magnets: a) *t*≈0 min. b) *t*≈7 min. c) *t*≈14 min. d) *t*≈20 min.

Results

Fig. 6 presents a series of images with a field of view of 21x23 µm in which the concentration of Np was the 0.42 g/l. The images were taken along an interval of 20 minutes.

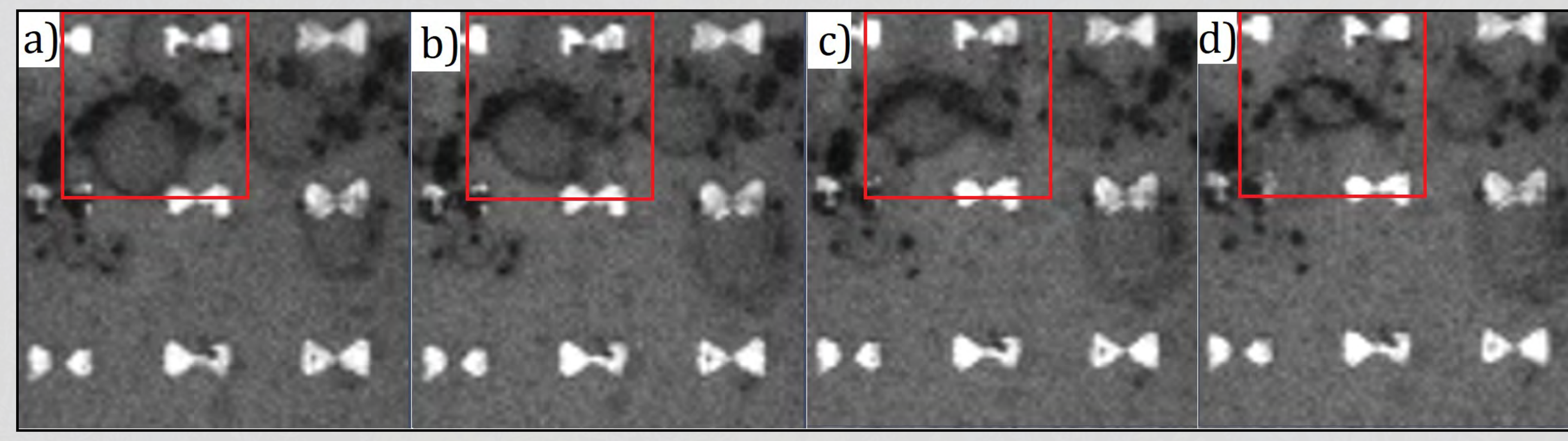

Fig. 6. Images discrete Na being irradiated by both λ_e and λ_o in a time of: a) *t*≈0 min. b) *t*≈7 min. c) *t*≈14 min. d) *t*≈20 min. Inside the *red square* we can observe the formation and dispersion of circles.

Fig. 7 shows the same area over the substratum, with the same Np, but now we turn off the λ_e, so the Np enter a period of relaxation of 20 min, this with the propose to analyze if the behavior observed in the Fig.6 is caused solely by the $\lambda_e$and not the by λ_o. As can be seen in Fig.7, there isn't an observable phenomenon, other than the slight fading of circles, along this period.

