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Gold and Silver Nanowires Impact on the Degree of Polarization of Light

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Abstract: Interaction of light with nanoparticles led to extensive knowledge about electromagnetic processes which is fundamental. One of the light effects on the metal nanowires, is the changing of the light polarization . The aim of this research is to study size effects and the surrounding environment properties of nanowires on the degree of polarization of scattered light. Gold and silver metallic nanoparticles due to wide spread use of properties were selected herein. Simulated polarization of scattered light with a FORTRAN program was obtained. Parameters affecting the intensity and degree of polarization of scattered light radius, refractive index and the wavelength of incident light was made nanowire. This research was based on theory as well as simulation method. Nanowire lengths, nanowire interaction with the surrounding dielectric environment were changed polarization of the surrounding molecular nanowires. It has been concluded that silver and gold had the same polarization pattern.

Key words: Metallic nanowire; Polarization; Optical properties; Intensity

INTRODUCTION

Study of the interaction between light and semiconductor nanoparticles, is leading to an extensive knowledge of the electromagnetic scale smaller than the wavelength of visible light [1]. On the other hand, due to the technological limitations, there is not the possibility of using large-scale laboratory model. Therefore, researchers are using simulation techniques. The results are close to experimental tests, as they were previously obtained [1,2].

Nanoparticles of certain metals such as gold and silver, have the shape and size-dependent optical properties, which are sensitive to environmental changes. They are different from large-scale surface properties[3]. This difference is due to the curved geometry of the particles that allows direct coupling of light to resonant collective electron plasma oscillations, so called particle plasmons [1]. The interaction of small nanowire compared to the wavelength of the exciting light can be described with plasmon excitation of dipolar character (real part of dielectric function of nanowire and dielectric constant of the surrounding medium of nano structure)[1,2]. However, most nanowires on a substrate have different dielectric Constant values. Optical phenomena in nanowire shaving a dielectric constant ε is essentially different from that of their environment ε0, if the researcher's knowledge of the relationship between the intensity and polarization of particles with the surrounding environment and how to control these factors are also rapidly increasing and expanding science of photonics.

EXPERIMENTAL

Materials: With the production of nanometer-scale electronic devices, it is necessary to produce metallic nanowires such gold and silver [4] .On the other hand, the science of photonics, is a suitable tool for technology development. Due to electromagnetic wave interaction with a nanowire, some optical properties such as light intensity, polarization and other parameters change. Although the experimental and theoretical studies can provide nanometer-scale studies[3], still is required the use of simulation, the concept of reflection, refraction as well as scattering [5-7]. To identify and control, effect on the degree of light polarization, suitable dielectric environment, nanowire that respond to environmental changes, by simulation, can be investigated [1].

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Physical Characterization: This article is intended to use simulation to determine the external factors affecting the degree of polarization. Other objectives of this paper is the study of nanowire material effect on the polarization spectrum and polarization curves are plotted.

Photonics is the branch of science and technology which has been paid much attention in recent years[1-4]. In Photonics, which optics is based. Metal nano particles have a major contribution which is allocated to the electronics. Optical behavior of gold and silver nanoparticles are depending on their shape and size. They are also sensitive to environmental changes. In addition, the electrical field around the nanowire with excitation light is about to change [6,9] Previously, the electric field was studied using light scattering. Symmetry with a glint of light refraction dielectric polarization of the molecules around the nanoparticle has changed [9]. However, the change of temperature as an important parameter in the optical properties of nanowires have been studied. In previous studies, graph depend on the intensity of light reflected by the geometry and material used in manufacturing nanowires and optical properties of the environment has been proved [14].

Theoretical results using the Fortran programming language and software, nano-scale polarization diagrams, depending on the angle between the screen of reflected and radiation was plotted. Wavelength of incident light and reflection, between 500 to 1000 nm was selected. These wavelengths are most widely used in photonics. Nanowires with cylindrical cross-section are one of the most important nanowires. Then, the effect of changing the radiation angle, refractive index and radius of nanowire surrounding area have been studied. In this study, two sections for the real part of the dielectric constant of nanostructured metal and environment, has been assumed[2].

The influence of nanowire cross section radius and refractive index surrounding the nanowires, depending on the angle between the radiation and reflection on the degree of polarization was measured. Subsequently the degree of polarization, depending on the angle was traced by statistical software Igor. Due to high conductivity and low heat generation, the elements of gold and silver have been selected. It is very important that if they are placed in different environments and their properties would be different [3-15]. In the simulation presented herein, the appropriate selected environment, the ability to control the angle and the range and peak dispersion curve are obtained.

