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Thickness prediction and uniformity optimization of films deposited by PVD on complexes substrates in motion

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Plasma thin film (≤10 µm) deposition nowadays state-of-the-art technology is used to provide added value to 2D and 3D complex substrates. Nevertheless, the deposition of films with uniform thickness on 3D complex shapes is still a challenge for various deposition systems. In the case of magnetron sputtering, concavities and different substrate orientations lead to macroscopic shadowing and affect the thickness uniformity. Also, the thickness uniformity for each part may be strongly affected by the load ratio of the chamber. The aim of this work is to present the current state of the implementation of multiple algorithms to tackle the challenge: the prediction and optimization of films thickness deposited by PVD technics on complexe shapes in rotation.
First, we use oriented meshed objects to describe the complex shape of the substrate. This meshing is performed with a Delaunay triangulation to minimize the triangular meshes angles. Secondly, we compute the start positions, directions and energies of the particles. Thirdly, these are transported through the gas phase by a combination of a 3D Monte-Carlo simulation describing the transport and a “Pseudo-Verlet-linked-cells-list” algorithm used to speed-up the simulation. For the detection of the atoms on the meshes, we use techniques of back-faces culling which take automatically into account the shadowing from the substrate itself or from other substrates in the chamber. This combination of algorithms allow us to predict the films thickness on a high amount of substrates in motion (multiple rotations) in a chamber whatever the cathode shape, position and the metal sputtered. Finally, a genetic algorithm is combined to the transport code to obtain the best experimental parameters leading to the maximum of uniformity. Experimental chrome deposition with a bipolar pulsed system on high shadowed substrates installed on planetary rotation axis has been performed to validate the code. Experimental and simulation results presents a general good accordance.

Keywords
PVD
Simulation
Uniformity Optimization
Complexe substrates