Soutenance de thèse

Jeudi 5 Octobre

14 h, Amphithéâtre C2N

En visioconférence : https://cnrs.zoom.us/j/98025767821?pwd=V1ozUjRaQzBYOFUxbUdSWlBWS0EyZz09

Crystal Phases and Electro-Optic Properties of ZrO_2 and HfO_2 Ferroelectric Thin Films

Ali El Boutaybi

Directeur de thèse : Philippe Lecoeur (professeur, UPSaclay, C2N)

- Les membres du jury :
Mario Maglione (directeur de recherche CNRS, ICMCB, Bordeaux) - Rapporteur
Alfred Kersch (professeur, Université de Münich, Allemagne) - Rapporteur
Agnès Barthélémy (professeure, UPSaclay, UMPhy CNRS/Thales) - Examinatrice
Nathalie Viart (professeure, IPCMS, Strasbourg) - Examinatrice
Jean Fompeyrine (Lumiphase AG, Zürich, Suisse) - Examinateur

Abstract :

The ferroelectricity in ZrO_2 and HfO_2 oxides was discovered in 2011 in ultrathin layers and has garnered significant attention for its potential applications in microelectronics. These materials offer the advantage of maintaining ferroelectric properties even at thicknesses below 10 nm, which is considerably thinner than perovskite ferroelectrics. Additionally, they are compatible with silicon and can be readily integrated into silicon foundries. As non-centrosymmetric crystals, ZrO_2 and HfO_2 ferroelectrics are expected to exhibit an even nonlinear response, characterized by nonlinear susceptibility terms such as $\chi^{(2)}$. Based on this effect, these materials can also be explored for electro-optic applications in silicon photonics. However, the low thickness that is advantageous for microelectronic applications becomes a drawback for photonic ones. Therefore, the initial challenge is to increase the thickness of ZrO_2/HfO_2 ferroelectric thin films to approximately 50 nm to make them suitable for photonic devices. Our research demonstrates that pure ZrO_2 can maintain a ferroelectric state at a higher thickness compared to HfO_2, reaching approximately 40 nm (versus 10 nm in HfO_2). Moreover, through first-principle calculations, we demonstrate that ZrO_2 exhibits higher electro-optic (EO) coefficients compared to HfO_2, making ZrO_2-based ferroelectrics an attractive candidate for further research to optimize them for electro-optic applications.