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# تصویربرداری پلاسمونی لایه نازک PVP شامل نانوسیم های نقره

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چکیده- امروزه ترموپلاســمونیک از اهمیت ویژه ای در زمینه های مختلف همانند تیمار فوتوگرمایی برخوردار اســت. از اینرو در این مقاله، از روشــی جدید در زمینه برانگیختگی پلاســمون و ایجاد نقاط داغ پلاســمونی در لایه نازک پلیمری شــامل نانوســیم های نقره اســتفاده نموده ایم. نتایج حاصــل نشــان دهنده افزایش نقاط داغ پلاســمونی با افزایش غلظت نانوســیم هاســت که می تواند در زمینه طراحی و ساخت نانوساختارهای پلاسمونی با قابلیت کنترل نقاط داغ در روش های درمانی استفاده شود.

کلید واژه- نانوسیم های نقره، تصویربرداری پلاسمونی، نقاط داغ پلاسمونی.

# Plasmonic Imaging in Thin Layer of PVP Contains Ag NWs

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**Abstract-** Silver nanowires are the favorable material in many applications based on their plasmonic double resonance in the visible region. In this work, thin layers of Poly-vinyl-pyrrolidone doped with Silver nanowires in different concentrations have been prepared to study the plasmonic properties. The plasmonic imaging system excite the Surface Plasmon by using high numerical aperture objective lens. The hot spot results from reflected light intensity of SPR proved that increasing of concentration of Silver nanowires yields to get better hot spot in plasmonic imaging systems which is useful in medical applications.

Keywords: silver nanowires; surface plasmon resonance; plasmonic imaging.

## 1. Introduction

Plasmonic imaging and collect data about the plasmonic hot spot is one of the main aims in this new born topic [1]. Plasmonic nanostructures proposed as new efficient heat source when illuminated by their correspondence resonance light source [1,2] to use them in nanoscale control of temperature distribution [3], drug delivery [4], cancer photo thermal therapy, photo thermal imaging and many other useful applications. These applications need to the ability of measure the temperature distribution in enough area with high signal-to-noise ratio (SNR). In this paper, we want to introduce new excitation method based on large numerical aperture (NA) lens and coupled charge camera.

## 2. Experimental part:

### A. Sample preparation:

The samples of this work contain of Polyvinylpyrrolidone (PVP) doped with Silver nanowires (Ag NWs) in different concentrations. As shown in Figure 1, the first step of samples preparation is solving PVP in deionized water in rate 3mg/ml. The second step mixture the Ag NWs with deionized water in five different concentrations as shown in Table 1. The third step is the mixture of PVP with Ag NWs in rate 50%. The last step is preparing the thin layer by spin cotter in condition 2000 rpm.

The samples named as sample 1 with 0.02mg/ml +3mg/ml PVP; sample 2 with 0.04mg/ml +3mg/ml PVP; sample 3 with 0.08mg/ml +3mg/ml PVP; sample 4 with 0.12mg/ml +3mg/ml PVP and finally sample 5 as 0.16mg/ml +3mg/ml. PVP

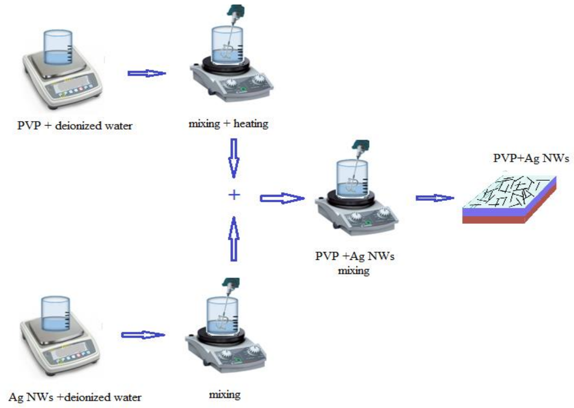


Figure 1: Sample preparation steps.

