Wrocław, 28.05.2025

ABSTRACT OF DOCTORAL DISSERTATION

MSc Maja Szymczak

"The investigations of the influence of the applied pressure on the luminescence properties of the Cr^{3+}-doped inorganic materials for luminescence manometry applications"

Precise control of pressure remains a fundamental requirement in high-pressure research and technology. Consequently, the development of more accurate and reliable pressure monitoring techniques and devices continues to be a central focus of experimental advancement. Among the most promising approaches are luminescent manometers - optical sensors capable of remote, non-invasive, real-time pressure readout by utilizing pressure-induced changes in the luminescent properties of phosphor materials.

The most prevalent strategy in luminescence manometry involves monitoring the pressure-induced spectral shift of a narrow emission line. Since its introduction in the mid-20th century, ruby has served as a robust and highly accurate pressure sensor in diamond anvil cell experiments under high pressure. However, despite its widespread adoption, ruby exhibits inherent limitations, including relatively low pressure sensitivity and considerable susceptibility to temperature fluctuations. These temperature-dependent effects can compromise measurement accuracy, particularly in experimental conditions where pressure and temperature change simultaneously. Such limitations highlight the critical demand for advanced sensing approaches and materials that combine high sensitivity to pressure changes, resistance to thermal perturbations, and outstanding measurement precision - key attributes required for the successful implementation of luminescence manometry in industrial applications.

In response to these requirements and the underlying challenges associated with proposed luminescent pressure-sensing approaches, the overarching objective of this doctoral dissertation was to conduct a systematic investigation of the pressure-dependent spectroscopic behavior of Cr^{3+} ions, with the aim of assessing their potential for application in luminescence manometry. The outcome of this research is the development and advancement of a novel class of luminescent pressure sensors that leverage the pressure-sensitive $^4T_{2g} \rightarrow {}^4A_{2g}$ electronic transition of Cr^{3+} - marking a significant leap forward in the development of high-performance optical manometers. The findings, as presented in the series of peer-reviewed publications constituting this dissertation, demonstrate that the proposed Cr^{3+}-based luminescent manometers exhibit high readout precision, outstanding sensitivity to pressure variations, and remarkable independence from temperature of the system. These attributes collectively define a new generation of luminescent pressure sensors with exceptional application potential, advancing the field toward practical deployment in complex, real-world environments beyond the constraints of the laboratory.