# FUNDAMENTAL STUDIES ON THE PHYSICAL PROPERTIES OF NIOBIUM OXIDES





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### Objectives

Develop a new family of solid electrolytic capacitor based on niobium oxides, as an alternative to the current tantalum technology.

Perform fundamental studies on niobium oxides to understand and control the mechanisms responsible for phase changes, oxidation and the creation oxygen vacancies.

Characterize the structural, electrical and optical properties of niobium oxides and also rare-earth orthoniobates.

## Methods and techniques

In this work, niobium oxide samples were synthesized by solid state reaction, laser floating zone technique, and Pechini method.

In-situ XRD and Raman spectroscopy were used to perform structural characterization.





Photoluminescence and photoluminescence excitation studies, at room-temperature and temperature dependent, were performed using different excitation wavelengths. Impedance spectroscopy from RT to 1200 °C was used to study the electrical properties of these materials.

#### Results

*In-situ* XRD allowed us to get a deep understanding of how the cubic phase of NbO oxidizes with thermal treatment and how do the niobium pentoxides change between different polymorphs. The region of temperatures between 300 and 500 °C is where NbO oxidizes into amorphous niobium pentoxide (Nb<sub>2</sub>O<sub>5</sub>).

This oxidation process gives rise to very different colours which we proved to be due to optical interference from the thin layer of niobium pentoxide growing around the grains of NbO. This result also helped us to justify the high capacity values measures at NbO samples treated at 300 °C, where the electrical conductive NbO is the majority phase. The optical properties of Erbium Orthoniobate (ErNbO<sub>4</sub>), but also from other rare-earth niobates, revealed an intense up-conversion luminescence changing colour from red to yellow and to green depending on the excitation power.





Colours of the NbO pellets heated in air from RT to 550 °C.



### **Publications**

(1) Nico C, Soares M, Rodrigues J, Matos M, Monteiro R, Graça M, Valente M, Costa F, Monteiro T. J Phys Chem C 2011;115:4879.

(2) Soares M, Leite S, Nico C, Peres M, Fernandes A, Graça M, Matos M, Monteiro R, Monteiro T, Costa F. J Eur Ceram Soc 2011;31:501.

(3) Nico C, Soares M, Matos M, Monteiro R, Graça M, Monteiro T, Costa F, Valente M. Microsc Microanal 2012;18:99.

(4) Nico C, Rino L, Matos M, Monteiro R, Costa FM, Monteiro T, Graça MP. J Eur Ceram Soc 2013;33:3077.

PL spectra of a ErNbO<sub>4</sub> pellet at 5 K excited with different powers of 980 nm laser.

UCTURES, DELLING AND RICATION











