NanoLab (Phys4970) **TEM & SEM Analysis Activity**
due at the beginning of class Thursday 05 Apr

Each group will prepare a summary report

Work in groups. This divides the work and multiplies the fun.

END RESULT

TEM
1) Particle size distribution for each Au nanoparticle sample. Average particle size and standard deviation.
2) Analyze the electron diffraction patterns. Index the rings, calculate the plane spacing, calculate the lattice constant for each ring, calculate the average value your measured (in this experiment) for the lattice constant of Au.

SEM
3) Show the SEM images of your AFM lithography sample.
4) Show the SEM images of your test sample. Include you EDX spectra identifying the main elemental peaks AND the area of the sample to which these correspond.

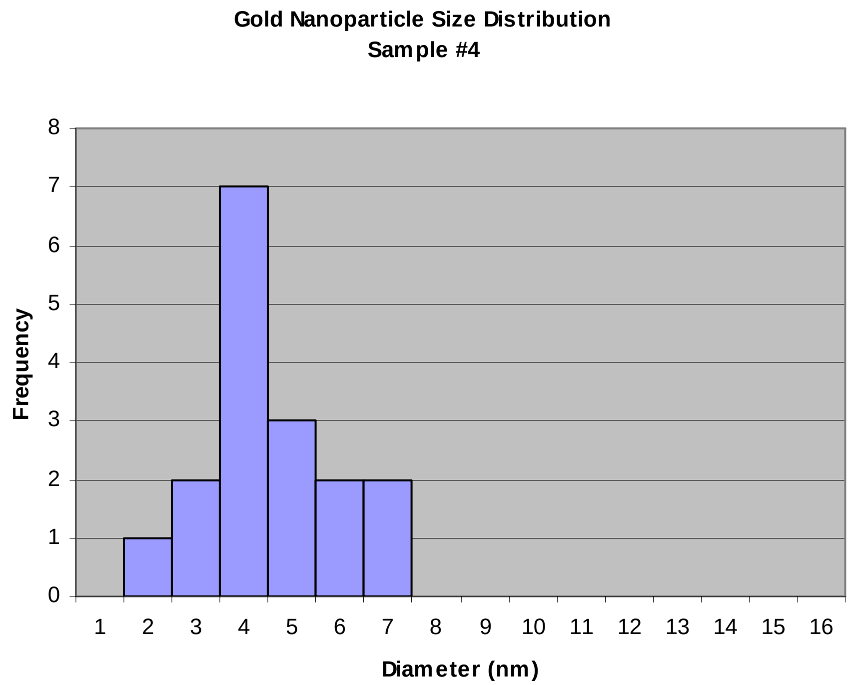
1) TEM: Measure Histograms of your particles.

If you have fewer than a total of 25 particles in all of the images of each sample, you are not required to report a histogram, only the average and standard deviation.

You will measure the size distribution of particles for each sample from the micrographs. Print the micrographs and use a ruler to measure the diameter of each particle. Enter the raw measurements into an Excel table. You will use the measurement of the scale bar to convert your raw measurements into nanometers. Your Excel table will consist of a single column of numbers, the raw measurement, and a second column of the measurements converted to nanometers.

If your particles are not round, but irregular, you will need to make two measurements for each particle, the 'minimum diameter' and the maximum diameter'. An area-weighted diameter can be obtained from the geometric mean (square root of the product) of these two measurements. Use the area-weighted diameter for you average, standard deviation, and histogram. Be sure to properly note this in your graphs and when you report your results.

Calculate the average particle size and the standard deviation. Create a histogram of the particle sizes. start with bin sizes of 1 nm and then increase the bin width until you get a histogram with at lease 20% of the particles within one bin. (see the example). Be sure the properly tile your histogram "Size Distribution of _______". The x axis should be labeled diameter or area-weighted diameter, as appropriate. The y axis should be labeled frequency. You will have a data table and a graph for each sample. Place the average particle size and the standard deviation on each graph.



2) TEM: Lattice Constant of Au from Electron Diffraction Rings.

For Au, you will also have an electron diffraction pattern of the gold nanoparticles. You will need to construct a table in excel. Print your images and measure the radius of the diffraction rings and record them in an Excel table. Be sure to scale your measurements to the actual size on the film/detector. Scanned films: the size of the scanned area is 2.30” × 4.00”. Direct digital images are 50 pixels/mm, thus the 768 pixels × 512 pixels images corresponds to a real space image size of 15.36 mm × 10.24 mm. For this analysis you will need three pieces of information:

1) The actual radius of the diffraction spots from the center.
2) The camera distance (for the film, this is around 80 cm, but is printed on the film).
3) The accelerating voltage of the electrons.

Calculate the de Brogglie wavelength of the electrons from the accelerating voltage of the electrons. Now you can calculate the plane spacing producing the diffraction ring. In order to measure the lattice constant of the gold, you will need to index the rings.

You can rapidly index your rings using a simple trial and error method. Add columns for *h*, *k*, *l*, and *a* as you did in you did for the x-ray experiment. Then you also know that for FCC crystals, diffraction is only observed for planes where *h*, *k*, *l* are either all *odd* or all *even*. You can rapidly index the rings by trying different *hkl* indices, if you have correctly matched the ring with its index, *a* will be close to the correct value. Once all of the rings have been properly indexed, the values of *a* will be self consistent. Turn in the diffraction pattern with the {*hkl*} indices labeled, the excel table showing the completed Bragg analysis, and the average value of the lattice constant that you determined by electron diffraction.

3) SEM: Show the SEM images of your AFM lithography sample.

4) SEM: Show the SEM images of your test sample. Include you EDX spectra identifying the main elemental peaks AND the area of the sample to which these correspond.