Light-emitting diodes (LEDs) based on semiconducting compounds (e.g., GaN) have been **successfully implemented in light illumination and display applications**. LEDs are characterized by higher luminous efficiency, longer life time, and weaker electro-thermal effects when compared to conventional light sources. Due to the rapid development of technology, inspection of novel materials with unique properties and hosting a variety of opto-electronic properties is crucial. **Two dimensional (2D) van der Waals (vdW) layered materials** being of vivid interest of scientists are composed of **several subgroups**, e.g. **transition metal dichalcogenides** (TMDCs), **metal monochalcogenides** (MMCs), **chromium trihalides** (CrTHs), and **metal phosphorus trichalcogenides** (MPTCs). As ultrathin TMDCs and MMCs possess unique photo-electrical semiconducting properties, including spin–valley interactions, nonlinear optical properties, single photon emission, and layer-dependent bandgap, it makes them an ideal platform for exploration of next generation electroluminescent devices at an ultimate limit of a luminescent medium with the thickness of a single atomic layer. On the other hand, the magnetic 2D materials, such as CrTHs and MPTCs, possesses both the band gap and the magnetic ordering, which makes them attractive thanks to potential applications in future spintronic devices.

In this project, we will study **the optical and electronic properties of LED architectures composed of stacks of ultrathin layered materials that combine multiple functionalities into a single device**, e.g., by merging (semi-)metallic electrodes, insulating tunnelling barriers, and luminescent semiconducting media. It is planned to study EL spectra of individual materials, e.g. $MoSe_2$, and of artificially-created vdW heterostructures, e.g. $WSe_2/CrBr_3$. **The innovative aspect of the project** lies in the inspection of the EL response of novel structures, e.g. **with different types (I or II) of band alignment**. We will also create novel control knobs by engineering a novel generation of LED **with intrinsic magnetic properties (ferromagnetic or antiferromagnetic)**. The choice of materials is motivated by the current state-of-the-art in the research of 2D vdW materials, which allows us to make educated predictions of potential findings. We envisage the creation of novel devices that combine functionalities beyond traditional light sources. By a a man-made combination of materials via van der Waals technology, our devices will be able to simultaneously act as light detectors, optically controlled memory storage units, magnetic field sensors,, and/or electrically controlled qubits.

The main experimental technique used in the project will be **EL**, which will be employed to investigate the optical and electronic properties of investigated structures **in a wide range of temperature and magnetic fields**. To observe EL signal, high quality samples will be fabricated allowing electrical injection of electrons and holes into the optically active area. Other experimental techniques, such as photoluminescence (PL), PL excitation, photocurrent, and reflectance contrast will be used to characterize the optical properties of the studied structures in accordance with the results of the EL measurements.

Investigation of the optical and electronic properties in new types of artificially created structures will have **a significant impact on the development of solid-state physics as well as material sciences**. This is associated with the considerable interest of scientific community in the 2D layered materials and the arising need to understand new physics behind novel functionalities, phenomena, and on-demand material properties.