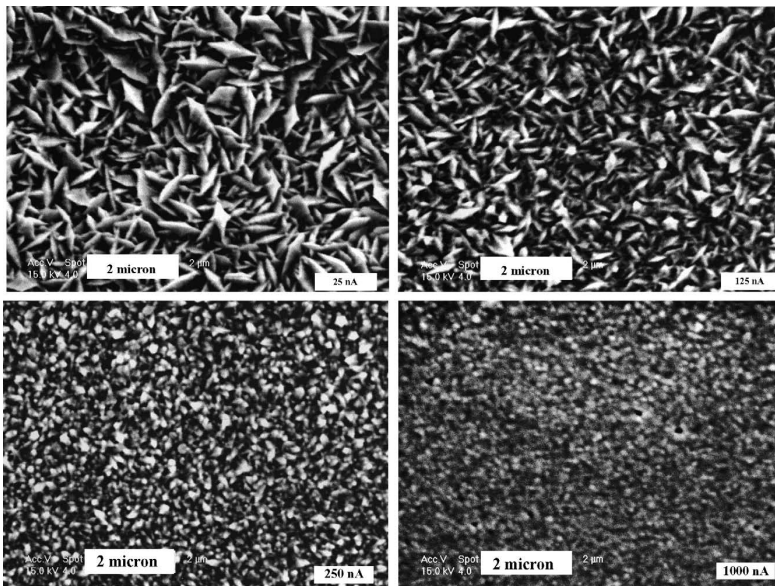# Exercise G

As we have seen in the previous exercise, the impedance of a typical metallic electrode for extracellular recording lies in range of several Mega Ohms. This is quite inconvenient because such high-impedance source is sensitive to external noise. Thus, it is desirable to decrease the impedance. Size of the electrode tip can't be increased because this will lead to picking up signals from the larger amount of cells in vicinity, and not only from the cell(s) of interest. The solution was found to cover the tip of the electrode by the thin layer of the conductive material with a non-flat surface. The typical substance for plating is gold. The electro microscopic photographs of the surfaces after gold-plating are shown below.


Experiment 1: Gold plating of the microelectrode

Measure the impedance of the 10um electrode wire fabricated in the previous Exercise G. If you don't have it, pool yourself with colleagues that have the electrode or fabricate it again. During one week the impedance may change. Thus, it is a good thing to measure it again. Then we shall gold plate it by applying current 10 uA in "Cisco process gold solution" for 10 seconds. The easiest way to reach this is to take 1 MOhm resistor and apply 10V voltage through this resistor to the electrtode. As impedance of the electrode itself is in Mega Ohm range, the current will be less than 10 uA. If it will be significantly smaller, increase voltage or time of goldplating to have the planned amount of plating (I*t = 10uA*10 sec). For gold plating negative potential of the power supply should be connected to the electrode, and positive – to the bath. "Cisco process gold solution" contains cyanide that is quite toxic. For this reason gold plating will be done in our chemical lab under the fume hood suggestively by the instructor of the course. The alternative solution is to use gold chloride (Au_2Cl_6), but it is also toxic. After gold-plating measure the impedance again. What has happened with the real and imaginary parts of impedance?

Metal electrode in a solution does not have the potential of solution, but differs from it by the so-called half-cell potential measured relatively hydrogen electrode and tabulated for standard concentrations of the metal salt (1M). It is given for zero current through the electrode. However, in reality different currents can flow through the electrode during electrophysiological measurements. They can depend on relative potential of the tissue, different

leakages in the measuring system and other factor that are difficult to control. We are normally interested in the potential of the tissue itself and not in the voltage drop at our tissue-electrode contact. Thus, it is desirable to have an electrode, whose tissue-electrode potential does not depend on current through such electrode. Electrodes with such properties are called non-polarized electrodes. They are especially preferable for measuring slow potentials (EEG, for instance). One of such electrodes is AgCl/Ag+ electrode. Why AgCl/Ag+ is an electrode at all? Why it is a non-polarized one? (In the AgCl crust, silver atoms have a low but useful mobility. The Cl atoms, in contact with a solution containing chloride, can be exchanged just like metal atoms in contact with a salt of that metal.)

Experiment 2: Fabrication of AgCl/Ag+ electrode, its properties

Measure the low-frequency properties of non-oxidized silver wire first. For this take a d = 0.005" silver wire in teflon insulation and remove this insulation from the tip, L = 3mm approximately. Place the tip of the wire in the saline bath (0.9% NaCl) and apply 1 Hz sinusoidal voltage of amplitude +/-10V through a 300 kOhm resistor. How the dependence of potential on time looks? Explain the phenomenon. Hint: An example of curves is presented below. It is a good idea to use the impedance meter with the coefficient of amplification one. Apply smaller voltages and lower/higher frequencies to see how the curves change.
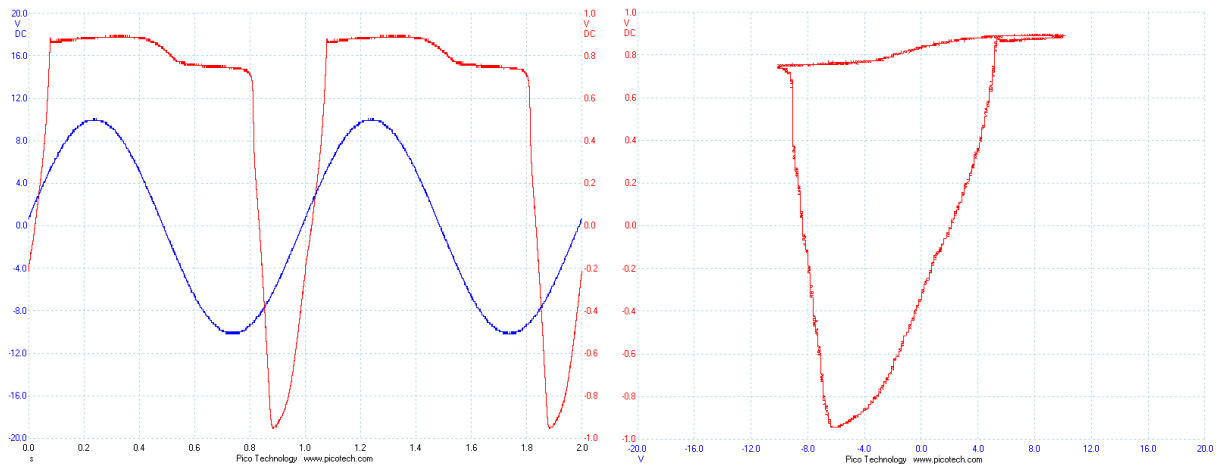
Oxidize silver wire in the 0.5M KCl solution by applying 1.5V to the electrode during 2 minutes (positive output of the power source – to the electrode, negative – to the aluminium bath). Repeat measurement done before (with the Ag electrode). How the properties of the electrode changed? Explain why this has happened. You can get curves similar to pictures below.