Transmission electron microscopy characterization of gold nanoparticles

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INTRODUCTION

The interest in noble metals particles like gold nanoparticles is caused by wide possibilities of applications in areas such as nanomedicine, nanophotonics or the protection of the natural environment. Nanoparticles of noble metals show the phenomenon of Localized Surface Plasmon Resonance (LSPR). This phenomenon is related to the oscillation of free electrons in the metal and therefore depends on nanoparticles size [1]. The LSPR has been used for the ablation of cancer cells - Plasmonic Photothermal Therapy (PPTT) [2]. The electromagnetic radiation of frequency corresponding to the resonance, excited localized plasmons which leads to a local overheating and damage cancer cells. This technique is minimally invasive method for healthy cells, but very effective in the destruction of cancer cells.

The most spectacular application of gold particles is to use them to generate the bioluminescence of plants, so far from the family *Bacopa caroliniana* [3]. Leaves of plants in which gold particles (~ 10 nm) were placed can light in the dark. The bioluminescence, induced by the presence of gold particles, can be further used for the production of energy efficient lighting such as tree in city streets.

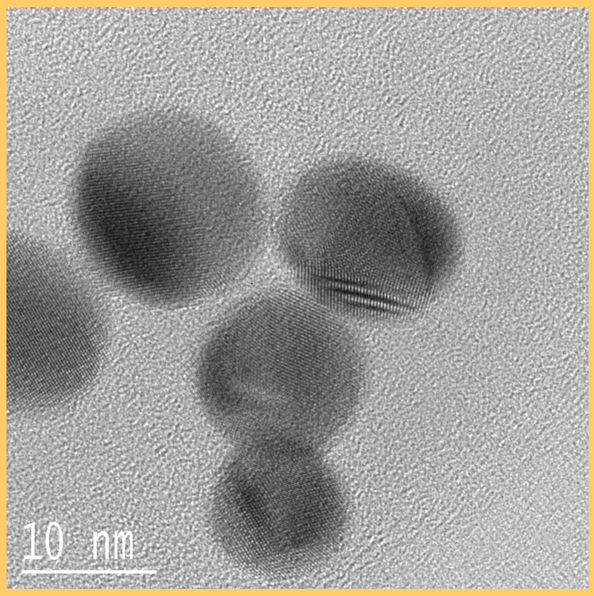


Fig. 1.TEM image of gold nanoparticles and electron diffraction pattern.

EXPERIMENTAL

Investigated nanoparticles were obtained from the gold colloids. Particles were embedded in the form of drops on the carbon film. For characterization of Au particles the Titan - Cubed 80-300 was used. EELS (Electron Energy Loss Spectroscopy), EDX, diffraction, STEM and HRTEM techniques were applied to investigte the structures.

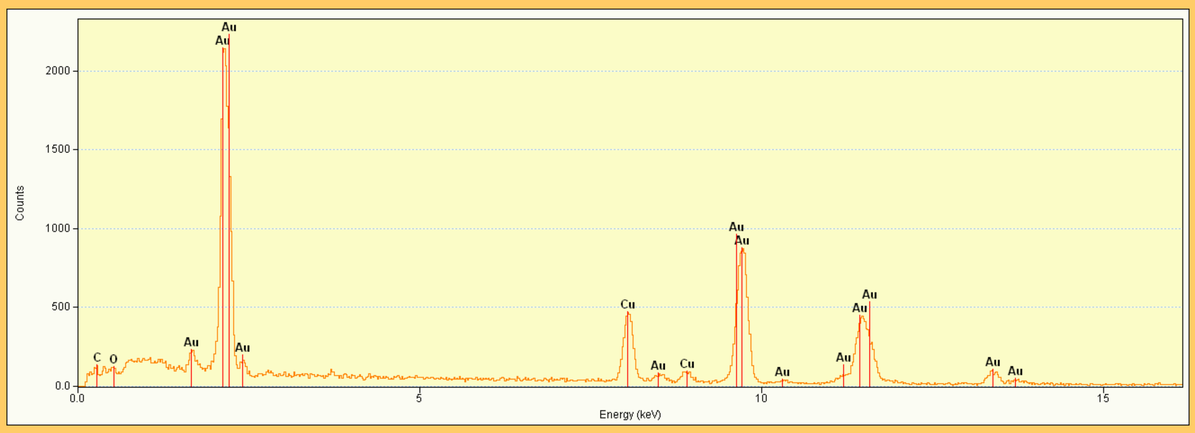


Fig. 2. EDX spectra collected from the single particle.

