The goal of the LOW-LIGHT project is to design stable and highly efficient hybrid nanomaterials for optoelectronic applications, i.e. collecting sunlight and transforming it into a different type of light or clean energy. The nanomaterials will be placed in prototype devices by a multidisciplinary and international team of chemists and experimental physicists. The research project focuses on the study of hybridization of selected nano-objects, the so-called Nano Building Blocks (NBBs) and their further transformation into stable colloidal dispersions (a form of moderately dense substance). NBBs as a colloidal dispersion, distributed in the form of a thin film on electrical devices, will be their integral part, transforming light into energy. The key to this research is to control the interactions and self-assembly properties of NBB at the nanoscale in order to optimize the relationship between structure, property and function of integrated nanosystems. The aim of the project is to obtain structures with high light conversion and achieve good performance and long-term stability in real devices.

The selected NBBs are carbon-based low-dimensional materials - so they are small organic particles, carbon quantum dots, nanoribbons, nanotubes and graphene. The study will focus on designing and transforming small, functional NBBs into larger integrated systems that will lead to integrated nanoarchitecture with highly efficient light collection / conversion and / or energy emission. In this way, different NBBs will be linked together by chemical methods to enhance energy transfer (ET) / charge transfer (CT) processes. The result of the combination will be the efficient accumulation of charges on the electrodes in response to the light stimulus, which will lead to the production of light by the electrical stimulus. Designing NBBs components will be done by computational modeling, followed by their synthesis by chemical methods, detailed characterization by spectroscopic techniques and integration into devices. The project's main challenge is to find a combination of materials that can provide limited charge / exciton recombination in binary nano-phases, while at the same time being able to perform efficient ET / CT processes for current / light production. The way in which the individual NBBs interact with each other is therefore crucial to creating working devices. This requires an in-depth knowledge of the chemical and physical nature of the interface between NBBs. During the design phase of the devices, different levels of nano-hybrid structures will be considered to increase photocurrent generation / electroluminescence and relate interface morphology to its function: component density ratio, relative distance, orientation and relative position.

In LOW-LIGHT we will use 1: multiscale computational methods to describe the chemical and physical properties of interfaces; 2: synthesis and characterization of hybrid interfaces; 3: optimization of optoelectronic functionality. The first point will be carried out using various computational approaches to correctly describe the light absorption and emission processes of NBBs. Importantly, the evolution of the interface over time will be modeled by classical molecular dynamics, in which atoms are considered as small spheres connected by springs. This method allows taking into account realistic model systems (thousands of atoms) and physically meaningful time scales (hundreds of nanoseconds) in order to study not only their evolution over time, but also the stability of various interfaces. Next, we will focus on more detailed computational methods to understand the energy and charge transfer mechanisms occurring at the interface and optimize them to eliminate charge recombination. The production of the nanohybrid, as envisaged in point 2, will be possible through the use of advanced nanochemistry methods based on both covalent and non-covalent interactions in order to obtain tight control over the final structures. This will be the key to the implementation of point 3: once the nano-hybrids have the appropriate characteristics, they will be stabilized into nanoinks ready for high-performance solution casting in the form of thin films ready for use in prototype devices. The performance of these devices will be used to draw conclusions on the effectiveness of the overall LOW-LIGHT approach. LOW-LIGHT will develop a suite of nano-structuring techniques with an emphasis on providing innovative rational design instructions for nanhybrid for the entire scientific community. The project will seek a unique combination of cutting-edge materials to create highly innovative platforms for optoelectronic technologies. Its objectives carry a significant risk if we take into account the extraordinary level of innovation, which combines modeling and synthesis of complex nanohybrid architectures based on low-dimensional materials, as well as testing their functionality in one project. However, the success of this research and innovation project means high returns, as it will offer the opportunity to develop cheap technology, while stimulating the further implementation of new technological solutions in the service of our society.