# Abstract

Over the past two decades, we have witnessed a scientific and technological revolution characterized by the miniaturization and multifunctionality of many technical devices. Key innovations include artificial intelligence, personalized medicine, and quantum cryptography. These advancements have been made possible, in part, by over a century of research on ferroelectrics. To understand the properties of a material, it is crucial to examine its response to various external factors such as temperature, pressure, mechanical stress, electric fields, magnetic fields, and electromagnetic radiation.

**The aim of this Ph.D dissertation is to investigate the influence of temperature and electric field on the properties of sodium-bismuth titanate $Na_{0.5}Bi_{0.5}TiO_3$ (NBT) and to provide new information on the stability of crystallographic phases in specific temperature ranges. Studies were also conducted to identify the reasons for its relatively high electrical conductivity.** A variety of complementary and precise experimental techniques were employed to achieve this goal, providing a comprehensive picture of the physicochemical properties of the crystal. The research aims to address existing ambiguities in the scientific literature concerning the thermal stability of crystallographic phases and the causes of high electrical conductivity in NBT.

A significant aspect of the study is the analysis of NBT's behavior under temperature variations, as this significantly influences its electrical, mechanical, and optical properties. Additionally, the high sensitivity of NBT to electric fields plays a critical role, making this material essential for modern technologies in electronics and optoelectronics. The paper is divided into three parts: a literature review outlining the current state of knowledge on ferroelectrics and NBT, an experimental section, and a summary with conclusions.

In the first section, we present literature data on the properties of ferroelectric materials, including the history of research, single crystal technology, crystal structure, and NBT phase transitions.

The second section details the preparation of samples for study, including the processes of polarization and annealing. Samples were prepared along selected crystallographic directions (001) and (111) and were tested both before and after being annealed in air at temperatures of 630°C and 830°C for one hour. Some samples were also polarized for specific tests.

A description of the measurement devices and methodologies precedes the presentation of experimental results and their analysis. The experiments included studies of structural,

calorimetric, dielectric, DC and AC conductivity, optical, thermoelectric, ferroelectric, and mechanical properties. Most tests were performed as a function of temperature, and some, such as dielectric, electrical, and mechanical tests, were also carried out as a function of frequency.

The research on monocrystalline sodium-bismuth titanate led to several key findings, including:

- The effect of the sample preparation process—specifically heating and polarization—on the tested properties.
- The direct influence of temperature on structural, thermoelectric, ferroelectric, and mechanical properties.
- The impact of electric fields on dielectric properties, electrical conductivity, and ferroelectric behavior.

Considerable attention was given to the study of how electric fields and temperature affect the transport of electric charge carriers in NBT. To this end, we examined current-voltage characteristics, depolarization currents, DC and AC conductivity, and the Seebeck coefficient. The research was further complemented by an analysis of the impedance (Z) and electrical modulus (M). In ferroelectrics, understanding the nature and order of electrical conductivity is crucial, as it affects other related properties such as piezoelectricity, pyroelectricity, and polarization conditions. Moreover, the phenomenon of electric charge carrier transport in NBT is rarely explored. The experimental section concludes with the results of the SHG method and mechanical properties tests conducted on NBT for the first time.

The third section of the paper provides a summary of the experimental findings and the conclusions drawn from tchem.