Subject of the study of light scattered polarization by gold and silver metallic nanowires is based on the angle of radiation and reflection. It has an impressive effect on the parameters studied herein, only three factors that have been covered. Obviously, other factors such as temperature and length of the nanowires is also effective scattering results. In the symmetric simulation of nanowires in the nanowire as a practical design in which we are actually faced with the shortcomings.

RESULT AND DESCUTION

At first, we studied the polarization of light by using cylindrical gold nanowires, along with the polarization of light from the gold with different radius. Light with a wavelength of 500 nm of gold were emitted. Figure 1 shows the degree of polarization - angle between this radiation and scattering for different radius. For 10 nm radius, maximum curve occurred at a 90-degree angle.

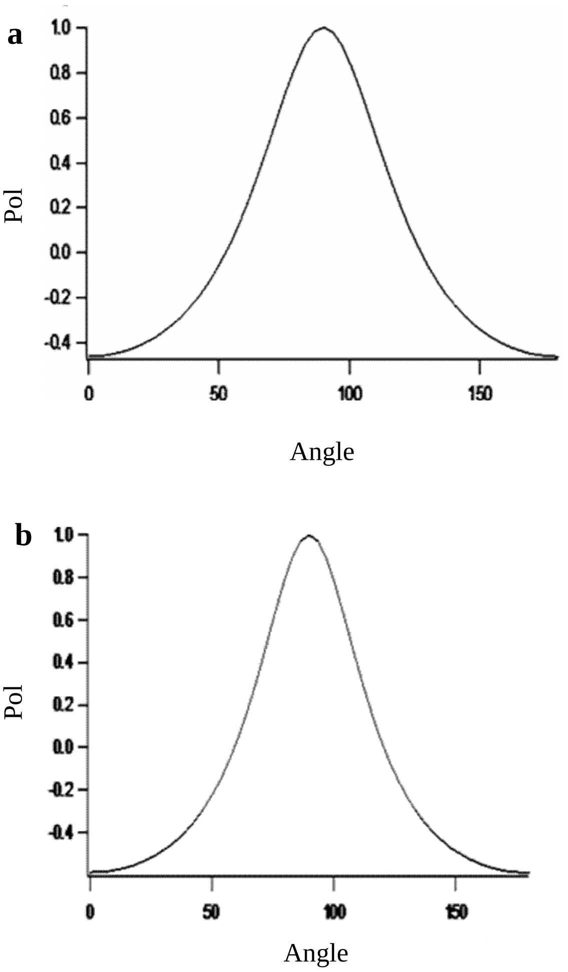

Fig. 1: (a) Degree of polarization Radius of 10 nm of Au in air. (b) Degree of polarization Radius of 10 nm of Ag in air

It can be stated that the scattered light was polarized. The positive and negative signs in the diagram represent vertical and horizontal polarization. Gold nanowires with increasing radius, up to 150 nm in both curves have been changed (Fig 2. a). For angles greater than 150 degrees and Max, a blue shift can be observed without changing the polarization.

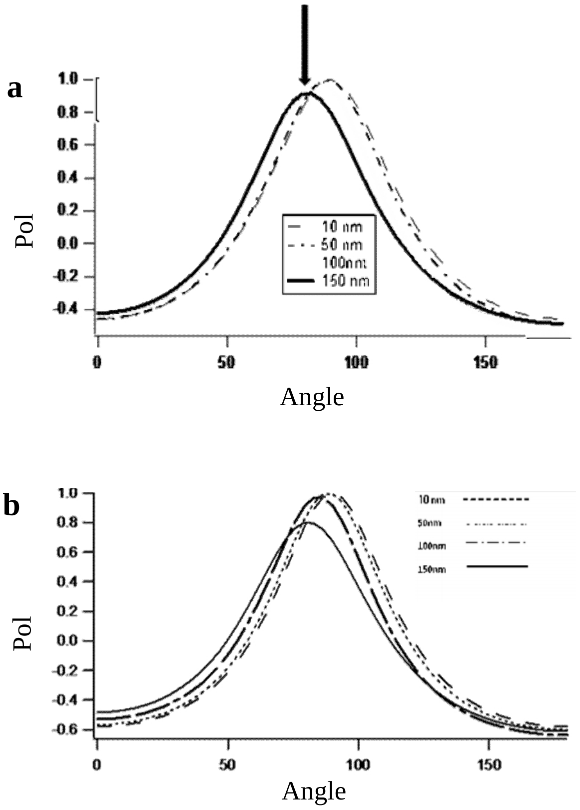

Fig. 2: (a) Degree of polarization Gold nanowires with increasing radius, up to 150 nm (b) Degree of polarization silver nanowires with increasing radius, up to 150 nm

