

# Comparison between Sputtering and Atomic Layer Deposition of ferroelectric doped and undoped HfO<sub>2</sub>

Jordan Bouaziz\*, Bertrand Vilquin\*, Pedro Rojo Romeo\*, Nicolas Baboux\*, Bruno Masenelli\*

\*Institut des Nanotechnologies de Lyon, CNRS, Ecole Centrale de Lyon, Université de Lyon, 36 av. Guy de Collongue, 69134 Ecully, France

In 2011 ferroelectricity was discovered in a binary oxide: Si-doped HfO<sub>2</sub> [1]. Thereafter, it has been demonstrated that a ferroelectric phase (f-phase) appears for a larger sort of cation dopants (Zr<sup>4+</sup>, Y<sup>3+</sup>, Al<sup>3+</sup>, La<sup>3+</sup>, Gd<sup>3+</sup> or Sr<sup>2+</sup>) [2], with the Pca2<sub>1</sub> space group. Most of the articles use electrodes to stabilize the f-phase. In this context, the stack TiN/Hf<sub>0.5</sub>Zr<sub>0.5</sub>O<sub>2</sub>/TiN have been particularly studied. And in 2015 the first Negative Capacitance Field Effect Transistor (NC-FET) has been fabricated using this stack on the top of the NC-FET gate [3].

TiN is frequently fabricated by sputtering [4], whereas ferroelectric HfO<sub>2</sub> is made by Atomic Layer Deposition (ALD). It could be interesting to have only one optimized process for the entire fabrication. But few articles have been dedicated to doped (and undoped) ferroelectric HfO<sub>2</sub> by sputtering [5-7]. In this context, we compare different aspects of the two deposition technics for ferroelectric doped and undoped HfO<sub>2</sub>.

## References

- [1] T.S. Böske et al., "Ferroelectricity in Hafnium Oxide Thin Films Ferroelectricity in Hafnium Oxide Thin Films," Applied Physics Letters 102903, no. 2011 (2011): 0–3, doi:10.1063/1.3634052.
- [2] Min Hyuk Park et al., "Ferroelectricity and Antiferroelectricity of Doped Thin HfO<sub>2</sub> -Based Films," Advanced Materials, 2015, 1811–31, doi:10.1002/adma.201404531.
- [3] Kai-shin Li et al., "Sub-60mV-Swing Negative-Capacitance FinFET without Hysteresis," 2015, 620–23.
- [4] Patrick Polakowski and Johannes Müller, "Ferroelectricity in Undoped Hafnium Oxide Ferroelectricity in Undoped Hafnium Oxide" 232905, no. 2015 (2016), doi:10.1063/1.4922272.
- [5] Lun Xu et al., "Ferroelectric Phase Stabilization of HfO<sub>2</sub> by Nitrogen Doping," Applied Physics Express 9, no. 9 (September 1, 2016): 91501, doi:10.7567/APEX.9.091501.
- [6] T. Olsen et al., "Co-Sputtering Yttrium into Hafnium Oxide Thin Films to Produce Ferroelectric Properties," Applied Physics Letters 82905, no. 2012 (2016), doi:10.1063/1.4747209.
- [7] Tomonori Nishimura et al., "Ferroelectricity of Nondoped Thin HfO<sub>2</sub> Films in TiN/HfO<sub>2</sub>/TiN Stacks," Japanese Journal of Applied Physics, n.d.