This project aims to develop and better understand advanced optical hydrogen sensors based on tungsten oxide (WO$_3$) thin films, a material distinguished by its unique ability to change optical properties when exposed to certain gases, a phenomenon known as gasochromism. WO$_3$ is considered a promising candidate for safe, efficient, and environmentally friendly hydrogen detection due to its abundance, low cost, and selective optical response to hydrogen.

Hydrogen is a key component of a sustainable energy future. Nevertheless, hydrogen exists as a colorless, odorless, and highly flammable gas (H$_2$) at room temperature. Its wide flammability range, extremely low ignition energy, and nearly invisible flame pose serious safety risks, including the potential for sudden explosions. Among the various solutions being explored, semiconductor sensors stand out due to their unique optical and electrical properties, making them a key area of interest. Although electrochemical hydrogen sensors are commonly used, their reliance on high operating temperatures raises safety concerns, particularly due to the potential risk of ignition. The advantages of sensors based on the gasochromic effect include improved operational safety, increased adaptability for various applications, and a unique selectivity, as the gasochromic response of tungsten oxide is exclusive to hydrogen.

In this study, we will analyze the influence of deposition process modifications, such as changes in deposition atmosphere, deposition angle, film thickness, and addition of a catalytic layer, on the structural and optical properties of WO$_3$ films and consequently on their hydrogen sensing performance. Advanced in situ methods will be used to track real-time changes in film properties during hydrogen exposure. These investigations will help clarify the mechanisms behind the gasochromic effect and support the design of highly sensitive and reliable hydrogen sensors that can operate across a wide range of concentrations, including very low (ppm) levels. This approach is novel, as no comprehensive studies have yet been conducted that correlate deposition parameters, film nanostructure, and in-situ gasochromic response in WO$_3$ systems for hydrogen detection.

The expected outcomes of the project include the development of a deeper understanding of the relationship between the structural and surface properties of WO$_3$ thin films and their gasochromic response to hydrogen. As a result, the research will provide guidelines for optimizing deposition techniques and thicknesses to achieve fast, reversible, and highly sensitive hydrogen detection at various concentration levels. The results will not only contribute to the development of innovative hydrogen sensors but may also have broader implications for smart coatings and devices.