

ALD cycle

Metal precursor

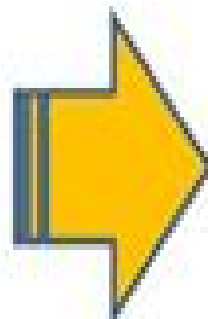
purge

dose

Oxidant (H_2O , O_2)

dose

purge



Metal oxide layer

surface roughness control

atomic-level control of film thickness

unparalleled conformality and uniformity

***the deposition of nanometer-thin films
in high-aspect-ratio structures***

interfacial control

Substrate

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Kevin James Hughes



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Handbook of Thin Film Deposition Krishna Seshan, Dominic Schepis, 2018-02-23 Handbook of Thin Film Deposition Fourth Edition is a comprehensive reference focusing on thin film technologies and applications used in the semiconductor industry and the closely related areas of thin film deposition thin film micro properties photovoltaic solar energy applications materials for memory applications and methods for thin film optical processes The book is broken up into three sections scaling equipment and processing and applications In this newly revised edition the handbook will also explore the limits of thin film applications most notably as they relate to applications in manufacturing materials design and reliability Offers a practical survey of thin film technologies aimed at engineers and managers involved in all stages of the process design fabrication quality assurance applications and the limitations faced by those processes Covers core processes and applications in the semiconductor industry and new developments within the photovoltaic and optical thin film industries Features a new chapter discussing Gates Dielectrics

Handbook of Smart Materials, Technologies, and Devices Chaudhery Mustansar Hussain, Paolo Di Sia, 2022-11-09 This handbook brings together technical expertise conceptual background applications and societal aspects of Industry 4.0 the evolution of automation and data exchange in fabrication technologies materials processing and device manufacturing at both experimental and theoretical model scales The book assembles all the aspects of Industry 4.0 starting from the emergence of the concept to the consequences of its progression Drawing on expert contributors from around the world the volume details the technologies that sparked the fourth revolution and illustrates their characteristics potential and methods of use in the industrial and societal domains In addition important topics such as ethics privacy and security are considered in a reality where all data is shared and saved remotely The collection of contributions serve a very broad audience working in the fields of science and engineering chemical engineering materials science nanotechnology energy environment green chemistry sustainability electrical and electronic engineering solid state physics surface science aerosol technology chemistry colloid science device engineering and computer technology This handbook ideal reference libraries in universities and industrial institutions government and independent institutes individual research groups and scientists

NASA Tech Briefs, 2008

Physics and Technology of High-k Gate Dielectrics 6 S. Kar, 2008-10 The issue covers in detail all aspects of the physics and the technology of high dielectric constant gate stacks including high mobility substrates novel and still higher permittivity dielectric materials CMOS processing with high K layers metals for gate electrodes interface issues physical chemical and electrical characterization gate stack reliability and DRAM and non volatile memories

Atomic Layer Deposition for Semiconductors Cheol Seong Hwang, 2013-10-18 Offering thorough coverage of atomic layer deposition ALD this book moves from basic chemistry of ALD and modeling of processes to examine ALD in memory logic devices and machines Reviews history operating principles and ALD processes for each device

Atomic Layer Deposition in Energy Conversion Applications Julien

Bachmann,2017-05-30 Combining the two topics for the first time this book begins with an introduction to the recent challenges in energy conversion devices from a materials preparation perspective and how they can be overcome by using atomic layer deposition ALD By bridging these subjects it helps ALD specialists to understand the requirements within the energy conversion field and researchers in energy conversion to become acquainted with the opportunities offered by ALD With its main focus on applications of ALD for photovoltaics electrochemical energy storage and photo and electrochemical devices this is important reading for materials scientists surface chemists electrochemists electrotechnicians physicists and those working in the semiconductor industry ALD 2008 Book of Abstracts ,2008 The Effects of the Purge Flow Rate and Its Flow Orientation in the Atomic Layer Deposition (ALD) Simulations of Aluminium Oxide (Al₂O₃) Charles Emeka Nwanna,2019 *AVS-ALD & Baltic ALD 2012 - 12th International Conference on Atomic Layer Deposition* American Vacuum Society,2012 *A Quantified Dosing ALD Reactor with In-situ Diagnostics for Surface Chemistry Studies* Thomas J. Larrabee,2012 *Atomic Layer Deposition for Continued Scaling of Interconnects* Michael Christopher Breeden,2022 With the need for more compute performance smaller semiconductor device dimensions and denser interconnections have required the use of ultra thin layers conformally deposited in three dimensional structures such as the gate all around MOSFET and in high aspect ratio interconnect vias Atomic layer deposition ALD with the ability to precisely control thickness as well as selectively deposit layers on different materials is used in current process nodes for gate oxides and barrier layers but new channel materials such as silicon germanium SiGe and new interconnect metals such as cobalt Co and ruthenium Ru require new surface preparation techniques and ALD processes Chapter 2 of this dissertation describes the passivation of defects in gate oxides deposited by ALD in SiGe channel devices SiGe s high carrier mobility shows promise for future devices but the presence of unstable germanium oxides GeO_x in the interface between oxide and channel results in high defect densities limiting device performance By nitridating the surface prior to gate oxide ALD using an RF plasma a reduction in defect densities is demonstrated TEM and XPS studies confirmed the formation of a GeN_x interfacial layer suppressing GeO_x formation during ALD improving gate oxide nucleation and decreasing defect densities With shrinking device dimensions interconnect via widths correspondingly shrink While copper has long been used for due to its low bulk resistivity ultra narrow **Investigating Area-selective Atomic Layer Deposition of Dielectric on Diverse Substrate Systems** Tzu-Ling Liu,2022 The manufacturing process for semiconductor devices has become increasingly complex and costly due to bottlenecks with conventional top down fabrication methods Hence researchers are looking for alternative approaches to address these issues Area selective atomic layer deposition AS ALD is attracting growing research interest because of its ability to form patterned materials in a bottom up fashion To achieve AS ALD self assembled monolayers SAMs are commonly used as inhibitors to block ALD processes SAM molecules can spontaneously form ordered structures on specific surfaces depending on the headgroup of the molecule By selecting the right type of SAM headgroup depending on

