Atomic layer deposition of HfO2 thin film using a novel Pyrrole based Hf precursor

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Group 4 metal oxide materials such as ZrO_2, TiO_2, and HfO_2 have attracted considerable attention for dielectric materials for microelectronic devices. HfO_2 films has an outstanding high-dielectric constant (κ ~ 20-25, t-HfO_2), large band gap Energy (Eg ~ 6.0 eV) and good thermal stability. For these reason, the HfO_2 thin film applicate microelectronic devices such as the dynamic random access memory (DRAM) capacitors and central processing memory (CPU) gate dielectric application.

The most representative Hf precursor, CpTDMAHf (HAC), is known to exhibit excellent film properties when reacted with O_3 at 320°C. Recently, research is being conducted to develop precursors that can replace HAC under various conditions (temperature, reactant gas). We have developed precursors that can be used in either high or low temperature deposition and recently, we have designed new precursors for the application of various reaction gases.

In this study, we propose a novel pyrrole based Hf precursor namely HEP. The physical characteristic of HEP was investigated by NMR Spectroscopy. Also, we measure the properties of the HfO2 thin film of HEP against usually used HAC by thermal atomic layer deposition (TALD). For both precursors HEP and HAC, the characteristic self-limiting ALD growth mode was confirmed. HAC reacts with O_3 at 320°C to form HfO_2 films, while HEP reacts with H_2O to form HfO_2 films.

Composition ratio of HfO_2 films were investigated by XPS. HfO_2 films deposited with HEP showed a comparable composition ratio to HAC at a lower temperature of 280°C. Also, C impurities in deposited film of HEP were 0.34, which is lower than that of HAC (0.59%). Surface roughness of HfO_2 films were investigated by AFM. The deposited film of HEP represented comparable roughness compared to that of HAC.

From this study, The HEP is expected to be advantageous precursor for low temperature thin film deposition technique.

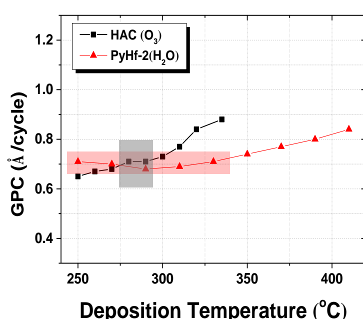

Fig 1. CPC data

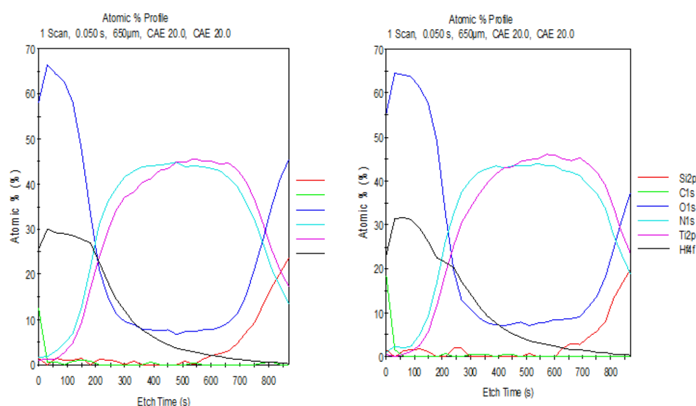

Fig 2. XPS data (left : HAC, right : HEP)