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Article

Synthesis and Deposition of Ag Nanoparticles by Combining Laser Ablation and Electrophoretic Deposition Techniques

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Abstract: Silver nanostructured thin films have been fabricated on silicon substrate by combining simultaneously pulsed laser ablation in liquid (PLAL) and electrophoretic deposition (ED) techniques. The composition, topography, crystalline structure, surface topography, and optical properties of the obtained films have been studied by energy dispersive X-ray spectroscopy (EDS), high-resolution transmission electron microscopy (HRTEM), X-ray diffraction (XRD), and UV-visible spectrophotometry. The coatings were composed of Ag nanoparticles ranging from a few to hundred nm. The films exhibited homogenous morphology, uniform appearance, and a clear localized surface plasmon resonance (LSPR) around 400 nm.

Keywords: silver nanoparticles; electrophoretic deposition; pulsed laser ablation in liquid

1. Introduction

Noble metal nanoparticles in solution and deposited as thin films have attained wide popularity in the last 10 years and aroused intense research interest in nanotechnology due to their well-known properties, such as good conductivity, localized surface plasmon resonance (LSPR), and antibacterial and catalytic effects [1–4]. They are used in many different areas, such as medicine, solar cells, nano- and microelectronics, scientific investigations [5]. Films based on noble metals are the object of intense investigation due to the optical properties introduced by the characteristic LSPR, which generates an optical local field enhancement. This collective coherent oscillation of electrons on the conductive band of metallic nanoparticles interacts with the electromagnetic field and produces a strong absorption in particular regions of the electromagnetic spectrum. In particular, silver nanoparticles can absorb light in the near UV region of the spectrum extending their wavelength response to visible light. Other metal nanoparticles than noble metals also show absorption in visible light, such as Cu and Al [6,7], but their LSPR is weak and suffers from relatively easy oxidation. The most intensely studied plasmonic nanoparticle materials are Au and Ag. Ag is cheaper than Au and presents an even stronger LSPR, making Ag nanoparticles good candidates for many different applications. They can be used for enhancing solar cell efficiency by means of light trapping in organic as well as inorganic solar cells [8,9] or they can be used together with TiO_2 to improve its photocatalytic activity. These nanoparticles produce an increased absorption in the visible region due to their aforementioned LSPR [10]. The very high electric field around the nanoparticles makes them very good candidates for enhancing the signal of Raman scattering spectroscopy (SERS) [11,12], luminescence, and cathodoluminescence [13,14].