the substrate materials selective SAM formation on specific areas of patterned substrates can be achieved leading to successful achievement of AS ALD. Although SAM assisted AS ALD is promising, challenges remain in developing more robust AS ALD systems with broader applicability. In the first part of this thesis, dodecanethiol DDT is used as the inhibitor for AS ALD on metal dielectric substrates. We show that a DDT passivation layer forms only on Cu but not on SiO₂ or low k dielectric surfaces, thus allowing AS ALD of ZnO and Al₂O₃ on the dielectric regions of metal dielectric patterned substrates to be achieved. By conducting DDT deposition on slightly oxidized Cu surfaces which consist mainly of Cu₂O, we further show that the packing of the DDT SAM can be enhanced, leading to improvement of the ALD blocking ability. In addition, because thiols have been shown to form multilayer structures on CuO covered Cu substrates, the impact of the DDT structure, i.e. monolayer vs. multilayer, on both the blocking ability and edge effects at the interface of metal dielectric patterns during AS ALD is studied. The results indicate that multilayer DDT blocks ZnO ALD more effectively than does monolayer DDT, while monolayer DDT is more efficacious in inhibiting Al₂O₃ ALD. The study on the interfacial effect in patterns with feature sizes of 20–100 nm shows that multilayer DDT can lead to some undesired effects: inhibition of ZnO at the SiO₂ edges and nonuniform ZnO deposition on SiO₂ regions; much thinner ZnO film at small pitch sizes. On the other hand, ZnO grows uniformly on SiO₂ regions without the above mentioned issues when monolayer DDT is used. The second part of the thesis focuses on developing new AS ALD systems. We demonstrate that an octadecyltrimethoxysilane (OTMS) SAM is selectively formed on SiO₂ of Cu/SiO₂ patterns only when DDT is first used as the protector on Cu surfaces to prevent OTMS adsorption on Cu. After selective removal of the DDT protector by thermal treatment prior to ALD, AS ALD of Al₂O₃ and ZnO on Cu regions of the patterns is demonstrated. In addition to selective deposition onto metal dielectric patterns, AS ALD on more general material systems for which chemically similar materials are present on the substrate surface at the same time is investigated. We achieve the selective formation of octadecylphosphonic acid (ODPA) SAMs on various metal oxide substrates including Al₂O₃, HfO₂, TiO₂, and Ta₂O₅ over SiO₂ by relying on the different reactivity of the ODPA headgroup on these oxide surfaces. AS ALD is then demonstrated with SiO₂ as the growth surface and the other four metal oxides as the nongrowth surface. To further obtain selectivity in more general systems, the solvent and deposition time for ODPA SAM formation are optimized. We show that selective deposition of ZnO and Al₂O₃ ALD between different metal oxide substrates can be achieved with especially good selectivity between Al₂O₃ growth surface vs. HfO₂ nongrowth surface. In the final part of this thesis, the breakdown behavior of SAM inhibitors in AS ALD is investigated. The octadecyltrichlorosilane (ODTS) SAM paired with Al₂O₃ and ZnO ALD is used as the model system for the SAM inhibitor and ALD process, respectively. The results show that no notable changes in the crystallinity and structure, thickness, density, and roughness of ODTS SAMs are observed until a significant amount of ALD nucleation occurs. The study also reveals different morphologies of the ALD materials deposited on top of ODTS SAMs: Al₂O₃ tends to form a relatively continuous film, whereas ZnO forms dispersed nanoparticles. Overall, the studies presented in this

thesis provide greater understanding of AS ALD and open up more opportunities for new applications of AS ALD *Atomic*
Layer Deposition of Vanadium Dioxide Guandong Bai,2022

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