Tutorials
Room Live - Session TU1-TuA
Tutorial Session: Tuesday Live

Moderators: Christophe Detavernier, Ghent University, Belgium, Harm C.M. Knoops, Oxford Instruments Plasma Technology, The Netherlands

1:00pm **TU1-TuA-1 Tuesday Tutorial Welcome & Sponsor Thank You***, **Christophe Detavernier,*** Ghent University, Belgium

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

1:15pm **TU1-TuA-2 ALD Precursor Chemistry: Synthetic Routes, Purification and Evaluation of Precursors***, **Anjana Devi,*** Ruhr University Bochum, Germany **INVITED**

An open challenge for forefront research is provided by innovative strategies based on the synergic combinations of precursor chemistry and material synthesis, opening new horizons for the development of advanced functional material systems. In the case of atomic layer deposition (ALD), the important figure of merit is the precursor. High volatility, reactivity and thermal stability are the main requirements for an ALD process. But several precursors do not possess all of these characteristics. Thus, the search for alternative precursors continues to grow to overcome the drawbacks associated with the well-established or commercially available precursors in order to meet the stringent demands for modern technological applications. The reports on the design of new precursors by systematic and logical variation of the ligand sphere remains a rare occurrence in literature. Apart from identifying new and suitable precursors for ALD, it is also important that the precursors can be synthesized and scaled up to larger batches, they are non-toxic and the purity of the product is of high relevance. In this presentation, the approaches taken to synthesize different classes of precursors, their purification and the methods employed to characterize them will be discussed. The focus will be on representative precursors for metals and metal oxides and evaluating the precursor purity, volatility, thermal stability relevant for ALD applications.

2:15pm **TU1-TuA-6 Atomic Layer Engineering: Hardware Considerations for ALD System Design and Process Development***, **Neil Dasgupta,*** University of Michigan **INVITED**

As the portfolio of ALD processes chemistries continues to broaden, there is an increasing need for hardware customization to ensure process compatibility. Furthermore, the manufacturing demands for ALD continue to push for higher throughput, without sacrificing film quality or process reliability. In particular, as the form factor of ALD substrates begins to deviate from planar wafers to 3-D architectures, coupled thermal, mass transport, and chemical kinetics play an increasingly important role in ensuring optimal ALD deposition. This tutorial will describe several critical, and often under-discussed, aspects of ALD reactor hardware design and process control. The discussion will begin with a primer on vacuum system design in general – materials compatibility, fittings, o-rings/gaskets, valves, flow controllers, pumps, and metrology tools. Next, precursor delivery to the substrate will be discussed, with consideration of special challenges for solid precursors and low-vapor pressure precursor delivery. Various chamber geometries will be compared, and the coupled thermal/fluid transport behavior during vapor transport and reactivity will be described. Incorporation of in situ process metrology will be described. Finally, vacuum exhaust line design will be discussed, with an emphasis on maintaining a safe, and reproducible system.

3:15pm **TU1-TuA-10 ALD on High Aspect Ratio and Nanostructured Materials: from Fundamentals to Economics***, **Angel Yanguas-Gil,*** Argonne National Laboratory **INVITED**

The ability to conformally coat high aspect ratio and nanostructured substrates over large substrate areas is one of atomic layer deposition's enabling capabilities. From the coating of trenches and vias to the extreme case of polymer infiltration, there are numerous examples in the literature illustrating how ALD's self-limited behavior can enable new architectures and applications. In this tutorial I will focus on the fundamental aspects of the coating of high surface area materials, and in particular how the surface chemistry affects the dynamics of infiltration, scale up, and tradeoff between throughput and precursor utilization. After a brief introduction summarizing experimental approaches for both growth and characterization techniques and some conventional and extreme applications, I will explore the impact that shape, pore size, the overall microstructure of nanostructured substrates, and precursor-surface interaction have on an ideal ALD process. The impact of these parameters can be codified in a few compact expressions that help us visualize and explore the scalability of a given ALD process. I will then move on to consider how other aspects of the surface chemistry, such the presence of surface recombination or deactivation pathways, ligand-surface interactions, and non self-limited and soft-saturating components affect conformality. I will also look at the coating of nanostructured materials from a reactor scale perspective, exploring through simple models and experimental observations how precursor transport is disrupted by the presence of high surface area substrates in both cross flow and static dose configurations, two of the most common experimental approaches. I will then conclude with an overview of experimental challenges and gaps in our understanding that, if solved, could help accelerate the development of novel processes involving high aspect ratio and nanostructured substrates.

4:00pm **TU1-TuA-13 Questions & Answers***, A Devi,* Ruhr University Bochum, Germany*; N Dasgupta,* University of Michigan*; A Yanguas-Gil,* Argonne National Laboratory

Feel free to ask questions to our panel of Tutorial presenters

4:30pm **TU1-TuA-15 Session Over - View On Demand Presentations***, C Detavernier,* Ghent University, Belgium*; **Harm C.M. Knoops,*** Oxford Instruments Plasma Technology, The Netherlands, Netherlands

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

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