### B. Surface Plasmon Polariton (SPP) Excitation:

High numerical aperture objective lens 10x (NA) used for SPPs excitation, as shown in figure 2 an oil immersion in contact with NA and surface of the sample, the input laser is focused by the NA, this NA satisfies the dispersion condition between SPPs and incident laser. The propagation constant of the polariton of Ag NWs is given by

$$k_{sp}(\omega) = \frac{\omega}{c}\sqrt{\frac{\varepsilon_1(\omega)\varepsilon_2(\omega)}{\varepsilon_1(\omega)+\varepsilon_2(\omega)}} \quad (1)$$

Where $\omega$ is angular frequency, c is the light speed in vacuum, and $\varepsilon_1(\omega)$ and $\varepsilon_2(\omega)$ are the relative permittivity's of Ag NWs and PVP, respectively.

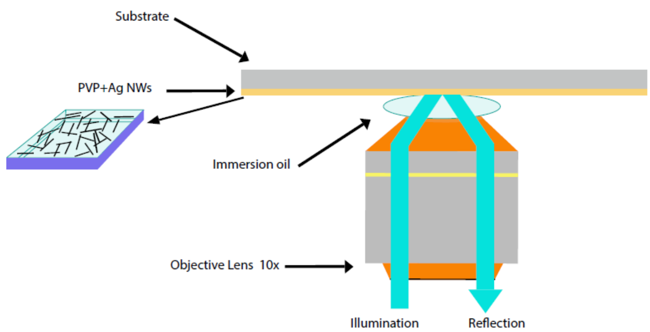


Figure 2: Illumination of sample by high numerical aperture objective lens

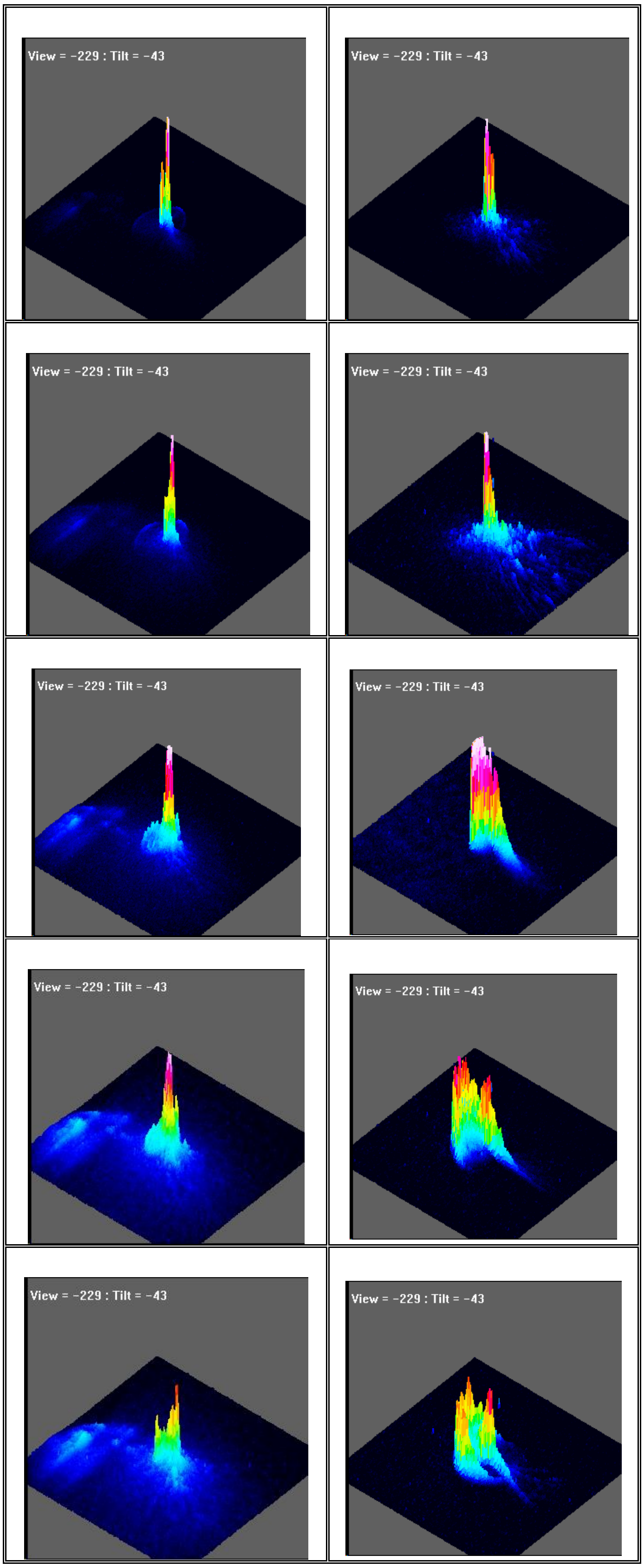


Figure 3: hot spot for five different concentrations (from top to bottom) samples, left images for green excitetion, right images for blue excitation.

## 3. Results and Discussion

The hot spot images for our five samples are shown in Figure 3. One can see the excited SPPs by two different wavelengths, 532nm in the left column and 405nm in the right column. This figure proved that the blue wavelength (405nm) can be excite the SPPs better than the green wavelength (532nm) that is because we have Ag NWs and this material have a good absorption in blue range. In addition, increasing of Ag NWs concentration yields to enhance hotspots width, because the increasing of SPPs due to increasing in the internal electric field. This fact can be approved in Tables 2 and 3 as we list properties of hotspot like as width at 14% of full intensity and at 50% and the peak value. In these tables, the width of hotspot in X direction not equal or close to the Y direction, because the polariton of Ag NWs. The logic trend can be seen below the half intensity of spots in X and also Y directions by enhancement in the Ag NWs concentrations. we can note the behaviour of peaks values; it almost decreases when the concentration on Ag NWs increases in our samples that is occurs because increasing in SPPs dispersion.

