Abstract

Chemiphores are entities, which exhibit wide-band light emission without any external light source (pump) but due to the chemical reaction resulting in chemiluminescence effect. Since the chemiphores usually have low quantum efficiency, the chemiluminescence is weak. Due to collective oscillations of the conduction band electrons in adjacent metal nanoparticles the chemiphores emission can be substantially increased. Here we suggest the prospects of two promising fabrication techniques: laser ablation into liquids and physical vapor deposition on solid substrates. Both techniques are affordable and produce ensembles of nanoparticles having shape and size distributions that can potentially fit the wide-band emission of chemiphore 1.

MATERIAL AND METHODS

The silver nanoparticles in distilled water were fabricated by laser ablation of a metallic target. As radiation source, we used the second harmonic of the Nd:YAG laser at the wavelength of 532 nm with the fluence of 100 mJ which lasted for 15 minutes. The numerical simulation of optical properties was performed with Finite Element Methods (FEM) implemented in the commercial COMSOL Multiphysics 5.3.

FABRICATION AND CHARACTERIZATION OF SILVER NANO PARTICLE

Figure 1: (a) Experimental set up of pulsed laser ablation of silver target in water solution. The dimensions are not to scale. (b-d) Atomic force microscopy (AFM) images of silver nanoparticle dried on the substrate. (e) Scanning electron microscope (SEM) image of silver nanoparticle on the carbon grid. (f) The size distribution of silver nanoparticles. \( \bar{d}_{\text{av}} = 24.6 \pm 0.1 \text{ nm} \).

Figure 2: Normalized optical density of colloidal silver nanoparticle prepared by laser ablation technique in aqueous solution. The spectrum was recorded in visible range.

NUMERICAL STUDY

Figure 3: The extinction of silver nanoparticle deposited on the different dielectric substrates. Overlap between measured chemiluminescence intensity of the luminol solution (blue line) and the extinction spectra, ACS (dashed) of silver nanoparticle; the 3D structure of luminol is shown in the inset with a carbonyl double bond (C = O).

The feasibility of obtaining such nanoparticles arrays is confirmed by the extinction spectra of the ensembles of silver nanoparticles on quartz substrates fabricated via physical vapor deposition. Figure 4 plots the corresponding extinction spectra of granular silver films with equivalent thicknesses of 3 and 9 nm.

CONCLUSION

We found that the optimum overlapping with the luminol emission bands at 452 and 489 nm is achieved for hemispherical silver nanoparticles with diameter of 18 and 73 nm on a quartz substrate. The colloidal solution of silver nanoparticles produced in this way has the desired absorption band at 400 nm and a red wing that reaches the emission spectra of luminol emission. Thus, the crucial condition for the efficient interaction between the plasmon excitation in silver nanoparticles and the radiative transitions in the products of the luminol oxidation has been achieved.

REFERENCES