**Proving or disproving the ferroelectricity of very thin oxides by PFM**

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Piezoresponse Force Microscopy (PFM) is by far the most widely used tool when ferroelectricity of thin films has to be proved at the nanoscale. Based on Atomic Force Microscopy, this technique relies on the converse piezoelectric effect and thus basically records a vibration under the action of an alternating voltage. In the last few years, many authors reported PFM signal on non ferroelectric materials including amorphous $LaAlO_3$ (see for example [1-3]). In parallel, the need for ultra-thin layers (less than 10 nm) for e.g. the microelectronics and nanoelectronics leads to delicate situations where at least three phenomena may lead to the appearance of a vibration under an applied electric field :

- The converse piezoelectric effect, as desired when ferroelectricity has to be proven
- The capacitive (electrostatic) force which may be dominant in certain cases
- The variation of molar volume due to the motion of charged ions in the volume of the layer, like oxygen vacancies

The consequence is that apparent ferrorelectric domains appear during PFM investigations, that may not originate from ferroelectricity. In this communication, we present cases, including $GaFeO_3$, where PFM is may not be able to prove ferroelectricity at the nanoscale. We show that in certain cases, PFM may reach its limits and discuss possible solutions to separate the ferroelectricity from the other parasitic signals.

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