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NOVEL APPROACHES TO THE FABRICATION OF GOLD NANOFLAKES

1. Introduction

Nanoparticles are particles of matter in which at least one dimension falls within the range of 1 to 100 nanometers. Due to their very small size, nanoparticles exhibit physical, chemical, and biological properties that differ from those of the same material in the macroscale. This results mainly from their large surface-to-volume ratio and from quantum effects occurring at the nanometric level. Gold nanoparticles, because of their unique properties, including biocompatibility, have found wide application in various branches of industry, for example in the production of biosensors and pharmaceuticals, as well as in the delivery of genes and proteins [1]. The broad applicability of these materials arises primarily from the unique combination of their physical, chemical, optical, and electronic properties.

This publication describes a new method for synthesising gold nanoparticles in the form of flakes with a controlled thickness of ≥ 0.1 nm, which not only produces high-purity nanoparticles but also allows a therapeutic agent to be incorporated into their structure.

2. Materials and methods

A homogeneous semiconductor crystal, sliced into ultra-thin discs, was used to synthesise gold nanoparticles; a photosensitive polymer material was applied to the crystal, and following appropriate preparation, a layer of Au was deposited. In the next stage, the recovered nanoparticles were purified. The synthesis methodology is currently protected by intellectual property rights nos. 15/2026 and 16/2026, which are the subject of an application to the Patent Office.

To verify the obtained nanostructures, analyses were performed using a Quanta 250 FEG scanning electron microscope equipped with an EDX attachment enabling X-ray microanalysis of chemical composition. Using emission spectroscopy methods with a Nd:YAG laser (Brio Quantel model) with a radiation wavelength of 1064 nm, pulse energy of 78 mJ, and gain of 2900, stratigraphic spectra of the examined sample were obtained. The radiation emitted by the generated plasma was recorded using an ESA echelle spectrometer, while the detector used was a Kodak KAF 1001 CCD array.

3. Results

The results of structural analyses of gold nanoplates, carried out using a Quanta 250 FEG/FEI scanning electron microscope, are presented below (Fig. 1).

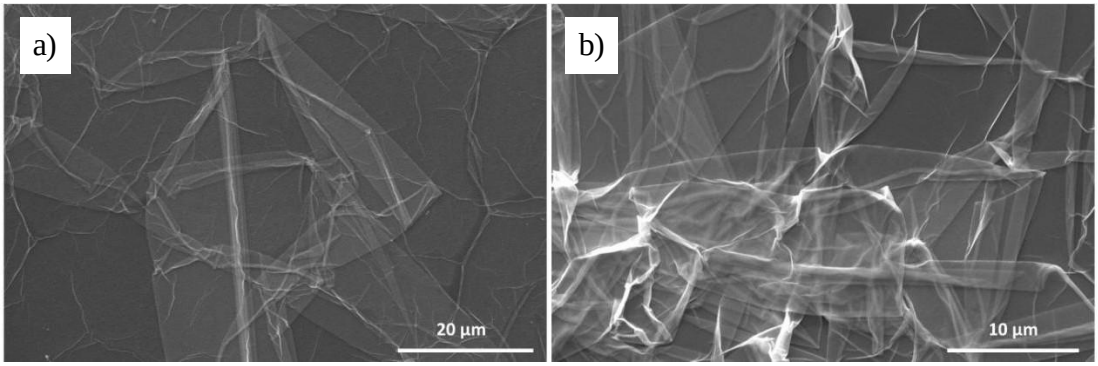

Fig.1. Structural analysis of the sample surfaces performed using SEM (a–b).

The stratigraphic spectra (Fig. 2) obtained using laser-induced emission spectroscopy showed the presence of characteristic peaks corresponding to Au at 242.795 and 288.349 nm, C at 247.856 nm originating from the photosensitive polymer material, and Si at 250.690, 251.611, and 252.611 nm, which originate from the substrate.

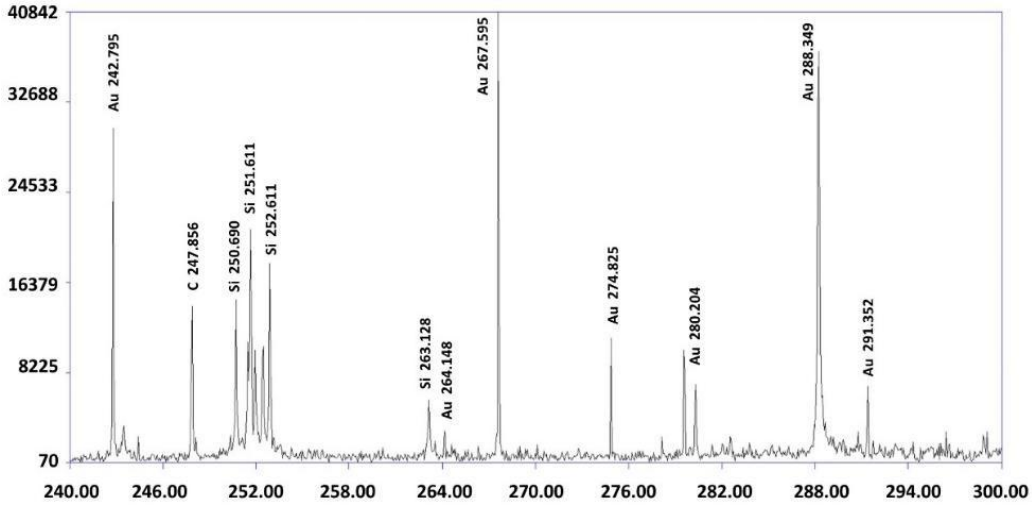

Fig. 2. Stratigraphic spectra of a silicon surface with gold nanoparticles.

Elemental composition analysis was also performed using an EDX detector coupled with a Quanta 25 FEG-FEI electron microscope, which confirmed the elemental composition obtained using the LIBS method, namely Au 88%, C 5%, and Si 7%.

4. Conclusion

Structural studies and X-ray microanalysis of the chemical composition of the samples, carried out using a Quanta 250 FEG scanning electron microscope with an EDX detector, enabled the identification of the nanoparticles obtained. Structures with a flake morphology were synthesised. EDX and LIBS analysis confirmed the presence of gold in the samples studied. LIBS peaks were observed at wavelengths corresponding to Au particles, and spectra were obtained representing silicon, originating from the substrate, and carbon groups from the photosensitive polymer material.

References

[1] Sardar, R., Funston, A. M., Mulvaney, P. & Murray, R. W. (2009). Gold nanoparticles: past, present, and future., Langmuir, vol. 25(24), p. 13840–13851. https://doi.org/10.1021/la9019475