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# Ferroelectric memory device can be improved with a better understanding of ferroelectric behavior

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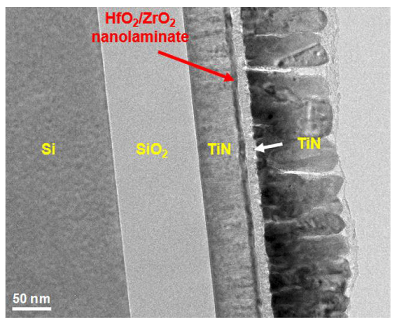
**Researchers investigated the origins of unusual ferroelectric behavior of newly found thin-film ferroelectric materials for semiconductor memory applications.**




Though modern electronic devices predominantly use solid-state drives (SSDs) for memory storage, these come with drawbacks. For one, SSDs are high in power consumption, which limit their portability. Ferroelectric materials are a promising alternative but have shortcomings of their own. Park et al. studied the origin of unexpected ferroelectric behavior in stacked thin films with fluorite structure to address these limitations and determined the ideal layer configuration for improved ferroelectric performance.

One of the challenges in developing thin-film ferroelectric materials with the fluorite structure is the formation of noncentrosymmetric orthorhombic phase structures, which are crystal lattices necessary for the onset of ferroelectricity. These structures are typically unstable and are formed in extremely high-pressure conditions, about 100 times the pressure used for normal thin-film processing.

“The most critical concern about the conventional ferroelectric material for memory applications was the so-called complementary-metal-oxide-semiconductor (CMOS) incompatibility,” said author Cheol Seong Hwang. In studying the ferroelectric orthorhombic structures of hafnium oxide ($HfO_2$) and zirconium oxide ($ZrO_2$), the researchers found both to be CMOS-compatible.

To unveil the possible origin for the formation of the ferroelectric orthorhombic phase under normal processing conditions, the authors compared the ferroelectric performances of different configurations of stacked $HfO_2$ and $ZrO_2$ samples deposited on a silicon substrate and determined trilayer compositions of $ZrO_2$ sandwiched between $HfO_2$ to be optimal. This $HfO_2$-$ZrO_2$-$HfO_2$ configuration showed the strongest ferroelectric performance with long endurance and high orthorhombic phase formation.

Following additional work, these ferroelectric stacks have the potential to perform similarly to the best SSDs. “The full functionality of the material is yet to be demonstrated,” Hwang said. “This is the most urgent area that needs further research.”

**Source:** “A comprehensive study on the mechanism of ferroelectric phase formation in hafnia-zirconia nanolaminates and superlattices,” by Min Hyuk Park, Han Joon Kim, Gwangyeop Lee, Jaehong Park, Young Hwan Lee, Yu Jin Kim, Taehwan Moon, Keum Do Kim, Seung Dam Hyun, Hyun Woo Park, Hye Jung Chang, Jung-Hae Choi, and Cheol Seong Hwang, *Applied Physics Reviews* (2019). The article can be accessed at https://doi.org/10.1063/1.5118737.