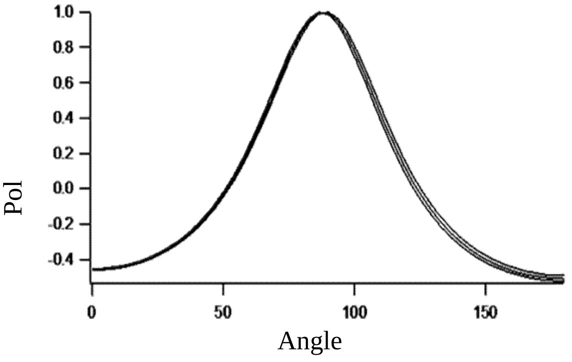

Fig. 3: change the wavelength of incident light, from 500 to 1000 nm with Au nanowire with radius 10 nm

The polarization spectrum of reflected light, for different radius of silver is given in Figure 2. b . In the air change the wavelength of incident light, from 500 to 1000 nm, not much polarization spectrum change. The air change in the wavelength of incident light, from 500 to 1000 nm, observed spectrum does not change too much. This result is determined from the diagram (Fig 3. a).

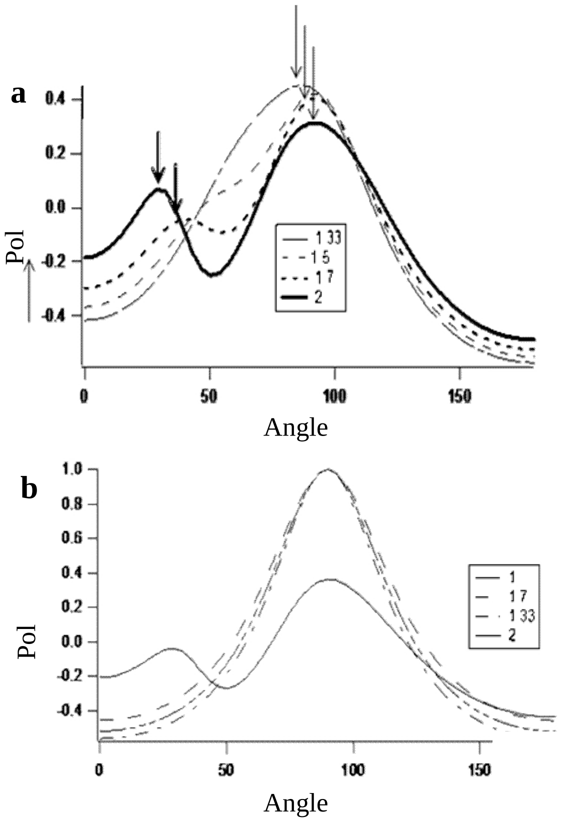

Fig. 4: (a) Changes in the degree of polarization with the refractive index change in the surrounding environment of Au nanowire 10 nm, (b) Changes in the degree of polarization with the refractive index change in the surrounding environment of Ag nanowire 10 nm

Another interesting result is the changing of surrounding refractive index on the polarization spectrum of light. By changing the refractive index, the degree of polarization decreased and the number increased, while the curve peak for small angles had significant changes toward more positive values. Light by changing the arrangement of the molecules around the nanoparticles and the small change of density, near the nanoparticle surface can justify peak polarization changing of light around it (Fig 3). When the radiation angle is 90 degrees, interaction and reflection of light caused by the symmetry of the resonance are consistent in this angle. It can be concluded from this diagram that the polarization spectrum of light is reflected by the geometry, material, and etc (depending on the surrounding refractive index).

CONCLUSIONS

Polarization light curves are sensitive to environmental indicators. Extent of this sensitivity depends on important factors (which it helped to have the ability to control the dispersion.) For the gold and silver, the spectrum of polarization degree depends on the surrounding refractive index and radius of cross section. The optical properties such as the design of devices (modulators, optical sensors, gratings) can be used. Environmental impacts, especially in liquid crystal environment, allows us to control degree of the polarization light.

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