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Annealing temperature effect on microstructure, optical and electrical properties of nanometer $GdYO_x$ high k films

Abstract

In this work, Metal-oxide-semiconductor (MOS) capacitors with sputtering-deposited ternary $GdYO_x$ high k gate dielectric thin films were fabricated by magnetron co-sputtering method on p-type Si substrates. Annealing temperature dependent microstructure, morphology, chemical bonding states, optical and electrical properties of nanometer $GdYO_x$ gate dielectric thin films were systemically investigated by x-ray diffraction, atomic force microscopy, x-ray photoelectron spectroscopy, optical spectroscopy and electrical measurements. Results have shown that the 500°C-annealed $GdYO_x$ composite films as well as those samples annealed at lower temperatures keep amorphous state. With the sample annealed at 600 °C, however, the amorphous phase disappears and the nanometer particles films were formed. The increase in band gap energy has been found with increasing the annealing temperature and maximum band gap is reached to 5.55 eV. Electrical properties of all samples based on Pt/Si/$GdYO_x$/Pt MOS capacitor have been investigated by means of the high frequency capacitance-voltage (C-V) and the leakage current density-voltage (I-V) characteristics. It shows improved performances at the annealing temperature of 500 °C, such as high dielectric constant (k) of 20.2, lowest current density of 1.44×10^{-2}A/cm^2(at V_{fb}-1V). In addition, the leakage current mechanism for 500 °C-annealed sample has been discussed in detail. 500°C-annealed $GdYO_x$ thin films can be acted as potential high-k gate dielectrics in future CMOS devices.

References

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Figuresa

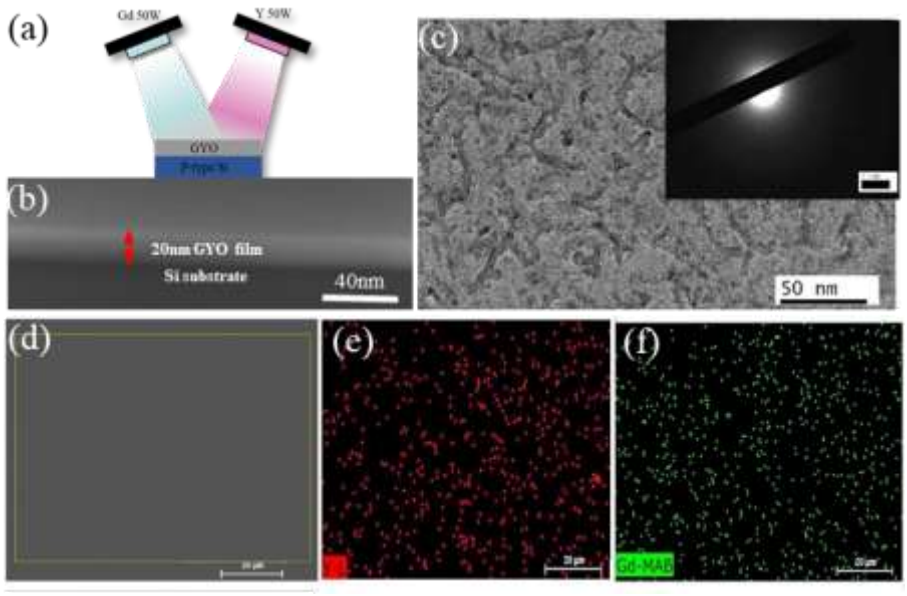

Figure 1:(a) Schematic diagram of $GdYO_x$ film prepared by magnetron sputtering. (b) Cross-sectional SEM image of a $GdYO_x$ film deposited on a silicon substrate. (c) TEM image, (d-f) EDS mapping of original sputtering $GdYO_x$ thin films

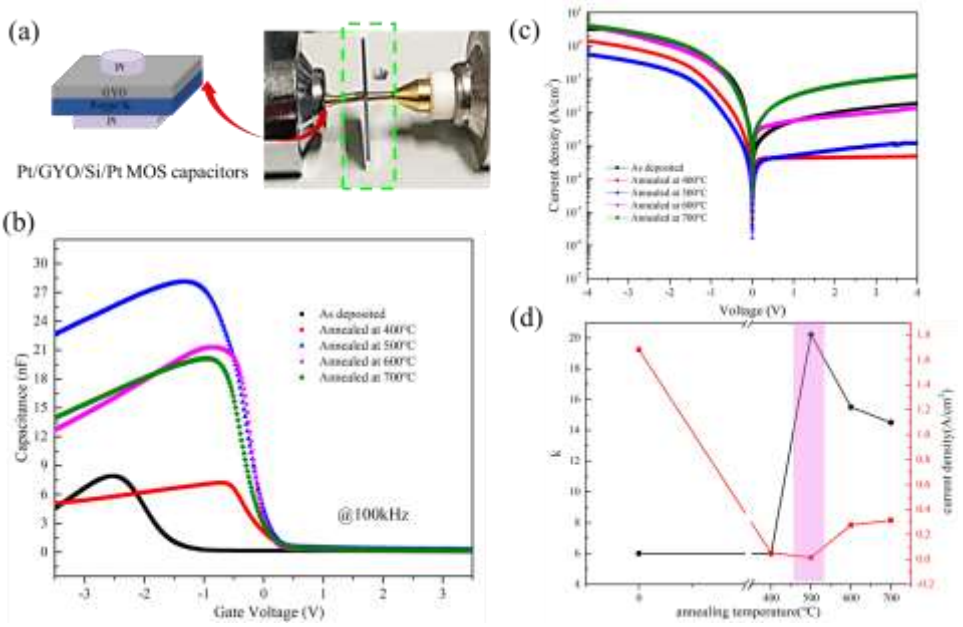

Figure 2: (a) Schematic diagram of Pt/ $GdYO_x$/p-Si MOS capacitors. (b) C-V characteristics, (c) I-V characteristics and (d) k value and current density of $GdYO_x$ thin films as a function of annealing temperature.