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# Augmented reality representation for the investigation of simulated inclined chromium thin films

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## Introduction

The PVD process produces coatings with columnar morphology. In OAD technologies, the columnar aspect is even more pronounced and becomes a major factor in the properties of the film.

In this study, an OAD simulation is investigated using existing softwares as well as tools developed specifically in order to better take into account the columnar morphology of the film. The simulation results are then presented using 2D SEM-like images while also adding an augmented reality overlayer to offer a more immersive experience and break through some of the limits of the 2D representation.

## Coating representation

The simulations in this study reproduce an experimental setup, where chromium thin films are synthesized on substrates with different inclination angles. The deposition occurred under argon pressure of 0.22 Pa and the distance between the target and each substrate is 0.15 m.

The growth simulation are run using the Virtual Coater NASCAM.

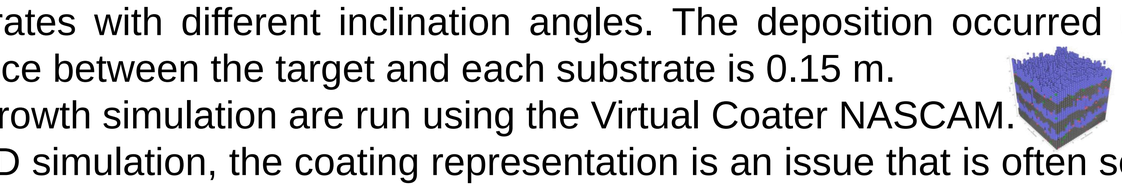
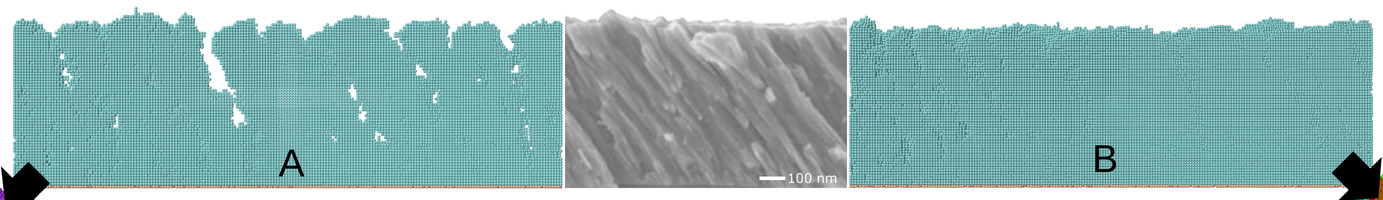



*Image of the modelized deposition setup in SIMTRA*

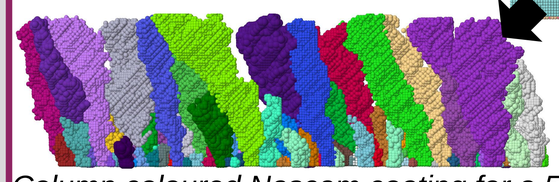
In PVD simulation, the coating representation is an issue that is often secondary compared to the evaluation of the physics of the film deposition. This directly translates to a poor readability of the simulation results, mostly for untrained eyes. As an example, two images of the same simulation (except the depth of the simulation box, 10 and 100 unit respectively), and represented using Jmol (Nascam default viewer), are presented below (A and B).

Porous ?
High angle ?



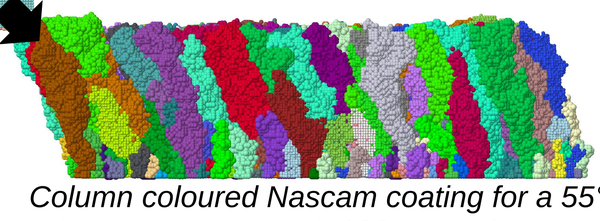

Dense ?
Low angle ?

*SEM image of a chromium OAD coating at 50° of incidence*



*Column coloured Nascam coating for a 55° incidence angle with 10 units of depth*

Using our home-made column segmentation algorithm[1] and the attribution of colors for each individual column improves the perception.

