# Study on The Crystallinity and The Dielectric Constant of $Zr_xGe_{1-x}O_2$ Films Using Mixed Zr - Ge Precursor by Atomic Layer Deposition.

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Scaling of Dynamic Random Access Memory(DRAM) requires high k dielectric materials for data storage capacitor. $ZrO_2$ is favorite material for storage capacitors becasue of large band gap, low leakage current, good thermal stability. Dielectric constant of ZrO2 depends on the crystal structure (monoclinic =19.7, cubic = 36.8, tetragonal=46.6). It was reported that doping of ZrO2 with elements such as Mg, Ca, Y, La, and Ge enhances tetragonal phase of $ZrO_2$. In general, such elements are incorporated in ZrO2 using laminated growth structure.

In this study, Ge-doped $ZrO_2$ films were fabricated using mixed Zr-Ge precursor ( $CpZr[N(CH_3)_2\}_3]$ and $C_{13}H_{26}GeN_4$ = 10 : 1) in the form of $Zr_xGe_{1-x}O_2$. The $Zr_xGe_{1-x}O_2$ films are grown by atomic later deposition with ozone as the oxidant at 300 ℃ and annealed in $N_2$ atmosphere at 500 ℃, 30s using rapid thermal annealing(RTA). The chemical bonding and structural properties of $Zr_xGe_{1-x}O_2$ films are investigated by X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD). XPS shows that as-grown $Zr_xGe_{1-x}O_2$ films contains about 0.8% Ge and XRD shows peaks of tetragonal phase in $Zr_xGe_{1-x}O_2$ films. The MOS structure of $Zr_xGe_{1-x}O_2$ films are analyzed dielectric constant and micro-structure. The leakage current of $Zr_xGe_{1-x}O_2$ films are measurened about 6 voltage using MIM strucuture. Also, the crystallinity and dielectric constant of $Zr_xGe_{1-x}O_2$ are compared with those of the laminated structure of $(ZrO_2)_x(GeO_2)_{1-x}$ films that are fabricated using Ge-$C_{13}H_{26}GeN_4$ and Zr - $CpZr[N(CH_3)_2\}_3]$ precursors.

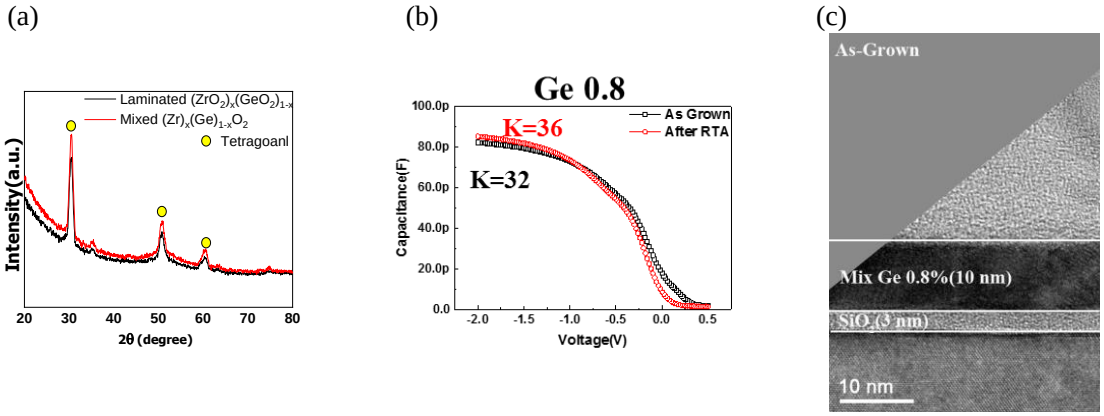


Fig 1. (a) XRD of $Zr_xGe_{1-x}O_2$ films and $(ZrO_2)_x(GeO_2)_{1-x}$ films.

(b) Capacitance of $Zr_xGe_{1-x}O_2$ film

(c) TEM image of $Zr_xGe_{1-x}O_2$ film

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**References**

[1] Bo-Eun Park, Yujin Lee1, I-Kwon Oh, Wontae Noh, Satoko Gatineau, and Hyungjun Kim, J mater Sci (2018) 53 : 15237-15245
[2] Jong-Ki An, Nak-Kwan Chung, Jin-Tae Kim, Sung-Ho Hahm, Geunsu Lee, Sung Bo Lee, Taehoon Lee, In-Sung Park, and Ju-Young Yun, MDPI(2018),11,386