Self-organization of Au an Ag nanoparticles inside TiO₂ thin films: Understanding the temperature rise and growth mechanism upon laser irradiation

Nipun SHARMA¹, Zeming LIU¹, Francis VOCANSON¹, Yaya LEFKIR¹, Guy VITRANT², Nathalie DESTOUCHES¹

1 Laboratoire Hubert Curien, UMR 5516, Université Jean Monnet
2 IMEP-LAHC, UMR 5130, Minatec, Grenoble-INP

Self-organized arrays of metallic nanoparticles upon laser excitation is an efficient and a low-cost way to produce plasmonic systems for the fabrication of extensive devices used for industrial and artistic applications. Our initial research work showed that self-organized arrays of silver (Ag) nanoparticles could be generated from the interference between incident wave and the guided mode propagating inside titanium dioxide (TiO₂) film when using continuous-wave laser.¹ Recently, our team also demonstrated a two independent self-organized systems of Ag nanoparticles in TiO₂ matrix (Ag:TiO₂) with pulsed laser, exciting a guided and a surface mode simultaneously.² These modes interfere with the incident light which gives rise to intensity modulation, triggering grating formation.

In this work, we investigate and compare the self-organization process of Ag and gold (Au) nanoparticles embedded inside a waveguide upon laser excitation. While in past, extensive research has been done by our group on studying self-organization processes of Ag nanoparticles within TiO₂ matrix upon laser excitation, thus investigating the self-organization processes of Au nanoparticles upon laser excitation becomes interesting for comparing the physics behind temperature rise and growth mechanisms of these nanoparticles. Here, we grow spherical Au nanoparticles of around 14 nm in TiO₂ matrix by a two-step chemical reduction process. The growth of such nanoparticles after laser excitation is assisted by a temperature rise due to plasmon absorption of the nanoparticles in the waveguide. The physics of such systems is strongly dependent on the chemistry of nanocomposites films. The self-organization and the location of the grown Au nanoparticles vary extensively when compared to Ag:TiO₂ systems irradiated with lasers which are manifested with different characterization techniques. Such self-organized array of the noble nanoparticles open routes for various applications including photocatalysis, photovoltaic, security and artistic.

References

Corresponding author email: nipun.sharma@univ-st-etienne.fr