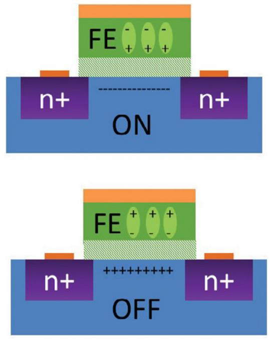
INTERMOLECULAR®

EMD Electronics

Accelerate Ferroelectric Materials Innovation with Intermolecular's High-Throughput Experimentation

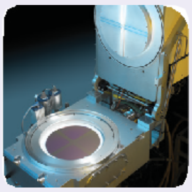
A ferroelectric (FE) material can change its polarization state when a voltage is applied across it, leaving an apparent stored charge after the field is removed. New ferroelectric classes of logic devices and memory overcome some of the integration, scaling, and power consumption challenges facing traditional semiconductor devices. For example, inserting a ferroelectric into the gate oxide of a transistor can yield a larger subthreshold slope and built-in data retention.



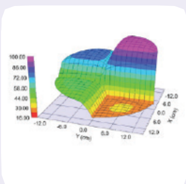
HfO_2 is a well-established material in the semiconductor industry and can be deposited in thin, conformal layers by Atomic Layer Deposition (ALD). However, in order to enable and maximize ferroelectricity in this material, the structure must be tuned by selecting processing conditions very carefully. Intermolecular's platform for high-throughput experimentation is ideally suited to explore this wide processing parameter space.

P30 PVD SYSTEM

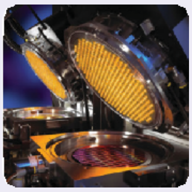
SITE-ISOLATED SPOT DEPOSITION



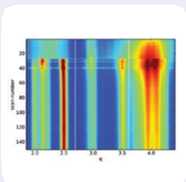
A30 ALD SYSTEM



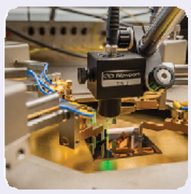
THICKENSS SKEW VIA COMBINATORIAL ALD



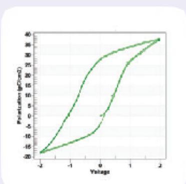
RTP



CRYSTAL STRUCTURE EVOLUTION DURING ANNEALING



ELECTRICAL TEST PROBING STATION



P-V LOOP

ELECTRODES

Intermolecular's P30 PVD systems can apply up to 30 different electrodes and interface layers on one wafer to tune the work function alignment, vacancy distribution, diffusion of dopants, strain and crystalline texture.

FERROELECTRIC LAYERS

Intermolecular's A30 ALD systems with up to five bubblers can vary the precursor, oxidant, film thickness, and deposition temperature, as well as introducing dopants and laminates to vary the structure of the material.

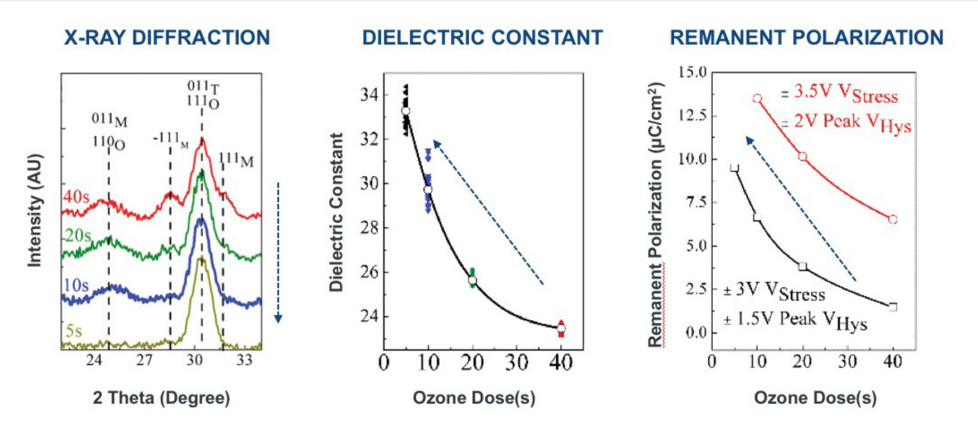
ANNEALING

Intermolecular's single-wafer heaters and rapid thermal processing systems tune the crystalline structure and electrical properties by varying the thermal profile.

ELECTRICAL TESTING

Intermolecular's semi-automated electrical testing platform and Radiant Ferroelectric tester explore the effects of electrical field cycling, including wake-up, ultimate remanent polarization, and endurance.

Using our high-throughput experimentation platform, Intermolecular has already made several substantial contributions to the understanding of HfO2-based ferroelectric materials.

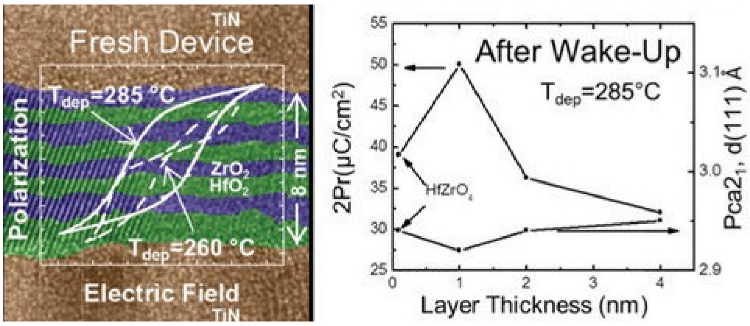


Reducing the ozone dose during deposition of pure HfO2 results in a greatly increased dielectric constant and remanent polarization owing to an increase in the ferroelectric fraction of the film.

Pal, Narasimhan, et al., APL, 2017 (DOI: 10.1063/1.4973928)

Laminated ferroelectric films of HfO2 and ZrO2 can outperform fully blended films of the same thickness and composition by tuning deposition conditions.

Weeks et al., ACS AMI, 2017 (DOI: 10.1021/acsami.7b00776)



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