Over the past decade, materials with perovskite structures have attracted and continue to attract significant interest from industry and academia due to their enormous potential in a range of optoelectronic applications - radiation detectors, photocatalysts, or light emitters. In particular, perovskites have gained public recognition as materials for photovoltaic cells that could be integrated into building facades, windows, or textiles. The most common perovskites for such applications are lead halides (chlorides, bromides, iodides). While useful for many applications, these perovskites are not free of disadvantages. Firstly, while well withstanding mechanical deformation, perovskites degrade quickly due to moisture, heat, and even intense light. In addition, lead halides are toxic materials because of their chemical composition. Therefore, finding new materials free of these problems is essential.

A promising new family of materials is the so-called double halide perovskites – materials in which lead is replaced by two other elements. It turns out that such structures are not only lead-free but also more durable and weather-resistant and degrade more slowly. In addition, because of the huge number of combinations of elements that can enter the double perovskite compounds, a very wide modification of the chemical composition of the material is possible. Notably, such changes can obtain the desired physical and optical properties while the basic crystalline structure is retained. Another way of modifying the properties of double perovskites is doping – adding tiny amounts of certain elements that form isolated centers instead of modifying the whole perovskite composition. The doping of double perovskites, mainly by transition metals, changes the energy structure of the compound by introducing additional energy states located in the energy gap energy between the valence band and the conduction band.

These additional electron states can be utilized in two ways. Firstly, we can obtain light emission associated with electron transitions between the energy states of the dopant. **We aim to obtain a group of materials with ultra-wideband and efficient near-infrared emission**. Such emitting materials are desirable for emerging technologies like biosensing, medical diagnostics, and food quality control. Secondly, due to the good electrical properties of double perovskites, light absorption by the energy states of doped luminescent ions can generate charge carriers and increase the material's electrical conductivity. **We expect to obtain a second group of materials that absorb light and efficiently convert light to electricity,** with the potential for use in solar cells and photodetectors.

Electrons cannot conduct electricity and be a source of emitted light at the same time, so research efforts in new material development are usually directed toward optimizing either luminescent or photoelectric properties. **With this project, we want to investigate electrical and optical properties simultaneously as a function of temperature and pressure. This will allow a better understanding of the electrical carrier generation processes responsible for luminescence quenching and answer why the luminescence of some transition metal doped phosphors is low while the luminescence of related materials is very high.** This research will be supported by theoretical modeling and advanced structural analyses in a synchrotron that will comprehensively indicate the direction of development of such materials. Only such a broad approach to the problem, involving the simultaneous study of the relationships between optical, electrical, and structural properties, will allow a complete understanding of the observed phenomena and significantly help in the practical design of new optoelectronic materials.