Another fact that appears from this figures is that we don't have non-logic trend in the intensity at 50%. This physical phenomenon is correct because non symmetric distribution of NWs in the coating processes.

Table 1: hotspots propertes for five different samples excited by 532nm

| Samples | width of hotspot at X direction (μm) | | width of hotspot at Y direction (μm) | | Peak value % |
|---|---|---|---|---|---|
| | at 14% | at 50% | at 14% | at 50% | |
| Sample 1 | 127.7 | 54.4 | 168 | 99.9 | 92.6 |
| Sample 2 | 166 | 76.6 | 114.7 | 57.1 | 91.8 |
| Sample 3 | 200.3 | 51.5 | 358.6 | 124.2 | 91 |
| Sample 4 | 349.7 | 53 | 424 | 145 | 90 |
| Sample 5 | 403.2 | 199 | 1047 | 228.4 | 64.2 |

Table 2: hotspots propertes for five different samples excited by 405nm

| Samples | width of hotspot at X direction (μm) | | width of hotspot at Y direction (μm) | | Peak value % |
|---|---|---|---|---|---|
| | at 14% | at 50% | at 14% | at 50% | |
| Sample 1 | 140.1 | 93 | 189 | 41.5 | 97.7 |
| Sample 2 | 244.8 | 40.6 | 249.5 | 99.3 | 100 |
| Sample 3 | 260 | 80 | 534 | 207.7 | 100 |
| Sample 4 | 413.7 | 33 | 752 | 615.8 | 77.8 |
| Sample 5 | 405.3 | 334.7 | 590 | 403.1 | 67.9 |

## 4. Conclusion

In summary, we used high numerical aperture objective lens to excited the SPPs on Ag NWs, the results that we have from this work proved the peak value of hot spot will be decreases when the concentration of Ag NWs increasing. This decreasing occurs by increment in dispersion of polaritons. Furthermore, the excitation of SPPs by blue laser is better than the excitation by green ones because the absorbance of Ag NWs near the blue range.

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