RESULTS

On Fig. 1. were shown the Au particles with electron diffraction pattern from these structure. The crystal structure have been identified as f.c.c. EDX spectra from one particle were collected - Fig.2. The presence of cooper and carbon is associated with supporting substrate. We analyzed size of NP and prepared a histogram of their size, which is shown on Fig. 3. We used a STEM (scanning TEM) equipped with an EEL spectrometer and monochromator to collected spectra from the single particle. We have chosen to study particle which is shown on Fig. 4. On STEM image marked a red dot where the electron beam was set. The use of monochromator in STEM mode allows to obtain an electron beam with an energy of 300000.00 ± 0,2 eV. Zero loss peak is shown on Fig. 5. The Fig. 6. shows the extracted EELS spectra (after zero loss peak removal) from edge of the particle which is shown on Fig. 4. Signal – to – noise ratios were found to be low, possibly due to background support and some colloid pollution (we observed a strong contamination). However, the peak from the LSPR could be seen – we marked with a red arrow in the Fig. 6.

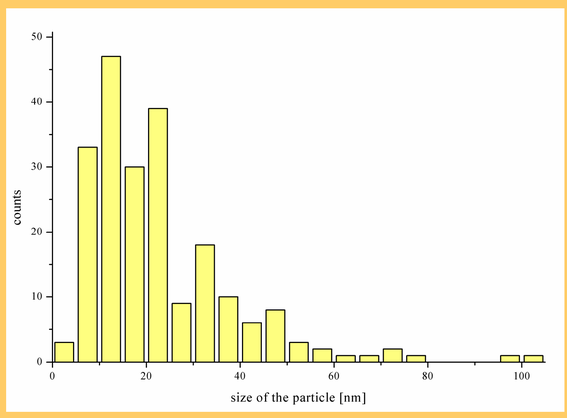
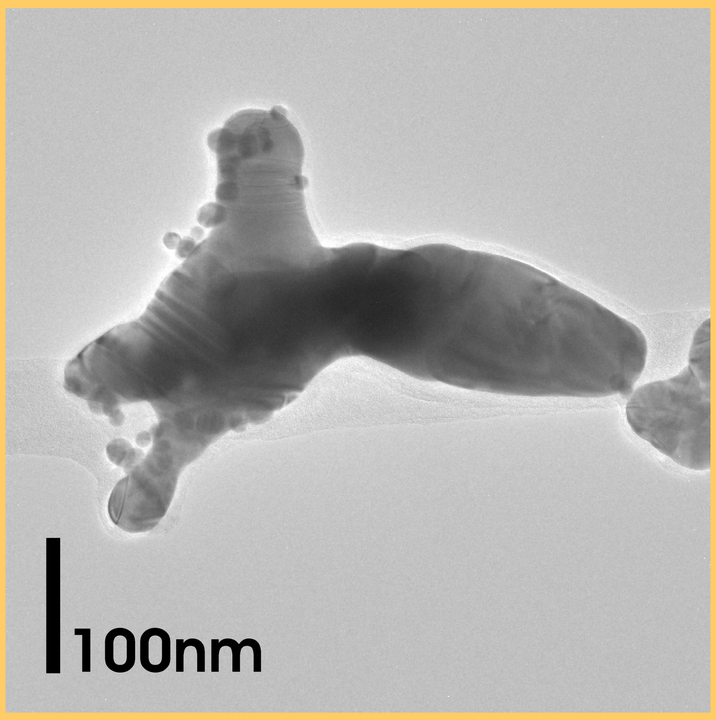


Fig. 3. Histogram of size of Au NP.