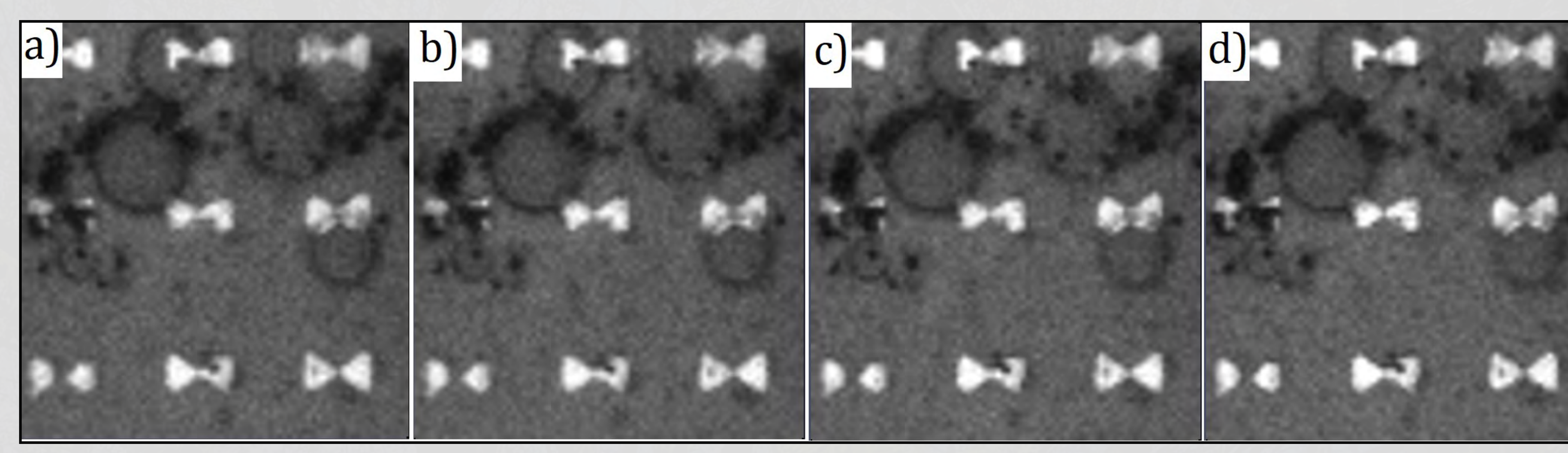

Fig. 7. Discrete Na without λ_e at a time: a) *t*≈0 min. b) *t*≈7 min. c) *t*≈14 min. d) *t*≈20 min.

The experiment was repeated over a different zone of the substratum, so we can observe the phenomenon again, but this time over an un-discrete cluster of Na, as shown in the Fig. 8. As we can observe in the aforementioned figure, the Np now seem to behave like little cumulus, instead of the foggy disperse medium.

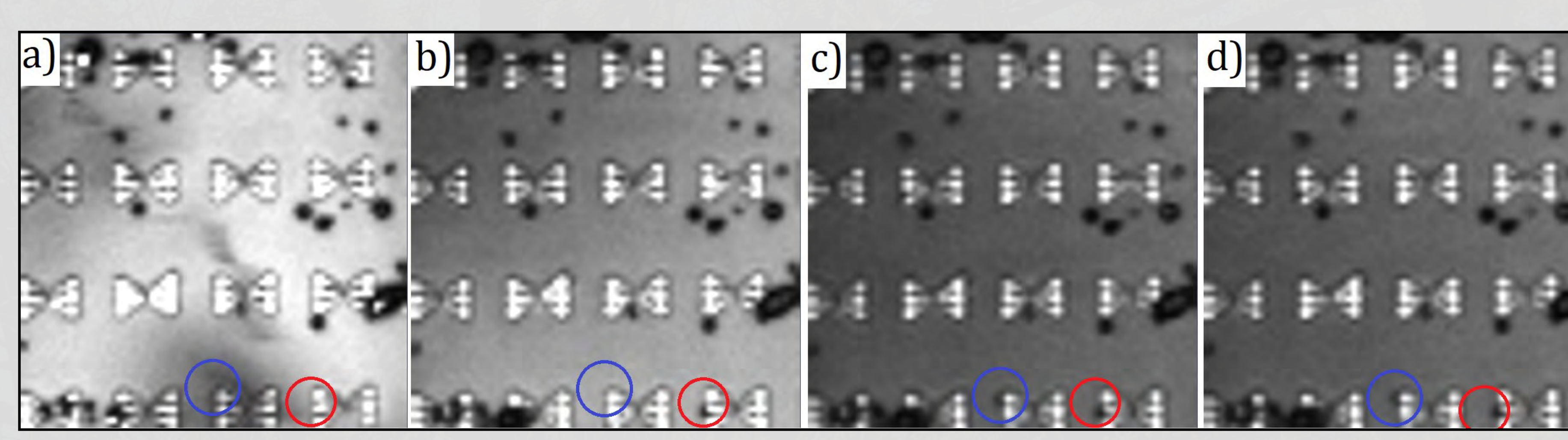

Fig. 8. Un-discrete Na with Np and λ_e at a time: a) *t*≈0 min. b) *t*≈18 min. c) *t*≈37 min. d) *t*≈55 min. Inside the *red* and *blue circles* we observe two different cumulus of Np which get caught by the Na in different moments.

Conclusions

In this preliminary research set as a proof of principle, we observed a rearrangement of the Np when the substratum was irradiated with the λ_e, but the same phenomenon did not repeat when the λ_e was absent, which make us think that the λ_o by itself is not enough to excite the Na. The observable response of the Np to the electromagnetic field produced by the Na is slow and not always the same (as the one presented here). As future work we intend to improve the experimental methodology until the dynamic clustering of the Np due to the electromagnetic field generated by the Na is repeatable. We will also characterize the dynamics of the Np as a result of the electromagnetic field from the excited Na.

Acknowledgments F. J. González would like to acknowledge support from Project 32 of "Centro Mexicano de Innovación en Energía Solar" and by the National Laboratory Program from CONACYT through the Terahertz Science and Technology National Lab (LANCYTT).

Reference

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