Development and characterization of ferroelectric layers for the fabrication of FeFET transistors

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Abstract: The context of the thesis concerns the field of memory evolution in microelectronics. Instead of being interested in their miniaturization, it is a question here of substituting the gate oxide by a ferroelectric material. The integration of such a material in the gate oxide of a memory transistor allows a low consumption of the latter resulting from a switch from one memory state to the other thanks to a low current.

The ferroelectric character of the orthorhombic phase of hafnium oxide was demonstrated in 2011. Moreover, this material is already well integrated in microelectronics for its high-k properties, which makes it a relevant subject of study in this thesis. The non-centrosymmetric structure of HfO2 targeted to observe the ferroelectric effect is the orthorhombic phase (Pca21 group). It is possible to elaborate doped HfO2 layers and to implement a thermal treatment to stabilize this phase instead of all other possible crystalline phases of HfO2.

The ALD (atomic layer deposition) process was used to produce thin films of the desired material. In addition to the precise control of the thickness, this technique easily allows the insertion of dopants within the material and a favourable stabilization of some crystalline phases for desired conditions. This thesis work mainly concerns the elaboration by ALD and the characterization of hafnium oxide-based layers with different dopants, such as aluminum, lanthanum or silicon. Different doping proportions are analyzed, coupled with a certain range of post-deposition annealing conditions in order to define optimal conditions to reach a predominantly orthorhombic HfO2 based material. Finally, electrical tests highlight the ferroelectric character of the most suitable layers to be integrated in a memory transistor.