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(LGEP-SUPELEC & University of Manchester)

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Room D420 (3rd floor, building D - Institut Néel) [Access Map]

Alliance 4 “Electrical energy” | Aliance 2 “Spintronique”

Synchrotron experiments and micromechanical models:

An efficient combination for the description of ferroelectric behaviour

Summary : Ferroelectric ceramics are widely used as the basis for electromechanical sensors and actuators for control, medical, electronic and micro-electromechanical systems (MEMS) applications. The macroscopic strain and polarisation under a given set of external electro-mechanical loading conditions results from a complex combination of the intrinsic piezoelectric effect, the extrinsic effects resulting from the evolution of the ferroelectric domain microstructure, and the development of internal inter-granular stresses.

High energy x-ray diffraction is a powerful tool to analyse the mechanisms responsible for ferroelectric behaviour in polycrystalline ceramics. Monitoring lattice spacing under electro-mechanical loading provides an insight into the evolving domain structure and internal stresses. The use of high energy allows an investigation into the bulk, avoiding surface effects.

From the modelling point of view, ferroelectric materials are particularly well suited to micromechanical approaches, due to their multiscale microstructure including intricate ferroelectric domains and polycrystalline structure. A major challenge is to describe the evolution of microstructure with sufficient details and accuracy but reasonable computation time.

The presentation will show recent diffraction results performed on ferroelectric materials under electro-mechanical loadings. In a second part a multiscale modelling approach to ferroelectric behaviour will be presented. The objective is to illustrate how the combination of local measurements from high energy x-ray diffraction and micro-mechanical approaches can help understanding the devices based on ferroic materials.

Keywords : Ferroelectricity - polycrystals - domain switching - x-ray diffraction - multiscale modelling

Laurent Daniel is Associate Professor at Université Paris-Sud, France and Visiting Academic at the University of Manchester, UK. His research interests include the definition, identification and validation of constitutive laws for coupled phenomena and particularly thermo-electro-magneto-mechanical couplings. He is involved in the development of multiscale methods for the prediction of such coupled phenomena. In 2011, he joined the School of Materials at the University of Manchester where he is involved in the set up and micromechanical analysis of high energy x-ray diffraction experiments on ferroelectric ceramics.