CHEMICALLY MODIFIED Ta_2O_5 DIELECTRICS FOR HIGH DENSITY DYNAMIC RANDOM ACCESS MEMORY (DRAM) APPLICATIONS

by

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(ABSTRACT)

Increasing demand for high-density memories has necessitated the search for new materials with higher dielectric constants to satisfy the minimum charge storage density requirements. Several materials such as Ta_2O_5, BST[1], BBT[2] are being investigated to replace the currently used Si based oxide/nitride dielectrics. Among the materials under investigation, Ta_2O_5 is one of the most promising, especially from the fab compatibility point of view. Ta_2O_5 thin films offer a six-fold increase in dielectric constant compared to conventional dielectrics. However, the significant improvement in dielectric constant is offset by higher leakage currents compared to conventional dielectrics. Improvement in both, dielectric and insulating properties is required for the successful integration of Ta_2O_5 thin films into devices. In the current research work, it was demonstrated that by chemically modifying the tantalum pentoxide matrix, significant improvements in its electrical properties can be achieved which would enable the fabrication of a reliable high-density memory device.

In the present work, the effects of Al addition on Ta_2O_5 thin films were systematically studied. The structural and electrical properties of these chemically modified thin films were investigated in detail to establish their potential for device applications. The effects on dielectric and insulating characteristics due to incorporation of Al in Ta_2O_5 matrix were studied in capacitor configuration. A metallorganic solution decomposition (MOSD) technique was used to deposit thin films onto Pt coated Si(100) substrates. The capacitors were fabricated by sputter depositing Pt electrodes on the top surface of the films. The dielectric and insulating properties of pure and modified Ta_2O_5 thin films and their dependence on film composition, processing temperature, and the

[1] Barium strontium titanate, [2] Barium bismuth tantalate

thickness were discussed and an attempt was made to provide theoretical understanding for the experimental observations.

The dielectric and insulating properties of Ta_2O_5 were found to be significantly modified by addition of Al. It was observed that Al addition has decreased the leakage currents approximately by an order of magnitude and improved thermal and bias stability characteristics of Ta_2O_5 capacitors. For example, the leakage currents in crystalline pure Ta_2O_5 thin films were found to be 4.5×10^{-7} A/cm^2 in a 1MV/cm *dc* field which decreased to 3.4×10^{-8} A/cm^2 for 10% Al modified Ta_2O_5 thin films. A typical dielectric constant of 42.5 was obtained for 10% Al modified Ta_2O_5 thin films. This is significantly higher compared to the commonly reported dielectric constant of 25 to 35 for Ta_2O_5 thin films. This enhancement was attributed to strong (100) orientation exhibited by both pure and modified Ta_2O_5 thin films. The high dielectric constant, low dielectric loss, low leakage currents and low temperature coefficient of capacitance suggest the suitability of Al modified Ta_2O_5 as a capacitor dielectric for future generation DRAM applications.

DEDICATION

To my parents

Kameswara Rao and. Lakshmi Suseela

And to my uncle and aunt

Dr. Seshu B. Desu and Mallika Desu

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