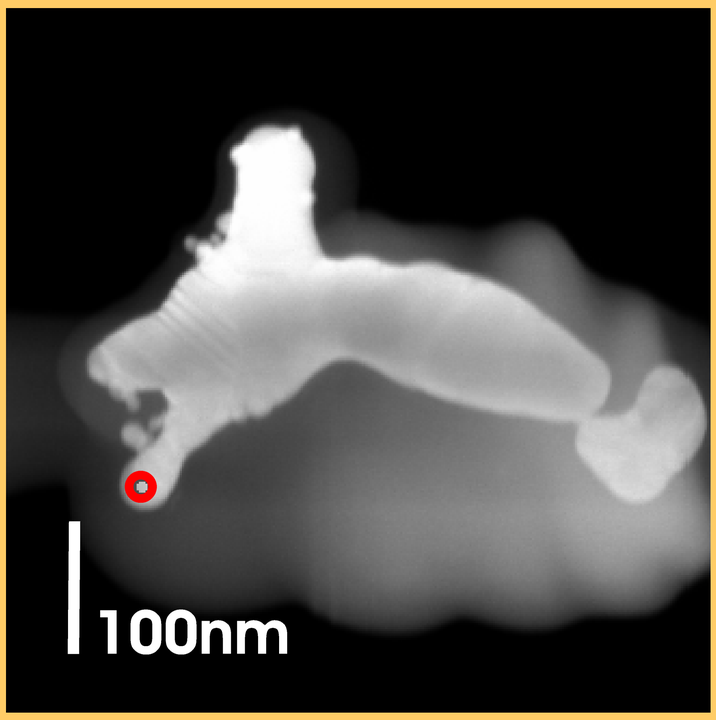


Fig. 4. TEM image (left) of Au particle and the same particle in STEM (right).

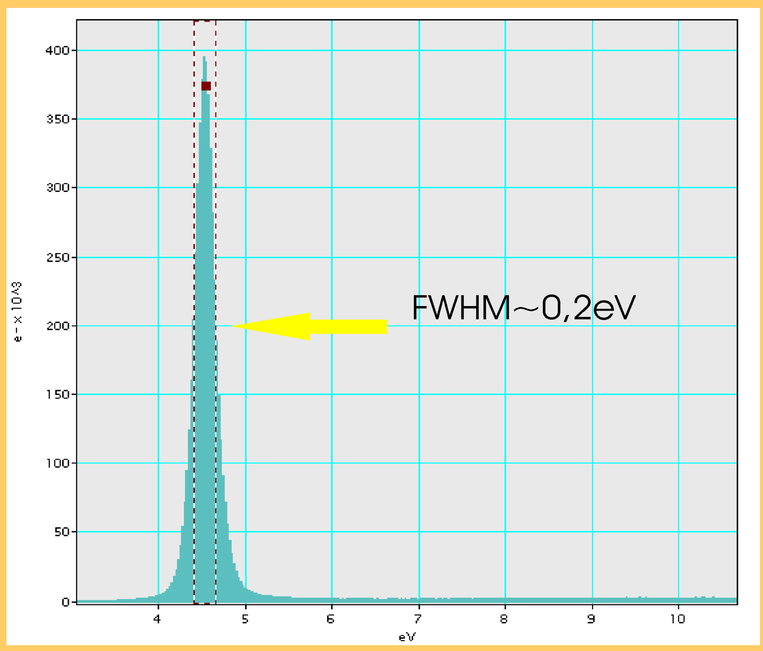


Fig. 5. The monochromatic electron beam.

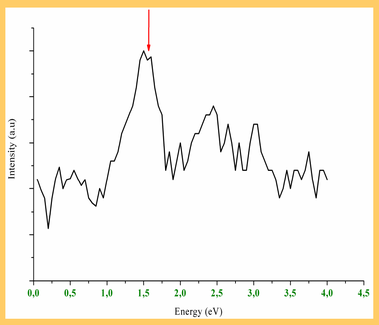


Fig. 6. EELS spectra from edge of the particle from Fig.4.

SUMMARY

Transmission Electron Microscopy (TEM) gives valuable information for nanotechnology. The knowledge of the size and shape of gold nanoparticles is very important because have a significant influence on the optical properties. We determined the crystal structure and analyzed the size of nanoparticles. TEM methods and especially one of them: Energy Electon Loss Spectroscopy (EELS) allows to collect spectra from individual particle, which can not be done by optical methods

[1] J.A. Scholl, Ai L. Koh , J.A. Dionne Quantum plasmon resonances of individual metallic nanoparticles. Nature 483, 421–427 2012
[2] X. Huang, P.K. Jain, I.H. El-Sayed, M.A. El-Sayed. Plasmonic photothermal therapy (PPTT) using gold nanoparticles Lasers Med Sci 23, 217–228 2008
[3] Y.H. Su , S-L. Tu , S-W. Tseng , Y-Ch. Chang , S-H. Chang, W-M. Zhang Influence of surface plasmon resonance on the emission intermittency of photoluminescence from gold nano-sea-urchins. Nanoscale 2, 2639-2646 2010