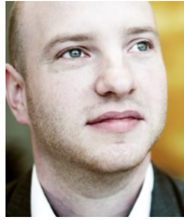
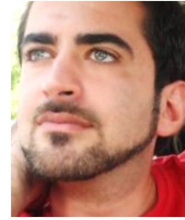
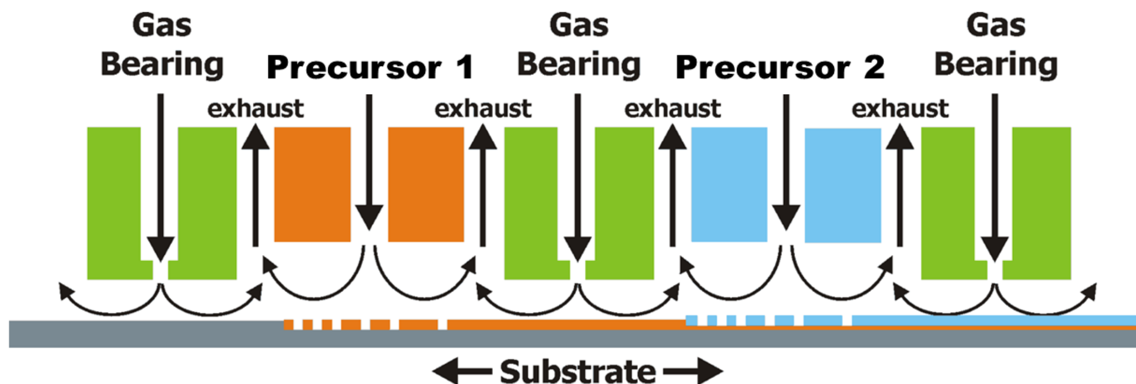

Dr. Paul Poodt
TNO


Alfredo Mameli
Eindhoven Univ. of Technology

# Spatial ALD vs Temporal ALD: What's different?

## Summary

Spatial Atomic Layer Deposition is an ALD method that emerged the past few years, allowing high throughput ALD for a number of applications and processes. It relies on a spatial separation of precursor exposures instead of temporal separation in conventional ALD. Spatial ALD has found use particular in large-area and/or flexible electronics, such as photovoltaics, OLED lighting and displays, where the unique qualities of ALD are a clear asset, but where high throughput processing (e.g, roll-to-roll) is required. There are several different ways to do Spatial ALD (atmospheric vs low-pressure, R2R, S2S, plasma, etc.) but in all cases it is an equipment enabled method and they share a common feature: it is all ALD.




*A Spatial ALD reaction scheme where the precursors are dosed simultaneously and continuously in half-reaction precursor zones separated by inert gas zones. Moving the substrate through two half-reaction zones completes one ALD cycle (Poodt et al., J. Vac. Sci. Technol. A 30, 010802 (2012)).*

In this session we try to identify differences and similarities between Spatial and Temporal ALD. We will discuss how high deposition rates can be achieved, and what limits deposition rates in both cases. We will review some specific Spatial ALD topics, including the difference between atmospheric and low-pressure ALD and ALD kinetics. Finally we will touch upon the balance between deposition rate, uniformity, performance and costs which will for a large part determine whether or not it makes sense to use Spatial ALD for a specific application.

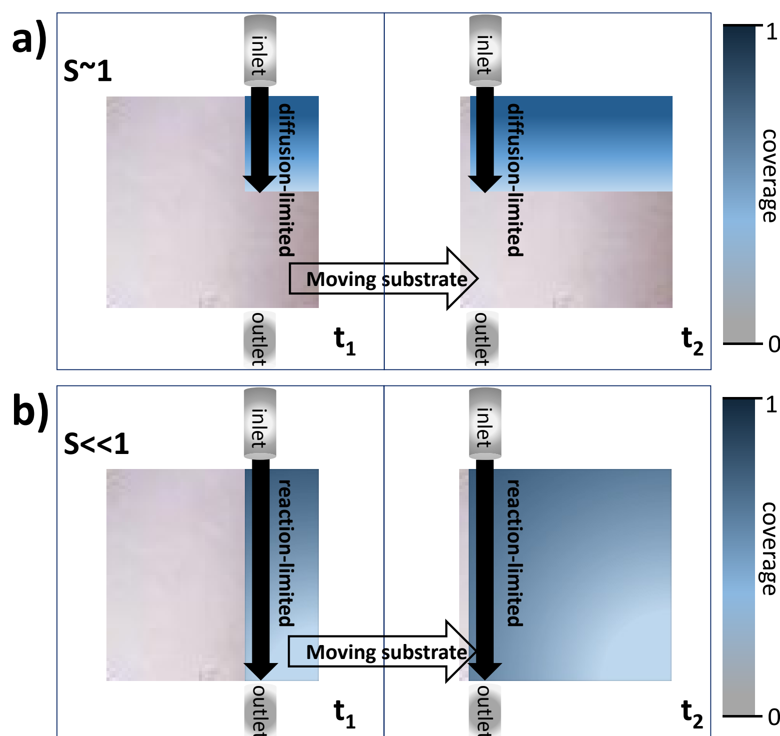
## Outline of the overview presentation

The following topics will be addressed during the introduction:

- Basic introduction Spatial ALD and comparison with conventional ALD
- Time scales in ALD, and what does “deposition rate” mean in ALD
- Atmospheric vs. low-pressure ALD
- Kinetics of Spatial ALD
- The balance between deposition rate, uniformity, performance and costs

## Case Study

Whether or not Spatial ALD can be efficiently used to speed up ALD processing depends on a combination of hardware and chemistry. In this case study we focus on the chemistry of the process as a key parameter that determines uniformity, throughput and precursor utilization efficiency. We address the chemistry aspect by considering the influence of the sticking probability (S) of precursors/reactants, a microscopic parameter that determines how fast an ALD half-reaction proceeds. A Monte Carlo Simulation has been developed to assess the relevance of the sticking probability distinguishing two fundamentally different deposition regimes: **(a)** the diffusion limited and **(b)** the reaction limited regime. In the first case the coverage uniformity can be controlled by adjusting the molar flow, while in the latter case the timescale to achieve a fully saturated chemisorbed layer is determined by the kinetics of adsorption, so that a fully saturated surface will generally require slower processing speed.




***(a)** A diffusion-limited regime is typically obtained for a process with precursor with a high sticking probability. By controlling experimental parameters saturation can be achieved at high processing speed.*
***(b)** A reaction-limited regime is typically obtained for a process with precursor with a low sticking probability. In this situation a more uniform chemisorption onto the surface is achieved, but the saturation time is now dictated by the sticking probability.*

## How to participate?

You can participate actively in the session about Spatial ALD 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 29$^{th}$ of May**, which will allow sufficient time for us to evaluate your contribution. You might receive suggestions from the session coordinators to fit it better 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.