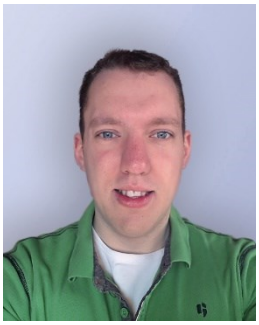
Dr. Adrie Mackus
Stanford University

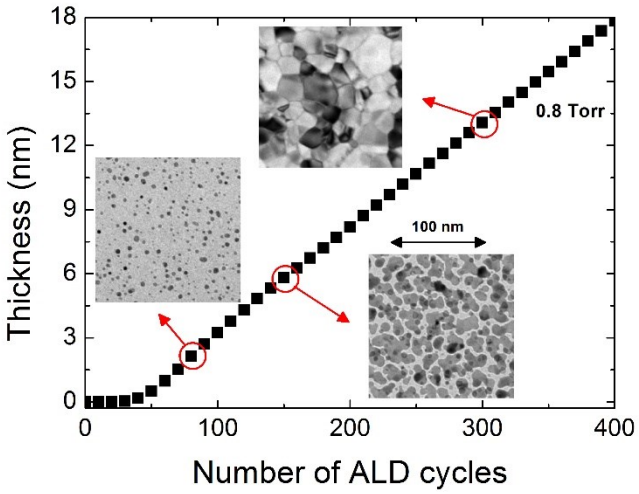


Roger Bosch
Eindhoven Univ. of Technology

ALD of metals: what about films or nanoparticles?

Summary

The deposition of (noble) metal thin films has attracted considerable attention in the last decade for various applications in microelectronics. Metal ALD typically suffers from poor nucleation and initiates as island growth, and consequently, many ALD cycles need to be carried out to obtain a closed film. In many recent studies, this so-called Volmer-Weber growth has been exploited to synthesize metallic nanoparticles for catalysis applications. By combining different metal ALD processes, also bimetallic and core/shell nanoparticles can be deposited. Although the reaction mechanisms of metal film growth have been studied extensively, not much is known about how the surface chemistry is different during the nucleation phase. Complex processes such as the diffusion of deposited atoms, particle sintering, and particle size-dependent catalytic surface reactions can play a role during this nucleation phase.



Film thickness as a function of the number of cycles for Pt ALD on Al_2O_3 as obtained by in situ spectroscopic ellipsometry data. The TEM images illustrate that Pt ALD evolves from island growth, via island coalescence, to film closure.

In this session we will discuss the growth and the underlying reaction mechanisms of metal ALD. Special attention will be given to the nucleation phase and it will be discussed how to exploit the Volmer-Weber growth to synthesize nanoparticles with control of the particle size.

Outline of the overview presentation

The following topics will be addressed:

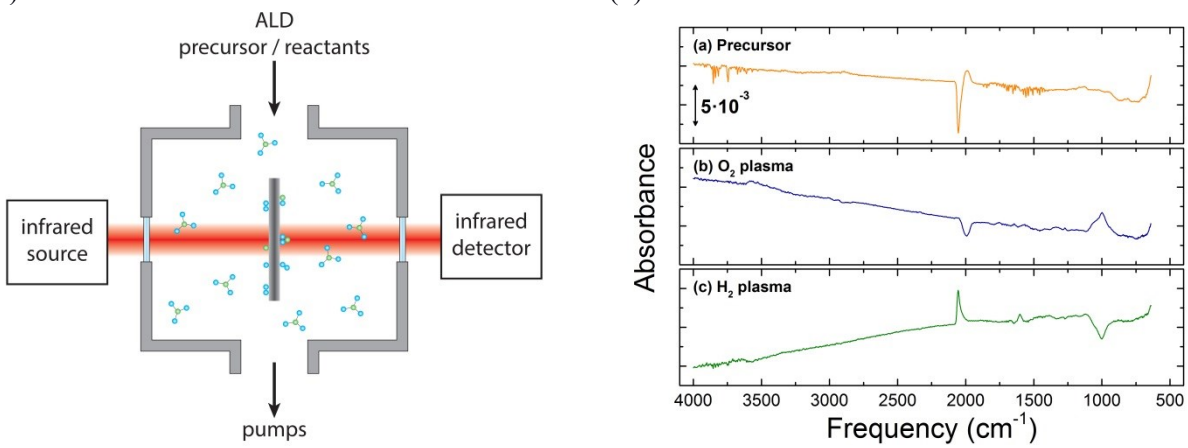
- Overview of the developed processes for metal ALD
- Reaction mechanism of Pt ALD
- The surface science of the Pt surface: interaction with O_2 / hydrocarbon species
- The importance of catalytic surface reactions in the reaction mechanism
- Nucleation on various surfaces

- Why does ALD of metals typically start with island growth?
- Nanoparticle synthesis with control of the particle size, composition, and structure
- The opportunities of ALD for catalysis applications

Case Study

Pt can be deposited at lower temperatures, down to room temperature, using a three-step plasma-assisted ALD process. This process uses $MeCpPtMe_3$ as precursor and O_2 and H_2 plasmas as co-reactants. The O_2 plasma removes any carbonaceous species from the surface which remained there after the precursor dose. The H_2 plasma removes the surface oxygen and reduces the deposited Pt. Nevertheless, the surface chemistry during the initial stages of the growth is still unknown or incomplete. Therefore, surface infrared spectroscopy has been applied to gain more insight into the surface chemistry of the ABC-like Pt ALD process, as will be shown in this presentation.

(a) (b)



(a) Schematic representation of infrared measurements within an ALD reactor. Surface species and/or surface species can be measured. (b) Typical surface infrared spectra of the precursor, O_2 plasma and H_2 plasma step during the room temperature Pt ALD process.

How to participate?

You can participate actively in the session about ALD of metals and metal nanoparticles by giving a short presentation or a pitch after the two presentations that are already scheduled. Please submit a short presentation clearly describing the **observation, issue or open question** that you would like to discuss to contact@nanomanufacturing.nl. We would like to receive your presentation **before the 29th of May**, which will allow sufficient time for us to evaluate your contribution. You might receive suggestions from the session coordinators to fit it in the session.

If your short-talk is accepted, you can chose to bring a poster in addition to giving the short talk. The poster will receive attention during the breaks and during lunch. The poster will allow you to present more background information and interesting findings which cannot be discussed during the sessions due to time constraints.