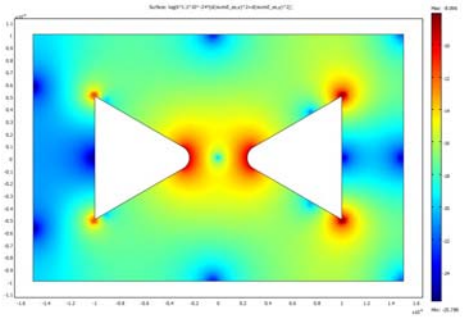
Dielectrophoretic trapping and electrical studies of nanoparticles and DNA.

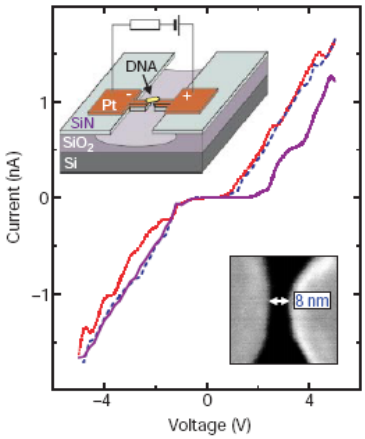
Supervisors: Leonid Gurevich and Peter Fojan

Molecular Electronics, one of the most dynamic research areas in nanotechnology, envisages future electronic devices as self-assembling entities where individual molecules in combination with nanoparticles can play role of transistors, memory switches and other non-linear elements of modern electronics. Complete functional device could be essentially self-assembled in a test tube in large quantities. As a first step in this direction, individual molecules can be connected to macroscopic electrodes and measured one by one.



Electric field gradient near triangular electrodes (2D-COMSOL model)

Due to its extensive self-assembling properties, DNA is considered to be one of the most promising materials for molecular electronics. Besides that, short dsDNA molecules were shown to exhibit semiconducting behavior.



DNA Trapping scheme and current-voltage characteristics of trapped DNA. from [1]

There are several ways how the molecules can be connected to the electrodes. The simplest one is a deposition of the molecules on top of the prefabricated electrode system. If the concentration of molecules is right, some of the electrodes will be connected by only one molecule. Dielectrophoretic trapping involves application of AC or DC electric field between the electrodes. An object with a polarizability ε higher than the environment will move along the field gradient and end up between the electrodes. In this way a molecule or a nanoparticle can placed precisely where it is needed.

In this project you will model electrical field around metal nanoelectrodes in solution and optimize condition for dielectrophoretic trapping of the molecules. You will further verify you prediction on a real nanoparticle, DNA or protein sample. As further step you can elaborate your model taking into account deprotonation effects in electrical field, extend to other geometries (e.g. EFM: tip molecule interaction) or work on the experimental technique.

Techniques to be used in the project:

1. AFM (for visualization of the deposited and trapped DNA molecules and nanoparticles)
2. COMSOL modeling for geometry optimization
3. Optionally, Molecular modeling for polarization of DNA and protein in electric field.
4. Optionally, e-beam lithography and deposition.

Relevant courses: Lab-on-a-Chip, Electromagnetism, Genetechnology

References:

[1] D. Porath et al, Nature 403, p.635 (2000)

[2] R. Hoelzel et al, Phys.Rev.Lett. 95, 128102 (2005)