Dielectric property and conduction mechanism of ultrathin zirconium oxide films

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Stoichiometric, uniform, amorphous ZrO$_2$ films with an equivalent oxide thickness of ~1.5nm and a dielectric constant of ~18 were deposited by an atomic layer controlled deposition process on silicon for potential application in metal-oxide-semiconductor (MOS) devices. The conduction mechanism is identified as Schottky emission at low electric fields and as Poole-Frenkel emission at high electric fields. The MOS devices showed low leakage current, small hysteresis (<5mV), and low interface state density (~2*10$^{11}$/cm$^2$V). Microdiffraction and high-resolution transmission electron microscopy showed a localized monoclinic phase of a-ZrO$_2$ and an amorphous interfacial ZrSiO$_4$ layer which has a corresponding dielectric constant of 11.

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High-k dielectrics by UV photo-assisted chemical vapour deposition

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An overview of our recent work on thin films of metal oxides deposited on silicon by a novel excimer lamp-assisted ultraviolet injection liquid source CVD (UVILS-CVD) process for advanced high-k gate dielectrics applications will be presented. Recent results on TiO$_2$, Ta$_2$O$_5$, ZrO$_2$, HfO$_2$, and TiO$_2$-doped Ta$_2$O$_5$ will be demonstrated. The physical, structural, interfacial
properties and electrical characterization of the as-deposited and UV-annealed new high dielectric constant (high-k) materials, determined using ellipsometry, Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy, UV spectrophotometry, SEM, TEM, and C-V, I-V measurements, showed that good quality layers could be produced. The investigation of high-k dielectrics grown by the UVILS-CVD process clearly demonstrates that low cost, high power density excimer lamp systems can provide an interesting alternative to conventional UV lamps and excimer lasers for industrial large-scale low temperature materials processing. UVILS-CVD is a promising technique for the controlled deposition of ultra thin high-k metal-oxide dielectrics for deep sub-micron CMOS devices at temperatures as low as 350°C.

출처
Microelectric Engineering, Volume:1 2002 000-000

논문제목
Annealing Effects On Ultra thin MOS Capacitors

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초록
Silicon oxide with thickness less than 9 nm is fabricated by tube furnace oxidation. Nitrogen is added to dilute the oxidation rate. Aluminum dots with radius of 0.05 cm are deposited on the oxide. High frequency capacitance-voltage (HF C-V), conductance-voltage (G-V) and current-voltage (I-V) characteristics are measured. Annealing under nitrogen atmosphere is carried out with different time and at different temperature. Densities of the interface states before and after annealing are compared. After annealing, a decrease in density of the interface states is found. Experiments show that 450°C annealing for 30 minutes has the lowest density of the interface states.

출처

논문제목
Effective electron mobility in Si inversion in metal-oxide-semiconductor systems with a high-k insulator: The role of remote phonon scattering.
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초록
The high dielectric constant of insulators currently investigated as alternatives to SiO2, in metal-oxide-semiconductor structures is due to their large ionic polarizability. This is usually accompanied by the presence of soft optical phonons. We show that the long-range dipole field associated with the interface excitations resulting from these modes and from their coupling with surface plasmons, while small in the case of SiO2, for most high-k materials causes a reduction of the effective electron mobility in the inversion layer of the Si substrate. We study the dispersion of the interfacial coupled phonon-plasmon modes, their electron-scattering strength, and their effect on the electron mobility for Si-gate structures employing films of SiO2, Al2O3, AlN, ZrO2, HfO2, and ZrSiO4, for "SiO2-equivalent" thickness ranging from 5 to 0.5 nm

출처

논문제목
Epitaxial growth of yttrium-stabilized HfOx high-k gate dielectric thin films on Si

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초록
Epitaxial yttrium-stabilized HfOx thin films were deposited on p-type (100) Si substrates by pulsed laser deposition at a relatively lower substrate temperature of 550 °C. Transmission electron microscopy observation revealed a fixed orientation relationship between the epitaxial film and Si; that is, (100)Si//(100)HfOx and [001]Si//[001]HfOx. The film/Si interface is not atomically flat, suggesting possible interfacial reaction and diffusion. X-ray photoelectron spectroscopy analysis also revealed the interfacial reaction and diffusion evidenced by Hf silicate and Hf-Si bond formation at the interface. The epitaxial growth of the yttrium stabilized HfOx thin film on bare Si is via a direct growth
mechanism without involving the reaction between HF atoms and SiO₂ layer. High-frequency capacitance-voltage measurement on an as-grown 40-A yttrium-stabilized HfO₂ epitaxial film yielded an effective dielectric constant of about 14 and equivalent oxide thickness to SiO₂ of 12 A. The leakage current density is 7.0 × 10e-2 A/cm² at 1 V gate bias voltage.

