Tutorials
Room Live - Session TU2-WeA
Tutorial Session: Wednesday Live

Moderators: Paul Poodt, Holst Centre / TNO, Erwin Kessels, Eindhoven University of Technology, the Netherlands, Jean-François de Marneffe, IMEC

1:00pm **TU2-WeA-1 Wednesday Tutorial Welcome & Sponsor Thank You***, **Paul Poodt**,* TNO/Holst Center, The Netherlands, Netherlands

Thank you for joining our Tutorial! We wish to thank our Sponsors for their support!

1:15pm **TU2-WeA-2 Growth Mechanisms and Selectivity During Atomic Layer Deposition***, **Annelies Delabie**,* KU Leuven – University of Leuven/IMEC, Belgium **INVITED**

Area-selective deposition (ASD) holds the potential to build nanostructures from the bottom up, only where needed, with atomic precision in both vertical and lateral direction. The technique is of great interest for nano-electronic device manufacturing, as it can be applied for bottom-up deposition in small trenches or holes, or to create nanoscale structures with great accuracy by self-alignment. In addition, ASD can simplify complex integration flows and is a cost-effective approach that consumes less chemical products and energy as compared to traditional top-down patterning. Today, many materials can be deposited by atomic layer deposition (ALD), but only few ALD processes show selectivity. ASD is governed by a complex interplay of several processes, including adsorption, desorption, surface reactions and diffusion. Fundamental understanding of the mechanisms during ALD can contribute to the design of new ASD processes for a wider range of materials. This tutorial will therefore first address the growth mechanisms during ALD on an initially homogeneous substrate surface. Several quantitative growth models have been proposed to describe the initial ALD growth regime. Next, we discuss the mechanism of ASD in nanoscale patterns, and how the growth behavior during ASD can differ from regular growth on homogeneous substrates. Finally, we address strategies to minimize deposition in the non-growth surface area, while simultaneously maintaining or enhancing growth on the growth surface area.

2:15pm **TU2-WeA-6 Self-limiting Surface Reactions for Atomic-level Control of Materials Processing***, **Simon D. Elliott**,* Schrödinger, Inc. **INVITED**

ALE and ALD have in common that their defining characteristic is a self-limiting transformation of the surface in each cycle. This leads to the well-known advantages of the techniques - uniformity, conformality and digital control of thickness etched/deposited. In this tutorial we will examine how the chemical interaction between a gas and a surface can be either self-limiting or continuous. Looking at how this depends on process conditions (temperature or pressure) gives a straightforward way to understand the process window and account for the etch/growth rate. The simple procedure for estimating etch/growth rates from surface coverage will be presented. We will discuss the various potential sources of self-limiting chemistry, such as the concentration of substrate sites, availability of co-reagent fragments, exposure of gaseous reagent and diffusion along the surface. Examples will be given from both acid-base and redox-based chemical mechanisms of ALE and ALD.

3:15pm **TU2-WeA-10 Fundamentals of ALE – Optimizing Passivation and Etch****, **Mark Kushner**,* University of Michigan **INVITED**

The ideal process of plasma based atomic layer etching (ALE) consists, in principle, of two independent self-limiting steps. The first is passivation of an atomically smooth surface with plasma produced radicals with the goal of lowering the binding energy of the surface resident atoms. The second is removal of the passivated layer of atoms with the activation energy provided by plasma generated ions of carefully controlled energies. Ideal ALE, the removal of a single monolayer per cycle, is rarely achieved. There are narrow process windows in terms of how much activation energy can be delivered during the passivation step and how many passivants can be present during the etch step. In addition to the intrinsic chemistry of the ALE process, the quality of the process is ultimately determined by how well the fluxes delivered by the plasma to the surface can be controlled – all of which contribute to the ideality of the process. ALE of dielectrics (ALE-D), typically using fluorocarbon gas mixtures, proceeds through deposition of a thin polymer layer which provides the precursors for the etch step. As such, ALE-D begins as being non-ideal as the passivation step is not self-limiting. ALE-D is perhaps better described as controlled EPC (etch-per-cycle). Depending on polymer thickness and ion energies, the EPC can be a fraction of monolayer or many monolayers. In this tutorial, ideal and non-ideal ALE processes will be reviewed with an emphasis on the plasma properties required to achieve ideal behavior. Examples will be used from computer modeling of reactor scale plasma generation of passivants and etchants, and feature scale profile simulation. Halogen plasma based ALE of conductors will be used to illustrate the process window requirements for ideal EPC. Simulation of ALE-D of SiO_2 and Si_3N_4 will be used to illustrate how control of plasma properties can produce controlled EPC, selectivity and surface smoothness. * Work supported by Lam Research Inc., TEL Technology Center America LLC and Samsung Electronics.

4:00pm **TU2-WeA-13 Questions & Answers***, M Kushner,* University of Michigan*; A Delabie,* KU Leuven – University of Leuven/IMEC, Belgium*; S Elliott,* Schrödinger, Inc.*; **Jean-François de Marneffe**,* IMEC, Belgium

Feel free to ask questions to our Tutorial presenters

4:30pm **TU2-WeA-15 Session Over - View On Demand Presentations***, **Erwin Kessels**,* Eindhoven University of Technology, Netherlands

You are now welcome to view all ALD/ALE On Demand Presentations

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