COMPARISON OF THE EXPERIMENTAL CARRIER TRANSPORT IN MIS DEVICES FABRICATED WITH ULTRA-THIN Al₂O₃ WITH STANDARD CONDUCTION MODELS AND SIMULATIONS

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Understanding conduction mechanisms (CMs) through a thin dielectric oxide is important in state-of-the-art Complementary Metal-Oxide-Semiconductor (CMOS) technology. This is because when an Electric field (E) is applied across the dielectric film; an undesired current appears which degrades the behavior of the device, thus shortening its life-span. One of the most widely used dielectric in microelectronics is Aluminum Oxide (Al₂O₃) because it presents a large bandgap (~8.8 eV) and relatively high-dielectric constant (k~9); it also presents great thermal stability and can passivate important interfaces with other electronic materials thus enhancing the performance of electron devices.

This work reviews the conduction mechanisms in Metal-Insulator-Semiconductor (MIS) devices fabricated using ultra-thin Al₂O₃ (5nm and 10 nm) deposited by Atomic Layer Deposition (ALD) at relatively low processing temperatures. After gate patterning, thermal treatment was performed using Forming Gas (H₂/N₂) at 450° C for 30 minutes. MIS devices were then electrically characterized using standard I-V and C-V measurements, taking the devices to dielectric breakdown; afterwards, experimental measurements were compared with semi-empirical tunneling models like Direct tunneling (DT), Ohmic Conduction (OC), Poole-Frenkel emission (PF) and Fowler-Nordheim tunneling (FN) in order to determine the precise conduction mechanisms and their corresponding physical parameters. After dielectric breakdown, Schottky diode conduction is obtained, thus demonstrating the nature of the post-breakdown event. Once these well known semi empirical models were validated through standard equations, SILVACO simulations were made in order to further validate the proposed models. Afterwards, physical parameters before and after thermal annealing such as effective mass (m), barrier height (φ) (before and after breakdown), and trap energy level ( were extracted. Finally, only one self-consistent equation containing all physical parameters and conduction models is obtained.

Keywords: Al2O3, conduction mechanisms, modeling and simulation

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