Wednesday Afternoon, June 25, 2025

ALD for Manufacturing
Room Samda Hall AB - Session AM2-WeA

ALD Equipment II

Moderators: Tae Wook Nam, Sejong University, **Bonggeun Shong**, Hongik University

4:00pm **AM2-WeA-11 Spatial Atomic Layer Deposition of Nanolaminate Barrier Coatings Enables Sustainable Packaging**, ***Denys Vidish,*** University of Waterloo, Canada*; Soumyadeep Saha, Louis Delumeau, Tristan Grovu,* Nfinite Nanotechnology Inc., Canada*; Kevin Musselman,* University of Waterloo, Canada

Plastic waste poses a worldwide challenge because of its detrimental effects on the environment, society, and economy. Flexible packaging materials are being used with different types of single-use plastics. To address their harmful impact on the environment, the packaging industry has been trying to move towards compostable polymer materials such as polylactic acid (PLA). However, these compostable polymers don't provide a sufficient gas-diffusion barrier to protect the product from water vapor and oxygen. For that reason, applying vapor-barrier coatings onto packaging materials is necessary to protect the product. However, most traditional barrier coatings don't perform well on PLA and/or compromise the composability of the packaging. In this work, we introduce nanolaminate barrier coatings for flexible, sustainable packaging materials that are based on alternating nanoscale layers of aluminum oxide (Al_2O_3) and zinc oxide (ZnO). These nanolaminates were deposited using an atmospheric-pressure spatial atomic layer deposition (AP-SALD) system, which is a scalable technique that is compatible with roll-to-roll manufacturing. We show that the water-vapor transmission rate (WVTR) and oxygen-transmission rate (OTR) of PLA and PET films are significantly improved after coating them with nanolaminates and that the performance of the nanolaminates is superior to single-layer barrier coatings. We note that the thickness of nanolaminate layers directly correlates with the improvement in barrier performance until an optimal value is reached. Moreover, we demonstrate that the nanolaminates are much more resistant to cracking under stress than single-layer coatings. They maintain their barrier properties (low WVTR and OTR) after bending and Gelbo flex tests, which is crucial for flexible packaging materials. As a result, we demonstrate nanolaminate coatings deposited via AP-SALD that are very promising for improving the barrier properties of biodegradable materials for the flexible packaging industry.

4:15pm **AM2-WeA-12 Advancing Atomic Layer Processing for Next Generation Devices: Atlant 3d'S Direct Atomic Layer Processing (Dalp™)**, ***Mira Baraket,*** ATLANT 3D Nanosystems, Denmark

As the demand for miniaturized and complex devices accelerates across industries, innovative and precise atomic layer advanced manufacturing techniques have become critical. ATLANT 3D's proprietary Direct Atomic Layer Processing (DALP™) technology is redefining thin-film processing by enabling spatially localized, atomically precise material growth with unmatched flexibility. Building upon Atomic Layer Deposition, DALP™ confines gas flows to a micrometer-scale area using advanced microreactors, enabling deposition of diverse materials on complex geometries and substrates with exceptional thickness control and conformality on complex structures.

DALP™ technology tackles key challenges in accelerating innovation within thin-film manufacturing. It enables rapid prototyping by allowing localized, multi-thickness depositions of diverse materials on a single wafer, significantly cutting prototyping timelines from months to hours compared to conventional methods.These capabilities have been demonstrated across diverse applications, including optics and photonics, MEMS, RF electronics, emerging memory technologies, advanced packaging, and energy storage.

This talk will explore ATLANT 3D's advancements in DALP™ technology, focusing on expanded material compatibility, enhanced resolution, and new opportunities it creates for thin-film processing. We will demonstrate how DALP™ technology drives innovation by enabling the fabrication of complete, functional devices. Through case studies, we will highlight how our advanced processing technique have been used to produce components and electronic devices. These examples illustrate how ATLANT 3D's platform not only improves material deposition processes but also revolutionizes prototyping and manufacturing, empowering industries to achieve faster and more efficient innovation.

4:30pm **AM2-WeA-13 Analysis of Controllable Coil Patterns to Improve Temperature Uniformity of Inducted-Heated Susceptor**, ***Jihyun Kim,*** *Hakmin Kim, Kwangson Jin, Tae S. Cho,* Wonik IPS, Republic of Korea

To uniform the temperature of wafers and to get higher temperature faster and more efficiently is desired in the semiconductor manufacturing processes such as metalorganic chemical vapor deposition (MOCVD) growth system[1)]. Induction heating is an alternative technology that provides fast and high temperature heating. In the process of induction heating, the susceptor remains free of physical contact with the work coil or inductor. Nevertheless, the temperature distribution of the wafer on the susceptor is uneven and challenging to manage with a single coil induction heating method, owing to the skin effect of the induced current in the susceptor[2)]. The temperature uniformity of induced-heat susceptor was hence investigated with various working coil patterns for induction heating system by ANSYS Maxwell 3D modelling and simulating. The working coil could be divided into a number of multi-turns or multi-layer coils or multi-zone. Then the material of susceptor was graphite with 5mm of thickness and 300mm of diameter. A travelling wave magnetic field was used to induce eddy current in the graphite susceptor. In order to generate the temperature uniformity of graphite susceptor, the phase angle between the currents differ by $\pi/2$ or $\pi/4$, the input current changes from 10A to 30A, and the input frequency varies from 20kHz to 60kHz. The simulation results showed that the temperature distribution of the susceptor was still not uniform with the single layer and multi-layer with the single zone due to the skin effect and heat conductor in the conventional susceptor. However, the temperature uniformity of the susceptor can be greatly improved by dividing several zones of the coil with different input currents and phases with same frequency. That is the temperature uniformity is improved with the multi-zone with multi-layer coil when the currents and phases of each zone are different. Higher temperature and faster heating rate can be obtained by increasing heating frequency and input current, but the lower and higher frequency can bring worse temperature uniformity. The higher magnetic field over the wafer that can affect to the semiconductor process can also be induced with increasing higher frequency and input current. Therefore, selecting the appropriate frequency and input current for the semiconductor manufacturing processes is essential. To enhance the uniformity of temperature in the graphite susceptor to the desired level, it is necessary to identify the appropriate number of coils turns and input current for each zone, as well as the phase difference between the applied currents.

4:45pm **AM2-WeA-14 Closing Remarks and Awards in Tamna Hall A**,

Author Index

Bold page numbers indicate presenter