Characteristics of high order silane-based Si and SiGe epitaxial growth under 600℃

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As conventional scaling reached the limit of Moore's law due to the short channel effects, MOSFET devices have been developed through strain-engineering, high-k/metal gate processing, and structural engineering such as FinFET or GAA-FET. However, these progress beyond 5nm node has been gradually slowed down which gave more attention to the 3D integration having advantages of low power consumption and reduced RC delay.

Since the 3D integration requires low temperature (<550℃) process to protect bottom layer from thermal damage, epitaxial growth of Si and SiGe under 550℃ should be performed. At low temperature, conventional Si precursors such as SiH_4 and SiH_2Cl_2 have very low growth rate under 1nm/min for Si epitaxy [1,2], due to its strong Si-Cl (90kcal/mol) or Si-H (47kcal/mol) bond strength [1]. For higher throughput, high order silanes (Si_nH_{2n+2}, $n \geq 2$) have been considered as alternatives because of its relatively weak Si-Si bond strength (33kcal/mol) [1-4].

In this study, epitaxial growth of Si and SiGe were performed using various high order silanes, such as Si_2H_6, Si_3H_8 and Si_4H_{10}, and germane (GeH_4), in temperature range from 500℃ to 600℃ with different flow rates. The obtained activation energies for epitaxial growth were analyzed to compare the growth characteristics of films depending on Si precursor. For SiGe epitaxy, the Ge concentration was observed additionally by ω-2theta scan of High Resolution X-ray Diffractometer (HR-XRD) to analyze the effects of Si precursor types and growth temperatures on the films.

References

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