

“Graphene biosensing and biophysics.”

Single-molecule studies provide detailed and valuable information about complexity and heterogeneity of multi-component systems, otherwise hidden by the ensemble-averaged measurement. This approach has significantly increased the sensitivity of biosensors and devices for molecular diagnostics by lowering the detection limit down to ultralow concentrations. Nowadays, single-molecule measurements are regarded as a critical part of many research fields and have become more and more common, what is undoubtedly related to the advances in nanotechnology and development of new analytical tools. Notwithstanding, the detection of single species, investigation of their properties and simultaneous measurements of many single molecules are still very challenging. This can be fulfilled only with well-designed and fully-controlled functional structures characterized with high homogeneity and reproducibility.

With this project, we aim at establishing a novel platform for the new field of graphene biosensing and biophysics. There are two major players: graphene and DNA origami. On one hand, we have a high quality graphene with outstanding optoelectronic properties but chemically inert. On the other hand, we have DNA origami structures folded solely from single-stranded DNA which allows for introduction of almost any entity (for example a chemical group) with very high (nanometer) precision. There is a great interest in both materials due to their unique properties, however it is very challenging to bring them together.

Our newly developed strategy allows for placing functional DNA origami structures on graphene using several aromatic molecules as a universal glue to connect these two materials in a controlled manner, without losing their intrinsic properties. On the way to realize the overarching goal there are several subsidiary goals. At first, we will elaborate the preparation of ultraclean graphene samples, using improved protocols for graphene transfer. At the same time, we would like to reduce production cost, increase throughput, and most importantly make the technology broadly available. Secondly, we aim for DNA origami structures that could act as a platform for biophysical and biosensing applications. Our initial envisaged design, specially prepared for this project, is L-shaped DNA origami. L'origami provides a thin DNA origami layer (“base”) that separates all incorporated entities from graphene as well as an adjacent “wall” that offers binding sites for biomolecular assays at all heights of the dye-graphene interaction regime. We will develop improved biorecognition units whose functioning will be monitored via interactions with graphene. The last but not least, we will explore new, fascinating biophysical properties of macromolecules which are of biological interest, using graphene-tethered macromolecule system.

Combining optimized graphene substrates and the DNA L'origami, we will have important new tools at hand that offer exciting applications for biosensing and biophysics, but also for superresolution microscopy, plasmonics, material sciences, and many more.