DS 11 Anorganische dielektrische Schichten

Zeit: Samstag 14:30–15:45 Raum: TU H110

DS 11.1 Sa 14:30 TU H110

Initial growth of Pr_2O_3 epitaxial layers on silicon substrates — •Laure Libralesso[1], Thomas Schröder[2], Tien-Lin Lee[1], Isabelle Joumard[1], and Jörg Zegenhagen[1] — [1]ESRF, Grenoble, France — [2]IHP, Frankfurt(Oder)

In microelectronics industry, the quality of the thermally and electrically stable Si-SiO_2 interface has made SiO_2 the gate-dielectric material of choice over the last 40 years. However, to follow in time the International Technology Roadmap for Semiconductors, the SiO_2 gate must be replaced by an alternative high-K dielectric layer. Among the proposed materials, thin Pr_2O_3 layers show outstanding dielectric properties. In the present study the Pr_2O_3/Si(111) system has been investigated as a model system.

The initial stages of Pr_2O_3 molecular beam epitaxy growth on Si(111) have been studied with in situ low energy electron diffraction and ultra high vacuum scanning tunneling microscopy (STM). Atomically flat Pr_2O_3 surfaces have been observed for coverages going from submonolayer range up to 2 monolayers. The evolution of the island size, the growth behaviour as well as the nucleation process will be described. Pr_2O_3 deposits have also been investigated on Si(001) substrates. STM as well as surface X-ray diffraction results will be briefly discussed.

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The initial interaction of Pr2O3 to (001) and (111) oriented Si substrates — •Dieter Schmeisser — Angewandte Physik-Sensorik, BTU Cottbus, Postfach 10 13 44, D-03013 Cottbus, Germany

The high surface sensitivity of synchrotron based core level spectroscopy is employed to study the initial growth of Pr2O3 on Si(001) and Si(111) substrates. The Si2p core levels are different for the two substrates when the exposure is below 1nm. The core level shifts indicate a single bonding of the oxide on the terminal Si atom in Si(111) while on Si(001) the two dangling bonds are reactive. On both surfaces a significant broadening in the substrate emission is found and interpreted in terms of non bonding Si atoms located at the interface. Upon increasing the Pr2O3 exposure above 1nm the Si back bonds in the first Si layer are attacked to form Si - O - Pr bonds which cause a silicate like core level shift.

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Heteroepitaxial silicon / Pr_2O_3 / silicon structures for nanoelectronics applications — •Thomas Schroeder[1,2], Peter Zaumseil[1], Christian Wenger[1], Gunther Lippert[1], Grzegorz Lupina[1], Hans Joachim Muessig[1], Laure Libralesso[2], and Joerg Zegenhagen[2] — [1]IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany — [2]ESRF, BP 220, 38043 Grenoble, France

Epitaxial Si/Pr_2O_3 /Si structures are promising semiconductor-insulator-semiconductor (SIS) stacks for applications as engineered wafer materials (silicon-on-insulator (SOI)) or for innovative transistor designs (multiple gate transistors). Here, we report the molecular beam epitaxy (MBE) growth of such structures on Si(111). The growth of Pr_2O_3 films on Si(111) was studied by reflection high energy electron diffraction (RHEED) to determine the growth mode. Scanning tunnelling microscopy (STM) visualizes the formation of a closed oxide overlayer. Synchrotron radiation-grazing incidence X-ray diffraction (SR-GIXRD) studies monitored the transition from pseudomorphism to bulk behaviour in the ultra-thin thickness regime (¡ 10 nm). Thicker oxide layers (up to 50 nm) were studied by XRD and X-ray reflectivity (XRR) to monitor the crystalline quality and surface roughness. The Pr_2O_3 film grows in the (0001) oriented hexagonal phase on Si(111) but annealing transforms the oxide in its cubic phase with (111) orientation. The Si overgrowth was carried out on hexagonal as well as cubic oxide layers to tailor the strain in the Si epilayer. Pr_2O_3 /Si multilayer structures are also addressed in brief.

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The interaction of Al, Au, Ag, and Ti metal contacts with Pr2O3 thin films — •Mohamed Torche and Dieter Schmeisser — Angewandte Physik-Sensorik, BTU Cottbus, Postfach 10 13 44, D-03013 Cottbus, Germany

Pr2O3 is one of the promising high-k oxides desirable to replace SiO2 for the sub-100nm field-effect transistors (FETs) and dynamic random access memory (DRAM) capacitors. Here we focus on the metallic contacts used for the MOS and MIM based structures. With the thickness of Pr2O3 being around 3nm the metal interaction is crucial to avoid a reduction of the dielectric properties by metal percolation, crack filling or diffusion processes. We use XPS and SRPS to study the initial interaction as well as the thermal stability of metals (Al, Ag, Au, and Ti) on Pr2O3 films. We show that Al, Ag, Au form initial metallic layer which react already at temperatures around 300°C. In contrast, Ti is found to be more stable than the other metals. We determine the formation of Ti-oxides at the Ti / Pr2O3 interface and its thermal stability. Ti is found to build a good diffusion barrier between the oxide and the metal.

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Preparation of microcrystalline Si thin films by pulsed plasma CVD at normal pressures — •Maki Suemitsu[1], Hirotatsu Kitabatake[1], Yasutake Toyoshima[2], Setsuo Nakajima[3], and Tsuyoshi Uehara[3] — [1]CIR, Tohoku University, Sendai 980-8578 — [2]ETRI, AIST, Tsukuba 305-8568 — [3]Sekisui Chemicals Co. Ltd., Wadai, Tsukuba 300-4292

By employing a pulsed discharge, microcrystalline Si films have been successfully prepared by plasma-enhanced chmical vapor deposition (PECVD) operated under near-atmospheric pressures. A gas mixture of only monosilane and hydrogen was used without any further diluent gases. Under the operating pressure of 500 Torr and the substrate temperature of 180C, a Si film with dominant crystalline phase is prepared at a deposition rate of 2.0 nm/s. The thickness and the Raman ratio (crystal/amorphous) of the deposited film showed variation along the gas flow direction, both of which are well explained by assuming delayed production and consumption of silyl radicals along the flow direction. In normal-pressure PECVDs, "flow"can be a feasible, additional degree of freedom in analyzing the growth mechanism of microcrystalline thin films.