Ferroelectric HfO₂ Thin Films
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Project Objectives
Goal: To enable ferroelectric device research at RIT and to that end:
1. Developing an RIT process for fabrication of ferroelectric HfO₂ devices
2. Enabling characterization of said films through set-up of a new ferroelectric test system

Background
Ferroelectricity - electrically induced polarization in the crystal lattice - is a promising candidate for non-charge based memory.
• Ferroelectricity in HfO₂ is stronger than ceramic films (1MV/cm vs 50 kV/cm), enabling reduction in gate height. [1]
• Doping of HfO₂ makes the ferroelectric phase more favourable. Ferroelectricity reported in ALD HfO₂ with Al, Y, or Si dopants. Results also seen with Y and HF reactive co-sputtering. [3, 4]
• TiN or SiOₓNx used as an interfacial layer between ferroelectric capacitor and substrate [1]
• TiN layer used above ferroelectric gate to help coerce the HfO₂ layer into a ferroelectric (FE) phase [2]

Previous RIT Work
RIT fabricated samples yielded what was potentially a ferroelectric film
• Further testing showed that memory window was dependent on CV sweep speed, ruling out ferroelectricity as the cause

Process Development
Experimental Setup and Results
The effects of top TiN, bottom TiN, anneal method (rapid thermal vs. furnace), and Al deposition method (sputtered vs evaporated) were investigated
• Thin Al deposited via sputtering dissolved during 2nd level lithography development
• Samples with top TiN layer show potential ferroelectricity
• Sample with bottom TiN shows larger memory window than the sample without a diffusion barrier
• Samples have 3 < k < 5, similar to the NaMLab sample (4.2)

CV Results – Furnace Anneal (1hr 600°C)

CV Results – Rapid Thermal Anneal

References

Conclusions
• Sputtered Al thin films may be less dense than evaporated films given their differences in dissolution rate when exposed to a base
• A TiN cap is seen to have a large contributing effect to inducing a ferroelectric phase in Al doped HfO₂
• Doped HfO₂ samples show a comparable memory window to PZT with a film that is a tenth of the thickness

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aixACCT TF1000 Ferroelectric Tester

• Discrete ferroelectric (PZT) capacitors measured and compared to company-reported “typical” performance data (above). Small differences likely caused by process variation [5]
• NaMLab fabricated anti-ferroelectric and ferroelectric HfO₂ samples measured by RIT (below).