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«Size Measurement of Spherical Nanoparticles Using Transmission
Electron Microscopy and Specialized Software»

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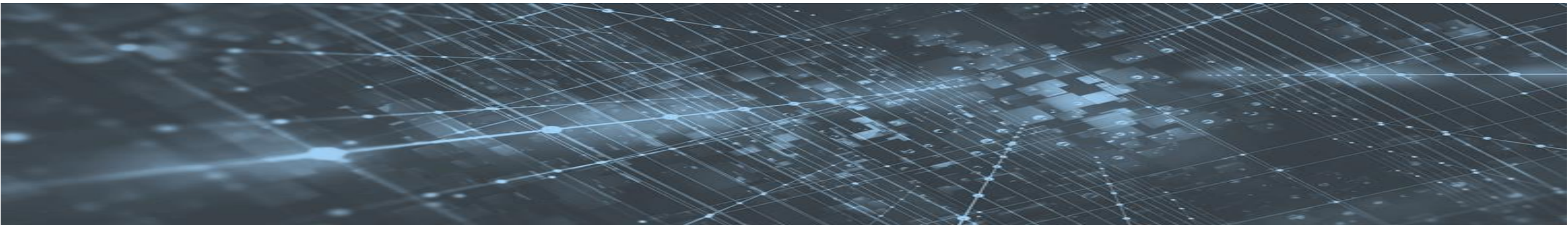
Problem statement

The problem of studying the sizes of nanoobjects of various nature is one of the key problems of modern science. One of the most commonly used methods for determining the size of metal nanoparticles is transmission electron microscopy.

To determine the size of nanoparticles depicted on TEM images, both traditional manual measurement and specialized software can be used.

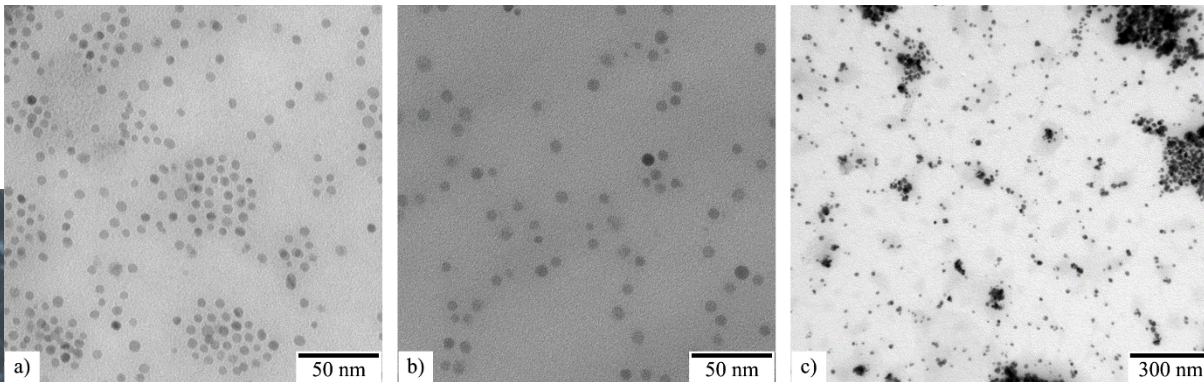
There are various software for performing this procedure. However, all these programs are based on different algorithms and have their own unique features, advantages and disadvantages.

The purpose of this work is to define the possibility of using ImageJ, Pebbles and SPIP software in various conditions for determining the size of spherical metal nanoparticles.



Solution methods

- Micrographs of Cu-containing and Pd nanoparticles were obtained by transmission electron microscopy. TEM-images differed in quality, characteristics of nanoparticles and conditions for their obtaining.
- The following methods were used for the analysis of TEM-images:
 - manual measurement
 - automatic processing in ImageJ, Pebbles and SPIP.
- The software application results were compared with manual calculation using examples of particle size distribution and calculated average diameters of nanoparticles.



TEM-images used: Cu-containing nanoparticles – sample 1 (a) and sample 2 (b); Pd nanoparticles (c).





Conclusions

This study shows that:

1. the measurement results significantly depend on the quality of microphotographs and the location of particles on them
2. the most important characteristics for the correct measurement of particles are the contrast relative to the background and the clarity of the particle boundaries
3. the effectiveness of the software varies in different conditions
4. it is impossible to select one program that would cope successfully with all images.

Sample	Average diameter of nanoparticles (nm)			
	Manual	ImageJ	Pebbles	SPIP
Cu – sample 1	5.80	5.73	5.76	5.47
Cu – sample 2	5.78	6.60	7.26	6.84
Pd	12.93	12.84	8.63	13.07

The calculated average diameters of nanoparticles demonstrate differences in measurements using the methods studied.

It can be seen that the results are comparable when using a high-quality image (Cu – sample 1).

And with the worsening of the nanoparticle display conditions, the results become incomparable.

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