ESRF	**Experiment title:** In-situ study of the growth of Fe on BaTiO3 with the aim of inducing multiferroic-like behaviour	**Experiment number**: SI 2150
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Report:

The aim of the experiment was to study in-situ the chemical and magnetic state of an Fe layer deposited on a ferroelectric $BaTiO_3$ substrate during its growth. In particular, the aim was to emphasis the magneto-electric coupling properties of the system at these different steps of growth. For that purpose we carried out in-situ nuclear resonant scattering experiment in an ultra-high vacuum environment. An isotopically enriched cell of ^{57}Fe was used to stepwise deposit atomic monolayer of ^{57}Fe in between the acquisition of the nuclear time spectrum. A specifically designed sample holder was used to allow for the application of an external electric field across the substrate. This was used to polarize the ferroelectric substrate and monitor the influence of this field on the magnetic state of the thin Fe film.

A series of experiment have been carried out. First, room temperature deposition has been done. At each thicknesses of Fe, a positive electric field was applied and the corresponding chemical/magnetic state recorded. Below 1.5 nm of nominal Fe thickness, the layer is not magnetically stable. At 1.75 nm, the films shows ferromagnetic order. However, the timespectrum shows that a large part of the film is in a non-magnetic oxidized structure. The application of an electric field does not modify strongly the state of the layer neither before or after the magnetic transition. The reason for the apparent decoupling is presumably due to the formation of this non-magnetic oxide, which is promoted by the electric field itself [1].

In order to improve the coupling, we decided to grow the Film at a temperature of 120°C, just above the Curie temperature of $BaTiO_3$. We then cooled down the sample in an applied electric field such that the $BaTiO_3$ can be fully poled. Surprisingly, we found

that this strategy induced a retarded non-magnetic/ferromagnetic transition. As can be seen in Fig. 1, the time spectrum for the 120°C grown sample shows high frequency beatings (indicative of a magnetic state) only at higher thickness. What is also clear is tha the non-magnetic oxide component shows different hyperfine parameters. This finding is quite interesting, since it indicates it may be possible to manipulate the interface structure of a ferromagnetic/ferroelectric composite by applying an external electric field during the growth. Further experiments are currently carried out in our laboratory to unravel all the details of this behavior.

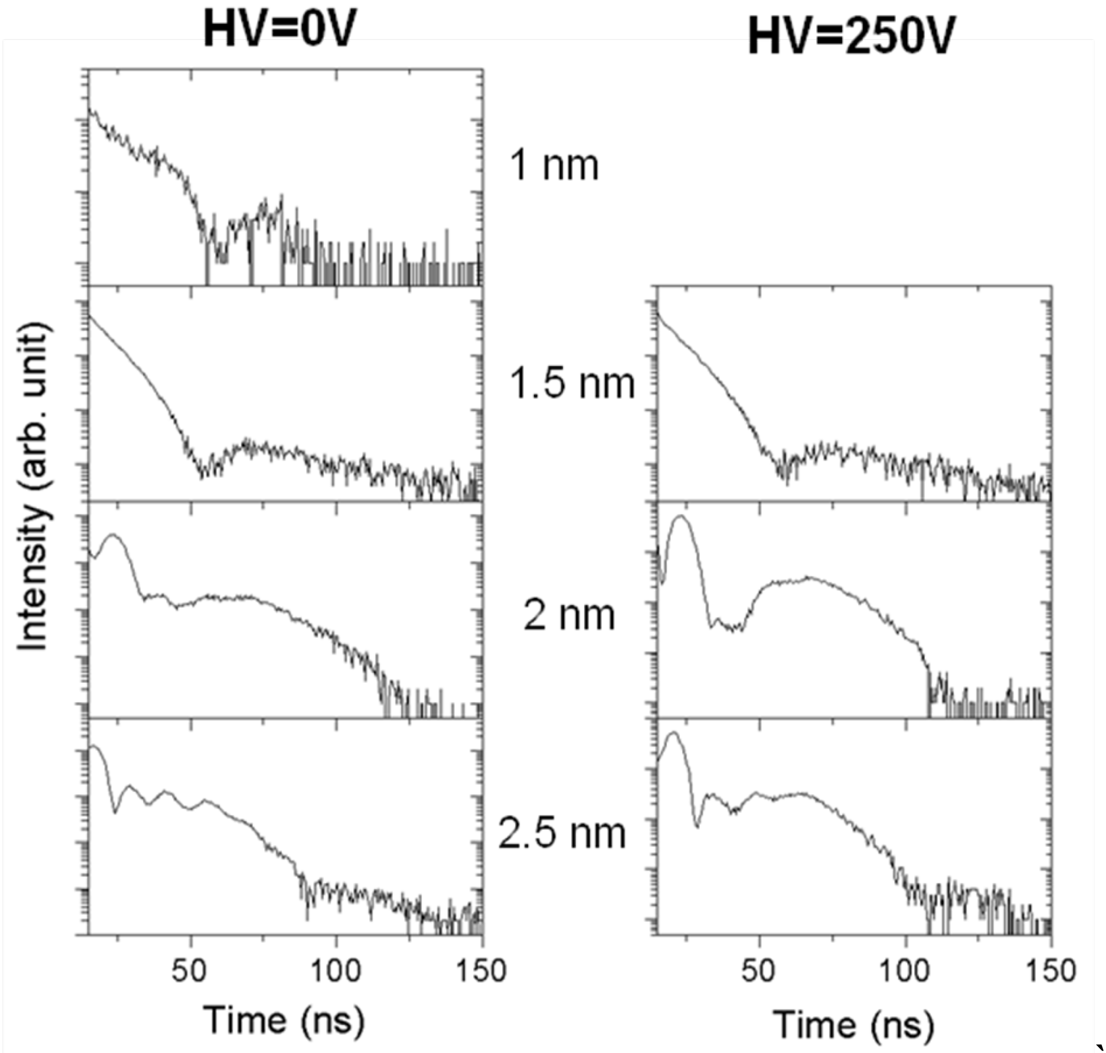

Fig. 1: time spectra recorded at different steps of the growth of an Fe film on $BaTiO_3$ substrate. The left and right panels are for samples grown wihtout and with an applied electric field respectively. Clear differences can be seen at the different stage of the growth which are likely to be due to the formation of a different oxide interface.

[1] S. Couet, M. Trekels, M. Bisht, M. Menghini, C. Petermann, M.J. Van Bael, J.-P. Locquet, R. Rüffer, A. Vantomme, K. Temst, Submitted to Phys. Rev. Lett.