

THIN HIGH-k DIELECTRIC FILMS

Research and development of thin films of high-k dielectric materials for micro and nanoelectronic devices and microsystems

ALD System at IMB-CNM

Atomic Layer Deposition: technique based on the sequential production of self-limiting gas-solid reactions, achieved by the alternating exposition of the substrate to the chemically tailored gas phase precursors.

ALD system at CNM: Thermal ALD Savannah 200, Cambridge Nanotech.



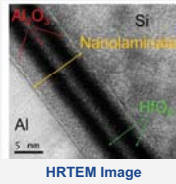
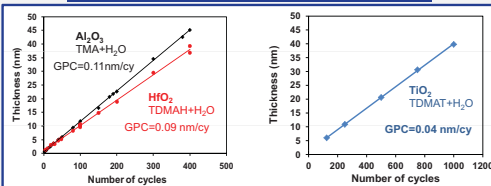
Al_2O_3 : TMA + H_2O or O_3

HfO_2 : TDMAH + H_2O or O_3

TiO_2 : TDMAT + H_2O or O_3

Nanolaminates

Growth Kinetics at T = 200°C on Silicon



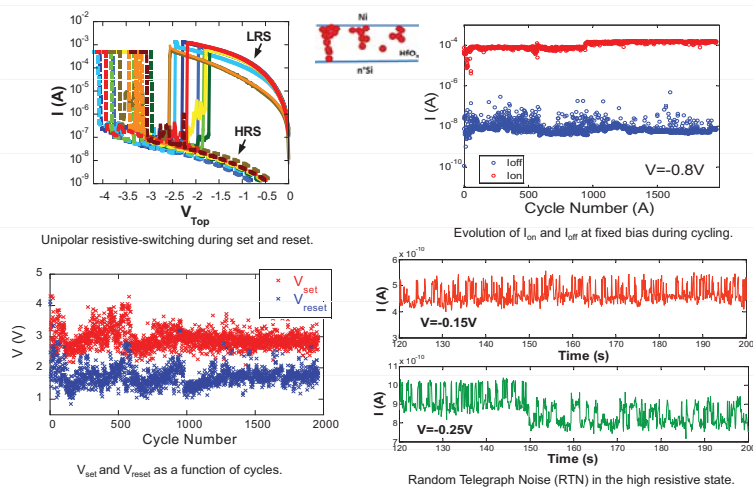
HRTEM Image

Resistive Switching for RRAM applications

Electrically programmable Resistive Random Access Memories (RRAM) based on metal-insulator-metal (MIM) configurations are considered a promising candidate for next generation non-volatile memory devices, because of their fast operation speed, low power consumption, high scalability and high density 3-D integration.

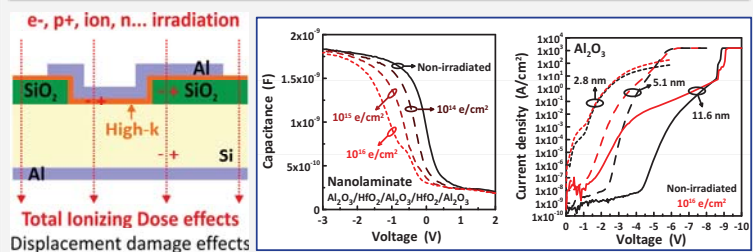
At IMB-CNM, MIS and MIM capacitors based on ALD dielectrics are fabricated, and the statistical physics, the impact of the processing conditions and electrode/dielectric material combinations on the switching properties are investigated.

Al/HfO₂-based Resistive Switching Structures



Radiation-Induced Degradation

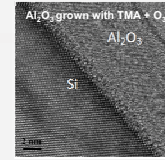
The radiation-hardness of the ALD high-k dielectric layers is assessed by means of electrical characterization of irradiated MIS structures. The capacitance-voltage and current-voltage characteristics of the different structures are analyzed as a function of irradiation dose paying special attention to the study of the effective trapped charges, generation of interface states, presence of hysteresis and electrical conduction through the layers. The interaction between radiation-induced and electrically-induced damages, as well as potential recovery processes are also of interest.



Film Characterization

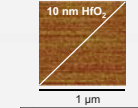
Physical Characterization

High-k / Silicon Interface



UHR-TEM Image

Surface Roughness

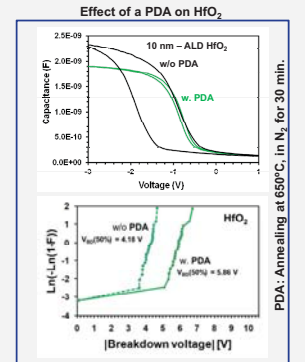
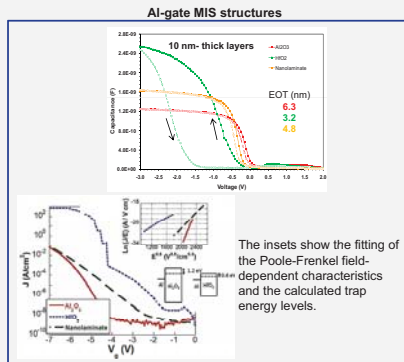


AFM results

Layer Thickness is measured by ellipsometry and/or interferometry.

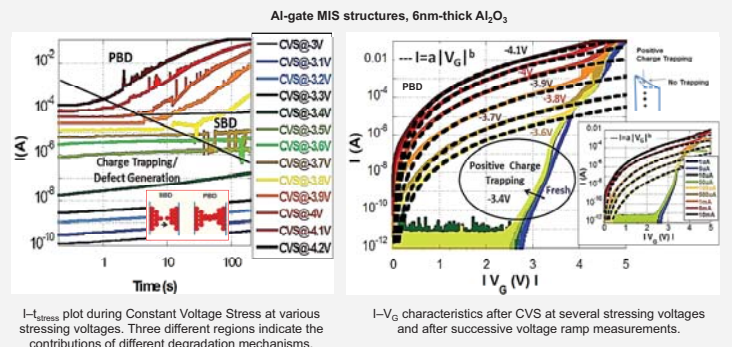
Electrical Characterization

The effect of ALD conditions, silicon substrate and post-deposition processing on the electrical properties of high-k layers is evaluated by means of measurement and analysis of Capacitance-Voltage and Current-Voltage characteristics of metal gate MIS structures.



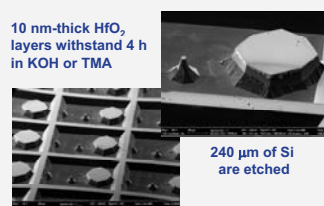
Stress Induced Degradation

The analysis of the electrical degradation of the layers is performed by measuring MIS structures after applying electrical stress. Pre-existing electrically active defects, stress induced degradation and dielectric breakdown phenomena are analyzed.



High-k films for MEMS Applications

HfO₂ for silicon micromachining



240 μm of Si are etched

Conformal coverage of 3D Structures

