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Influence of Annealing Temperature on the Structural, Interfacial, and Dielectric Properties of ZrO_2 Thin Films

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Abstract: Zirconium dioxide (ZrO_2) thin films were deposited on silicon substrates using a sol–gel spin coating technique with a precursor concentration of 0.5 M. The deposited films were annealed at different temperatures (350 °C, 550 °C, and 750 °C) to investigate the influence of thermal treatment on their structural and surface morphological properties. X-ray diffraction studies reveal that the unannealed film is largely amorphous, while annealed films exhibit enhanced crystallinity with the coexistence of monoclinic and tetragonal ZrO_2 phases. An increase in annealing temperature leads to improved phase formation and grain growth. Field emission scanning electron microscopy images show uniform, crack-free surfaces with gradual densification and grain evolution upon annealing. The results indicate that annealing temperature plays a crucial role in tailoring the microstructural properties of ZrO_2 thin films, making them suitable for silicon-based microelectronic and sensor applications.