Material discovery may help realize low-cost and long-life memory chips

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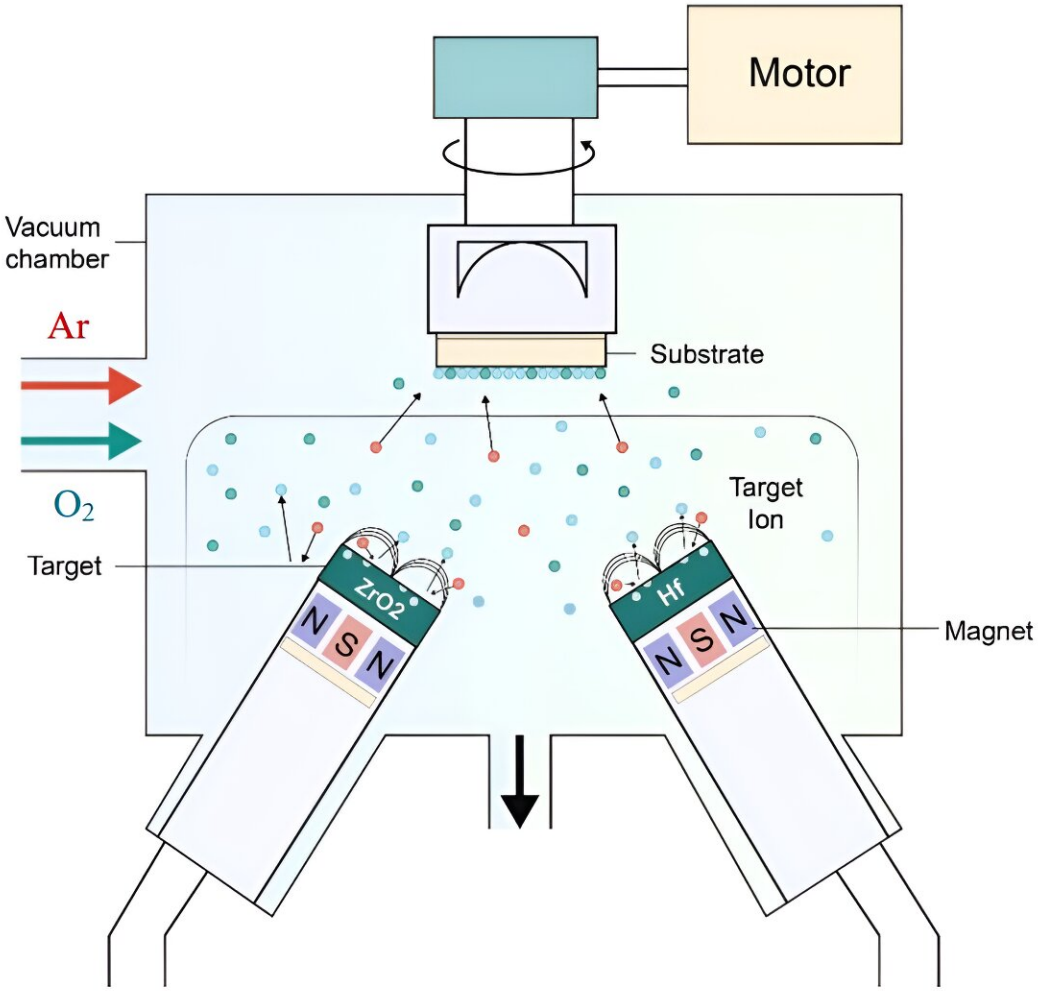

Deposition method of HZO layer. HZO layers of the TiN/HZO/TiN capacitor

were deposited by magnetron Co-sputtering of Hf and ZrO_2 targets, and oxygen (0.6 sccm) and argon (40 sccm) are forced into the chamber. To vary the Hf/Zr content between samples, the ZrO_2 source power was kept constant (at 110 W) while the Hf source power was varied from 20 W to 28 W. Credit: *Science* (2023). DOI: 10.1126/science.adf6137

Hafnium oxide-based ferroelectric materials are promising candidates for next-generation nanoscale devices due to their integration into silicon electronics.

In a study published in *Science*, researchers from the Institute of Microelectronics of the Chinese Academy of Sciences (IMECAS) and the Institute of Physics of CAS made the discovery of a stable rhombohedral ferroelectric $Hf(Zr)_{+x}O_2$ which exhibits an ultra-low coercive field.

The intrinsic high coercive field of the fluorite ferroelectric $Hf(Zr)O_2$ devices leads to the incompatible operating voltage with advanced technology nodes and limited endurance. In this work, a stable ferroelectric r-phase $Hf(Zr)_{1+x}O_2$ material which effectively reduces the switching barrier of ferroelectric dipoles in HfO_2-based materials was discovered.

Scanning transmission electron microscopy (STEM) verified the intercalation of excess Hf(Zr) atoms within the hollow sites, forming an ordered array. Density functional theory calculations (DFT) provided insights into the underlying mechanism that the intercalated atoms stabilize the ferroelectric phase and reduce its switching barrier.

The ferroelectric devices based on the r-phase $Hf(Zr)_{1+x}O_2$ exhibit an ultra-low coercive field (~0.65 MV/cm), a high remnant polarization (Pr)

value of 22 μC/cm^2, a small saturation polarization field (1.25 MV/cm) and high endurance (10^{12} cycles).

The work has applications in low-cost and long-life memory chips.

More information: Yuan Wang et al, A stable rhombohedral phase in ferroelectric Hf(Zr) 1+ x O 2 capacitor with ultralow coercive field, *Science* (2023). DOI: 10.1126/science.adf6137

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