Surface Dependence and Selectivity during Atomic Layer Deposition of $Ge_2Sb_2Te_5$

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The complex device architecture for Phase change Random Access Memory (PCRAM) has garnered attention towards Atomic Layer Deposition (ALD) for conformal or selective deposition. $Ge_2Sb_2Te_5$ is one of the promising phase change materials which has been used in PCRAM devices. $Ge_2Sb_2Te_5$ devices use either W or TiN as bottom electrode and SiO_2 or SiN as isolating material for confining heat within the cell [1]. The development of selective deposition processes for such device structures benefits from insight in the growth behaviour of $Ge_2Sb_2Te_5$ ALD. In this work, we therefore investigate the substrate dependence and selectivity of $Ge_2Sb_2Te_5$ ALD where TiN and SiO_2 were selected as substrates. $GeCl_2$. $C_4H_8O_2$, $SbCl_3$ and $((CH_3)_3Si)_2Te$ have been used as precursors to deposit $Ge_2Sb_2Te_5$ by alternating GeTe and Sb_2Te_3 subcycles. The growth-per-cycle of $Ge_2Sb_2Te_5$ ALD is 0.36 nm/cycle. Rutherford Backscattering Spectrometry (RBS) confirmed that $Ge_2Sb_2Te_5$ layers of ~20 nm has the 2-2-5 composition. We observe linear ALD growth behaviour on both TiN and SiO_2 substrates, indicative of fast film formation. Further, both substrates were treated with dimethylamino-trimethylsilane (DMA-TMS) to alter the surface properties for evaluating the selectivity of $Ge_2Sb_2Te_5$ [2]. The DMA-TMS treatment on TiN shows minor effect on the surface composition and $Ge_2Sb_2Te_5$ ALD growth behaviour. In contrast, the DMA-TMS treatment on SiO_2 substantially inhibits the growth of $Ge_2Sb_2Te_5$ (figure 1) and no nanoparticles are observed using scanning electron microscopy (SEM) till 64 cycles, while a $Ge_2Sb_2Te_5$ layer of ~20 nm is obtained on DMA-TMS treated TiN. For higher number of cycles, nanoparticle analysis on DMA-TMS treated SiO_2 indicates that growth of $Ge_2Sb_2Te_5$ follows particle migration and coalescence (figure 2). Thus, the modified surface properties due to chemical treatment provides the selectivity of $Ge_2Sb_2Te_5$ towards SiO_2. This is confirmed by a demonstration of 20 nm of $Ge_2Sb_2Te_5$ ASD in nanoscale SiO_2/TiN line-space patterns.

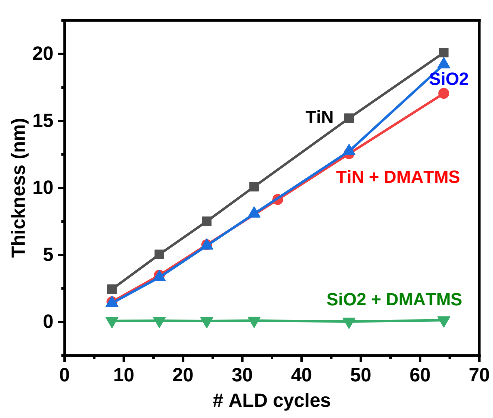

Figure 1 Thickness of $Ge_2Sb_2Te_5$ during ALD cycle

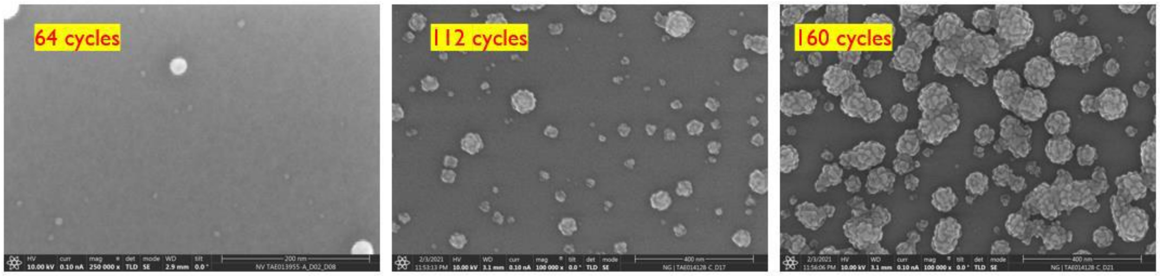

Figure 2 SEM images of $Ge_2Sb_2Te_5$ deposited on DMATMS treated SiO_2

References:

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[2] J. Soethoudt, S. Crahaij, T. Conard, and A. Delabie, "Impact of SiO2 surface composition on trimethylsilane passivation for area-selective deposition," *Journal of Materials Chemistry C*, vol. 7, no. 38, pp. 11911–11918, 2019, doi: 10.1039/c9tc04091a.