ALD Applications
Room Tamna Hall B - Session AA4-WeA
Medical Applications

Moderators: Junsoo Kim, SK Hynix, **Se-Hun Kwan**, Pusan National University

4:00pm **AA4-WeA-11 Room-Temperature Atmospheric Pressure ALD for Pharmaceutical Powder Coating: Tailoring Surface Properties and Controlling Drug Release***, Viet Phuong Cao, Kim Hue Dinh, Phi Huu Bui, Truong Duc Dinh, Quoc Viet Hoang, Diem Quyen Nguyen, Tuan Hiep Tran,* ***Hao Van Bui****,* Phenikaa University, Viet Nam

The pharmaceutical industry faces persistent challenges in optimizing drug delivery systems, including achieving controlled release, improving drug dispersion in liquid formulations, and enhancing the bioavailability of poorly soluble drugs. Current strategies often involve complex processes that can compromise the stability of active pharmaceutical ingredients (APIs). To address these challenges, we have developed a novel coating process using atmospheric pressure atomic layer deposition (AP-ALD) at room temperature in a fluidized bed reactor. This scalable and chemically benign method tailors the surface properties of pharmaceutical powders. Specifically, we demonstrate that AP-ALD coatings can: (1) prolong the dissolution of pharmaceuticals by up to eightfold for extended-release applications, as demonstrated with metformin and atenolol; (2) prevent sedimentation of hydrophilic drugs, enabling long-term dispersion in liquid formulations, as shown with diclofenac; and (3) enhance the dissolution rate of poorly soluble drugs, improving their bioavailability, as demonstrated with gliclazide. Our findings reveal the transformative potential of AP-ALD in pharmaceutical manufacturing, offering precise control over surface interactions while preserving the chemical integrity of APIs and paving the way for advanced drug delivery systems.

4:15pm **AA4-WeA-12 Atomic Layer Deposition for Medical Applications***,* ***J. Ruud van Ommen****, Alina Y. Rwei, Antonia G. Denkova, Volkert van Steijn,* Delft University of Technology, Netherlands

While nanotechnology could play an enormous role in the medical field, it is not straightforward to make nanostructured materials for pharma and medical devices in a scalable manner. We will show that ALD can be used to make nanostructured materials for several health applications in a scalable way.

Modifying the surface of grains of powder – as used, for example, in dry powder inhalers for treating respiratory diseases – can increase the powder flowability while also adding a controlled release functionality. In this way, the powder is used more effectively, and the side effects on the patient can be reduced significantly [1,2].

In targeted radionuclide therapy a major hurdle is the dependence on a very limited number of nuclear reactors worldwide to produce these radioisotopes. ALD can provide a way to prepare radionuclide generators, that can be placed in hospitals, providing on-site and on-demand supply. By modifying sorbent particles for isotope separation by ALD, we have made the first step towards 99Mo/99mTc radionuclide generators [3]. By using Lu ALD on nanoparticles, we have taken a step in producing 177 Lu radionuclides [4].

We also apply ALD to substrates other than powders. Polydimethylsiloxane (PDMS) is a widely used material for lab-on-a-chip and organ-on-a-chip devices. It is very versatile, but the drawback is its low stability, especially when in contact with organic solvents. We will show that modifying the surface with ceramic oxide using ALD is a way to get much more durable microfluidic devices, usable for a range of health applications [5,6].

Summarizing, we can conclude that making nanostructured materials using ALD has a range of applications in the medical field. The combination of nanoprecision and scalability gives it a lot of potential.

References

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4:30pm **AA4-WeA-13 Recent Advances in Multifunctional Antibacterial Neural Interfacing Electrodes Manufactured via Atomic Layer Deposition and Hierarchical Surface Restructuring***,* ***Shahram Armini****,* Pulse Technologies*; Henna Khosla,* Villanova University*; Wesley Seche,* Pulse Technologies*; Daniel Ammerman,* Rowan University*; Matthew Maniscalco, Alexander Blagojevic, Pouya Tavousi,* University of Connecticut*; Sahar Elyahoodayan,* University of Southern California*; Gregory A. Caputo, Jeffrey Hettinger,* Rowan University*; Sina Shahbazmohamadi,* University of Connecticut*; Gang Feng,* Villanova University

The long-term performance of neural interfacing electrodes is critically dependent on their electrochemical stability and resistance to post-implantation infections. Surgical site infections remain a major challenge, often leading to device failure and increased patient risk. While conventional strategies rely on systemic antibiotics, the rise of antimicrobial resistance necessitates alternative, device-integrated solutions. This work highlights recent advancements in the development of multifunctional antibacterial neural electrodes utilizing hierarchical surface restructuring and atomic layer deposition (ALD). Femtosecond laser-induced surface restructuring significantly increases electrode surface area, leading to enhanced charge storage capacity and reduced impedance. ALD is then employed to deposit ultra-thin conformal metal oxide coatings, such as copper oxide and zinc oxide, to impart antibacterial functionality. The combination of structural and chemical modifications enables these electrodes to achieve unprecedented electrochemical performance while effectively inhibiting bacterial growth. A detailed evaluation of the electrochemical properties, including charge injection capacity, impedance, and specific capacitance, is presented alongside antibacterial performance studies against Escherichia coli and Staphylococcus aureus. Results demonstrate that the engineered electrodes maintain high electrochemical stability while exhibiting strong bactericidal effects, making them promising candidates for next-generation neural interfacing applications.

4:45pm **AA4-WeA-14 Closing Remarks and Awards in Tamna Hall A***,*

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