· 출처

· 논문목록
Basic characteristics of metal-ferroelectric-insulator-semiconductor structure using a high-k PrO₅ insulator layer

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· 초록
A metal-ferroelectric [SrBi₂Ta₂O₉ (SBT)]-high-k-insulator(PrO₅)-semiconductor(Si) structure has been fabricated and evaluated as a key part of metal-ferroelectric-insulator-semiconductor-field-effect-transistor MFIS-FET memory, aiming to improve the memory retention characteristics by increasing the dielectric constant in the insulator layer and suppressing the depolarization field in the SBT layer. A 20-nm PrO₅ film grown on Si(100) showed both a high of about 12 and a low leakage current density of less than 1 × 10e-8 A/cm² at 1.5 MV/cm. A 400-nm SBT film prepared on PrO₅/Si shows a preferentially oriented (105) crystalline structure, grain size of about 130 nm and surface roughness of 3.2 nm. A capacitance-voltage hysteresis is confirmed on the Pt/SBT/PrO₅/Si diode with a memory window of 0.3 V at a sweep voltage width of 12 V. The memory retention time was about 1104 s, comparable to the conventional Pt/SBT/SiO₂/(SiO₂x)/Si. The gradual change of the capacitance indicates that some memory degradation mechanism is different from that in the Pt/SBT/SiON/Si structure.

· 출처
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· 논문목록
Atomic layer chemical vapor deposition of ZrO₂-based dielectric films: Nanostructure and nanochemistry

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· 초록
A 4 nm layer of ZrOₓ (targeted x=2) was deposited on an interfacial layer (IL) of native oxide (SiO₂, t=1.2 nm) surface on 200 nm Si wafers by a manufacturable atomic layer chemical vapor deposition technique at 300°C. Some as-deposited layers were subjected to a post-deposition, rapid thermal annealing at 700°C for 5 min in flowing oxygen at atmospheric pressure. The experimental x-ray diffraction, x-ray photoelectron spectroscopy, high-resolution transmission electron microscopy, and high-resolution parallel electron energy loss spectroscopy results showed that a multiphase and heterogeneous structure evolved, which we call the Zr-O/IL/Si stack. The as-deposited Zr-O layer was amorphous ZrO₂-rich Zr silicate containing about 15% by volume of embedded ZrO₂ nanocrystals, which transformed to a glass nanocrystalline (with over 90% by volume of predominantly tetragonal-ZrO₂ (t-ZrO₂) and monoclinic-ZrO₂ (m-ZrO₂) nanocrystals) upon annealing. The formation of disordered amorphous regions within some of the nanocrystals, as well as crystalline regions with defects, probably gave rise to lattice strains and deformations. The interfacial layer (IL) was
partitioned into an upper SiO$_2$-rich Zr silicate and the lower SiO$_2$. The latter was sub-toxicorhenium and the average oxidation state increased from SiO$_{0.86}^-$ in SiO$_{0.5}$ (as-deposited) to SiO$_{1.32}^-$ in SiO$_{0.5}$ (annealed). This high oxygen deficiency in SiO$_2$ was indicative of the low mobility of oxidizing specie in the Zr-O layer. The stacks were characterized for their dielectric properties in the Pt/[Zr-O/IL]/Si metal oxide-semiconductor capacitor (MOSCAP) configuration. The measured equivalent oxide thickness (EOT) was not consistent with the calculated EOT using a bilayer model of ZrO$_2$ and SiO$_2$, and the capacitance in accumulation (and therefore, EOT and kZr-O) was frequency dispersive, trends well documented in literature. This behavior is qualitatively explained in terms of the multilayer nanostructure and nanochemistry that evolves.

- 출처
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- 논문제목
  Interfacial properties of ZrO$_2$ on silicon

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- 초록
  The interface of zirconium oxide thin films on silicon is analyzed in detail for their potential applications in the microelectronics. The formation of an interfacial layer of ZrSiO$_x$ with graded Zr concentration is observed by the x-ray photoelectron spectroscopy and secondary ion mass spectrometry analysis. The as-deposited ZrO$_2$/ZrSiO$_x$/Si sample is thermally stable up to 880°C, but is less stable compared to the ZrO$_2$/SiO$_2$/Si samples. Post-deposition annealing in oxygen or ammonia improved the thermal stability of as-deposited ZrO$_2$/ZrSiO$_x$/Si to 925°C, likely due to the oxidation/nitridation of the interface. The as-deposited film had an equivalent oxide thickness of ~1.3 nm with a dielectric constant of ~21 and a leakage current of 3.2 × 10e-3 A/cm$^2$ at 1.5 V. Upon oxygen or ammonia annealing, the formation of SiO, and SiH$_2$N$_x$O at the interface reduced the overall dielectric constants.

- 출처
  Journal of Applied Physics, Volume:93 Issue:10 May 2003 Page(s): 5945-5952

- 논문제목
  Dielectric properties of Pr$_2$O$_3$ high-k films grown by metalorganic chemical vapor deposition on silicon

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- 초록
  Praseodymium oxide (Pr$_2$O$_3$) thin films have been deposited on Si(100) substrates by metalorganic chemical vapor deposition using praseodymium tris-2,2,6,6-tetramethyl-3,5-heptandionate as source material. Film structural, morphological, and compositional characterizations have been carried out. Dielectric properties have been studied as well by capacitance-voltage and current-voltage measurements on metal-oxide-semiconductor capacitors of several areas. The Pr$_2$O$_3$ films have shown a dielectric constant ~23~25 and a leakage current density of 8.8 × 10e-8 A/cm$^2$ at +1 V.

- 출처

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