GO-OXI-UV: **G**raphene and low-dimensi**O**nal crystalline **OXI**des – pathway toward smart **UV** absorbers with sensing capabilities

The main goal of the project is to explore paths for the creation of transparent and flexible electronic systems based on two-dimensional (ultrathin) oxides fabricated on graphene. This goal revolves around finding methods to create transparent p-n junctions. The development of such junctions will influence the consumer electronics sector, as it will make it possible to create transparent devices, such as phones, computers, and monitors, in visible light. Furthermore, the use of ultrathin materials in combination with graphene will ensure that the resulting devices will be flexible!

Oxides are chosen because, due to their electronic properties, most of them are transparent in the visible light range and only begin to absorb radiation in the ultraviolet range. However, creating p-n junctions based on oxides is a major challenge because most oxides naturally exhibit electron conduction (n-type). Therefore, we will focus on finding ways to induce hole conduction in oxides. In this project, we plan to focus on four oxides: MoO3, Re2O7, Sb2O3, and Bi2O3, hoping to find a method for p-type conductivity in one of them. Our previous research has shown that ultrathin crystalline layers can be created using these oxides. We have also demonstrated that single-layer thick crystalline oxides, have better properties than their thicker, amorphous counterparts. It also appears that ultrathin crystalline oxides on graphene substrates can be flexible. We aim to use epitaxy, surface oxidation of metal (SOM), and CVD for growth. To induce hole transport, we plan to attempt replacing some oxygen in these oxides with nitrogen through interaction with nitrogen plasma. Additionally, we aim to use ion bombardment to remove metal cores, which should introduce p-type doping. We will also attempt to introduce dopants such as In, Gd, and CuO during growth, which in some cases have led to hole conduction in oxides.

Another challenge we will face is the construction of p-n junctions. This task involves treating ultrathin oxides as building blocks from which the final system will be assembled. We plan to carry out this assembly in one of two ways: by self-organized growth of one oxide on another or by mechanically transferring one oxide onto the surface of another. Such systems, known as hybrid heterostructures, are currently under intense research, as it was shown in 2019 that superconductivity is induced in two artificially stacked and slightly twisted graphene layers, and in November 2024, that superconductivity is also induced in two twisted layers of the semiconductor WSe2. These discoveries raise hopes for the identification of new physics in other assembled and twisted materials, including oxides. Thus, in our research, we expect to observe new phenomena induced by the proximity effect of different oxides and graphene in the fabricated heterostructures.

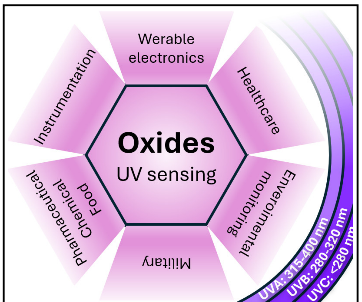

Fig. 1. UV sensors

As proof of concept, in the final phase of the project, we will focus on using the created p-n junctions in ultraviolet sensors. There is a wide range of applications for such sensors (see Fig. 1), among others in wearable electronics to monitor personal exposure to UV in order to avoid burns or skin cancer. They are also used in pharmacology, food disinfection, military, as well as in environmental monitoring, water purification, and measurement equipment.

The methods which we plan to use during our investigations will allow us to characterize samples morphologically, electrically and also their electronic structure. The experiment will be supported by intensive theoretical research, which will indicate the directions of experimental work.