Toetab TÜ ja TTÜ doktorikool
"Funktsionaalsed materjalid ja tehnoloogiad" (FMTDK)

ESF projekt 1.2.0401.09-0079

ATOMIC LAYER DEPOSITION AND CHARACTERIZATION OF ZrO_2-Er_2O_3 AND ZrO_2-Gd_2O_3 NANOLAMINATES

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Atomic layer deposition (ALD) is a deposition technique appropriate for the creation of metal oxide layers the nanolaminates for a variety of applications. During the recent years, novel metal precursors, in particular cyclopentadienyls of hafnium and zirconium, have been investigated and adapted [1,2]. ZrO_2 as a high-permittivity (high-k) dielectric gate and memory oxide is studied in this work. In addition, mixing with rare earth oxides, such as Gd_2O_3 and Er_2O_3, is investigated. ZrO_2:Gd_2O_3 and ZrO_2:Er_2O_3 thin films and nanolaminates were grown by atomic layer deposition from tris(2,2,6,6-tetramethyl-3,5-heptanedionato) erbium, ($Er(thd)_3$), tris(2,2,6,6-tetramethyl-3,5-heptanedione) gadolinium, $Gd(thd)_3$, bis(methylcyclopenta-dienyl)methoxymethyl-zirconium and ozone as precursors at 300 or 350 ºC. In the films with nanometric thickness, metastable higher-permittivity cubic or tetragonal phases can easily be formed and their resistance against transformation upon annealing significantly increased by adding rare earth oxides. The structure of nanolaminates was rather stable against long-term and rather aggressive heat-treatment up to 900-1100 ˚C. (Fig.1.). The combinations of Gd_2O_3 or Er_2O_3 with ZrO_2 have allowed increment in capacitance and acceptable leakage current densities. Capacitors based on nanolaminate dielectrics demonstrated high capacitance and good insulating properties with low leakage current density at approximately 10^{-7}A/cm^2.

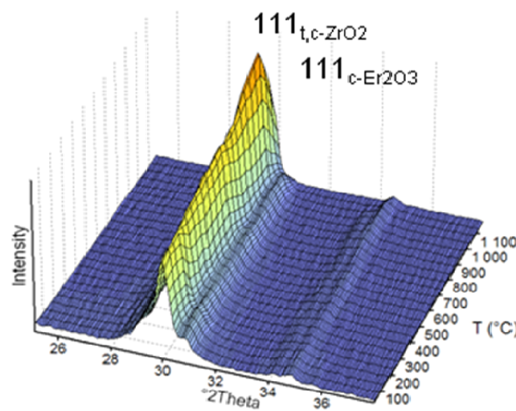

Fig.1. High-temperature three-dimensional XRD patterns of a nanolaminate grown using cycle sequence 2 × [95 × ZrO_2 + 280 × Er_2O_3] + 95 × ZrO_2 (12 at.% Er).

References

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