Saturable absorption by surface plasmon resonance effects in zinc nanoparticles onto the core of an optical fiber

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Abstract-The presence of saturable absorption (SA) in zinc nanoparticles photodeposited onto the core of an optical fiber by a coherent source is reported. An analysis based on Mie theory was carried out to demonstrate the interaction of the absorption coefficient with the particle sizes in the proximity of surface plasmon resonance in the infrared region. This work opens a new scheme for the implementation of photonic devices.

Considerable research has been done on nonlinear optical properties in metal nanoparticles for applications in communications, switching, and high-speed demultiplexing among others. These properties are based on their resonance frequency excited frequency by electromagnetic fields, phenomenon known as surface plasmon [1].

In this work, the saturable absorption of zinc nanoparticles (ZnNPs) photodeposited onto the core of an optical fiber is studied by a high gain pulsed amplifier [2]. The size-dependent absorption of ZnNPs was analyzed in the proximity of surface plasmon resonance. The photodeposition technique was previously reported [3]. It was used 10 mg of zinc powder in 10 ml of isopropyl alcohol, and an optical fiber placing it inside the solution as shown in Fig. 1a. Finally, it was used a continuous wave fiber laser to carry out the photodeposition of zinc nanoparticles onto the core of the fiber. The irradiance dependent transmission measurements were studied using a high gain amplifier by P-scan technique with samples of 3 dB of transmission as shown in Fig. 1b.

The calculations show that for ZnNPs smaller than 100 nm of radius, the absorption dominates over scattering, and determines the extinction coefficient. On the other hand, for radii larger than 100 nm, the scattering dominates over absorption and determines the extinction coefficient (Fig. 5). According to the results obtained, the transmittance increases until it saturates. The value of the imaginary part or third-order
susceptibility was calculated according to the curve fitting, obtaining \( \beta \approx -4.56 \times 10^{-6} \) (m/W) and \( \text{Im}(\chi^{(3)}) \approx -2.52 \times 10^{-15} \) (m\(^2\)/V\(^2\) (\( \approx -2.27 \times 10^{-6} \) esu), respectively.

Fig. 2. (a) Dependence of the extinction for ZnNPs, (b) Dependence of the transmittance.

The nonlinear absorption reveals that the ZnNPs photodeposited onto the core of an optical fiber have good nonlinear optical response and could be chosen as a good candidate with potential applications in optical communications in the near infrared region. To our knowledge, this is the first report of nonlinear characterization in the near infrared region of metallic nanoparticles deposited on the core of an optical fiber, which is ideal to make photonic devices for optical communications.

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REFERENCES