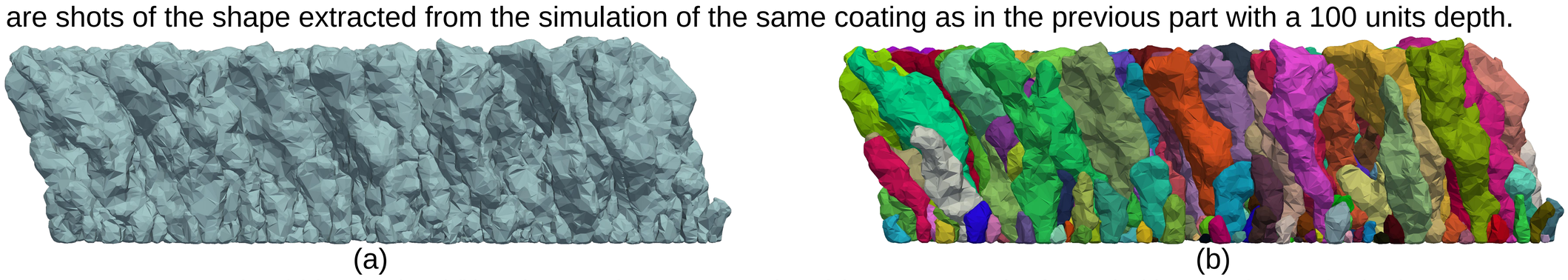


*Column coloured Nascam coating for a 55° incidence angle with 100 units of depth*

[1] Watiez, N. *et al.* (2023). Finite Element Mesh Generation for Nano-scale Modeling of Tilted Columnar Thin Films for Numerical Simulation, PLM 2022

## Making use of the augmented reality

Even with added coloration, the Jmol viewer has limits in the representation of coatings, particularly for high depths due to a lack of shading. This has been dealt with using 3D surface recreated from the simulation results through an algorithm developed in LaBoMaP[1]. The following images are shots of the shape extracted from the simulation of the same coating as in the previous part with a 100 units depth.



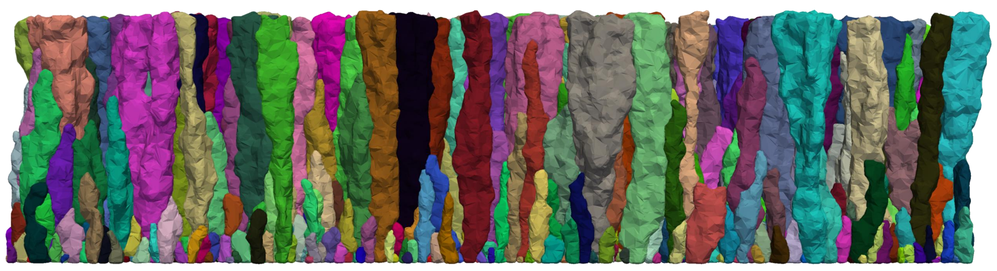
(a) (b)

*Uncolored (a) and colored (b) 2D images of 3D representation of the Nascam coating for 55° incidence and 100 units depth*

It is obvious that even without the coloring, the representation is a more readable than the one from Jmol. This format although better for a 2D representation, only really shines due to the ease of incorporation in any 3D viewing platform, allowing for more freedom compared to a simple 2D visualisation. With this kind of representation, it is possible not only to have a view any side of the coating but also to move around and even inside the coating.

Through an **augmented reality application**, it is possible to add an immersive and intuitive experience to the reader by breaking through the shackles of the 2D frame imposed by the poster.

Some interactions are even possible to implement between the viewer and the coating, i.e. to switch between a normal “compact” view and an “exploded” view.



*Colored 2D image of 3D representation of the Nascam coating for 0° incidence and 100 units depth*

## Conclusions

- The columnar colorization of the coating helps the immediate visualization of the columnar angles and shape, as well as giving insight into the properties of the film.
- The 2D representation with shading is particularly useful when looking for the morphological properties of the whole film and can be combined with the columnar colorization.
- The augmented reality as used in this study is mostly a mean of enhancing communication through easier portable visualization compared to regular 2D shots of the 3D structure.
- The augmented reality can be easily implemented from any surface- or volume-based 3D structure such as meshes.