The role of defects in photoresponse of devices made of two-dimensional transition metal dichalcogenides monolayers

Two-dimensional materials have attracted the attention of scientists from all around the world due to their unusual properties, which very often differ from the properties of their bulk counterparts. A group of materials that show great potential for use in applications are transition metal dichalcogenides, i.e. compounds of a transition metal atom (e.g. molybdenum or tungsten) and a chalcogen, i.e. element from group 16 of the periodic table (sulfur, tellurium, selenium). What distinguishes these materials from the others is their unusual property that under the illumination, when electrical voltage is applied, they generate current associated with lighting called photocurrent. Materials with this property are suitable for use in photodetectors.

In the case of two-dimensional materials where we deal with a single layer of atoms, all properties depend on the material's surface, making them very susceptible to various changes related to the environment, for example the presence of oxygen in the air. In order to be able to use two-dimensional materials in applications, it is necessary to know their properties in particular their operation in atmospheric conditions and with the influence of naturally occurring imperfections in their structure (defects). In this project we plan to study the impact of the environment as well as structural defects in two-dimensional materials - molybdenum disulphide and tungsten disulphide (MoS_2, WS_2). We also expect that the defects in the material can be saturated by treating them with appropriate chemical compounds - for example thiols (compounds with the -SH group) and acids (e.g. sulfuric acid).

Saturation of defects using these methods is not yet clearly explained by current state of the art. We know, however, that defects in the structure of the material, although they negatively affect the electronic properties of the devices, also give the opportunity to modify the material by attaching different molecules to them. We expect that by creating defects in MoS2 and WS2 using plasma, we will be able to distinguish the influence of defects on the operation of devices based on these materials from the influence of the environment. In addition, we are going to try to change the properties of our devices by saturating defects in the structure and functionalizing the surface with chemical treatment. These studies can help designing future applications based on two-dimensional materials.