Using lasers, genetic algorithms and microfluidic devices to modify silver nanoparticles

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Abstract: This work presents a technique to control silver nanoparticles dimensions using a femtosecond laser, a microfluidic device and a genetic algorithm. The importance of this technique is related to its interdisciplinarity and potential to actively control the nanoparticles dimensions and geometries.

1. Introduction

Silver nanoparticles have fundamental importance for several applications. They cover industrial[1], scientific[2] and medical applications[3] like cancer treatment[4], antibacterial action[5, 6] and virus replication inhibition.
The synthesis of silver nanoparticles with green techniques using natural substances is important to preserve the environment, and can be combined with the photoreduction processes to assist a controlled formation technique. The silver nanoparticles dimensions and geometries con be modified using light irradiation, coming from ultrashort pulses lasers, with high peak power and large bandwidth, avoiding thermal effects and using the plasma formation and Coulomb Explosion to fragment silver nanoparticles clusters.
The laser pulses can be controlled using spectral pulse shapers that introduce several orders spectral phase components, changing the pulses energy distribution. A genetic algorithm can be used to control the pulse shaper and, as consequence, indirectly modify the nanoparticles dimensions, and the use of microfluidic devices minimizes the sample volume and allows the optimization process, which needs many irradiations and measurements. This technique makes possible to determine the optimized pulses that generate the silver nanoparticles with the desirable dimensions and shapes.
Figure 1 shows the results obtained for silver nanoparticles modification using a pulse shaper controlled by a genetic algorithm. The ~40 fs pulses coming from a Ti:Sapphire amplifier (Odin) are directed to samples inside a microfluidic device. The process involves the irradiation of samples by pulses with different phase characteristics and the measurement of the absorption spectrum of each irradiated sample. Each spectrum is analyzed by a genetic algorithm that estimates the nanoparticles sizes and shapes. After hundreds of irradiations and measurement of the samples, the one with the optimized size or shape characteristic is obtained.

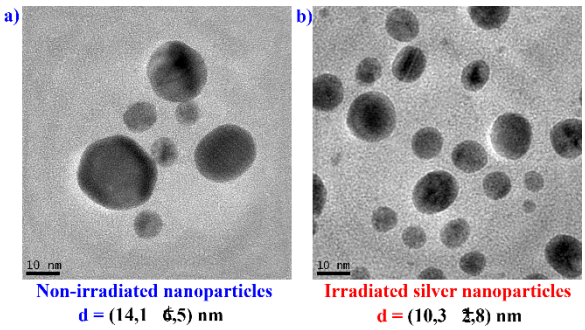

Figure 1 – Silver nanoparticles dimensional change with femtosecond laser: a) non-irradiated case; b) irradiated using genetic algorithm and microfluidic device.

2. References

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