Transmission Electron Gain of Si_3N_4 Thin Films

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Silicon nitride (Si_3N_4) thin films possess core properties such as high temperature resistance, structural stability, and excellent insulation[1], making them high-performance functional thin film materials for regulating electron transport and enhancing device stability.[2]

This study focuses on the transmission electron gain of Si_3N_4 thin films. A 50 nm-thick Si_3N_4 thin film, with a 2 nm Pt film deposited on its upper surface, was selected as the research object. Systematic analysis of the transmission electron gain under normal incidence of electrons with different initial energies was conducted via a combination of Monte Carlo simulation and experimental testing. Simulation results indicate that the transmission electron gain of the Si_3N_4 thin film generally shows a decreasing trend with the increase of incident electron energy. In contrast, experimental results reveal that the transmission gain first increases rapidly with incident electron energy, then tends to stabilize and slightly decreases. The simulation and experimental data agree well in the high-energy region (>7KeV), but exhibit significant discrepancy in the low-energy region (<7KeV), where the experimental values are notably lower than the simulation results. This discrepancy is attributed to the generally low energy of transmitted electrons under low incident energy, which are difficult to be effectively captured. To verify this theory, a 20 V bias voltage was applied at the film to improve electron collection efficiency. Comparative analysis of the two sets of experimental results shows that the transmission gain in the low-energy region is significantly improved for the group with bias voltage, while the high-energy region (>7KeV) data remains nearly unchanged. The optimized experimental data agrees better with the Monte Carlo simulation results. This study provides reliable experimental basis and clear parameter optimization directions for the application of Si_3N_4 thin films in electron transport-related devices, and also offers valuable references for the design and calibration of low-energy electron detection systems.

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[1] Alain E. Kaloyeros *et al* 2020 *ECS J. Solid State Sci. Technol.* **9** 063006.

[2] Konyuba Y *et al* 2018 *Microscopy (Oxf).* 1;67(6):367-370.

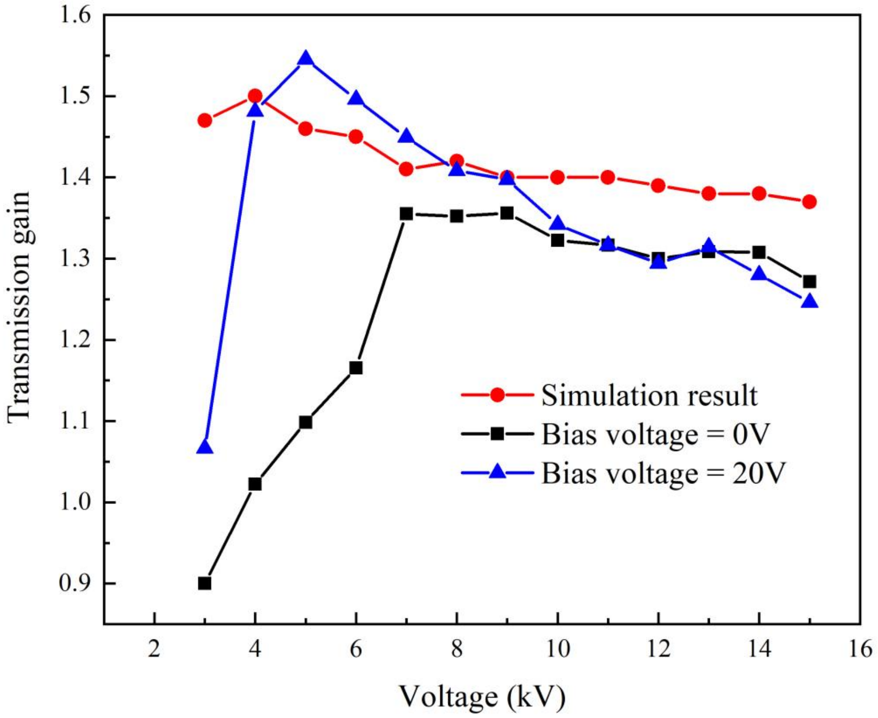

Figure. 1 Simulation and experimental results of the transmission electron gain of 50 nm-thick silicon nitride (Si_3N_4) thin films under different voltage from 3 to 15 kV.