
Uniformity Optimization for Static Substrates Using the Swing DUO™ Software

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DWELL BASED SWING CATHODE MOTION PROFILES

When using an array of rotary magnetrons to coat static substrates, the coating uniformity is typically a function of the physical arrangement between the cathodes and the substrates. To improve the coating uniformity, equipment suppliers and end users utilize techniques such as using curved cathode arrays, moving the magnet bar within the cathode, and turning off the plasma while moving the magnet bar based on the relative magnet bar angle. The Swing DUO™ software uses a different approach to improve the coating uniformity. Instead of changing the physical location of the cathode relative to the substrate or turning off the plasma during the magnet bar motion, the Swing DUO™ software uses variable time dwells in the motion profile to apply specific amounts of coating at key angles.

INPUT VARIABLES

The simple web based input interface makes setting up a simulation based on existing hardware extremely easy. Drop down menus allow for the selection of the magnet bar type and the number of degrees per step. The number of cathodes, target material diameter, target to substrate distance, substrate width, and cathode spacing are all text based numerical inputs that have an example of the geometry available when you click the question mark next to the input.

The magnet bar input is restricted to a selection of the TRM, mQRM, or QRM magnet bar. The sputter angle for each magnet bar is already loaded into the software allowing customers to run simulations with each design.

The degrees per step input parameter defines the number of dwell angles to simulate. Larger

numbers such as 10 degrees per step will allow the simulation to solve much faster but may degrade the optimum uniformity. Using larger degrees per step numbers is useful for determining the initial geometry for an application while the smaller degree per step numbers are useful for determining the final motion profile.

The number of cathodes input is a critical input that requires careful consideration. An even number of cathodes may be required if the deposition process uses AC or Bi-Polar DC power supplies. An odd number of cathodes may be used for processes requiring DC or Pulse DC power supplies.

When the number of cathodes is combined with the cathode spacing variable, the position of the cathodes at either end of the array needs to be taken into careful consideration. Cathodes that are too close to the edge or past the edge of the substrate will end up depositing a large amount of the target material off the edge of the substrate as waste. For expensive target materials such as ceramic ITO, the designer may want to try to minimize wasted sputtered material. It is also important to consider leaving enough space between cathodes to perform maintenance or for components that may need to be located between the cathodes such as gas manifolds and anodes.

The target to substrate distance (TTS) is also a very important variable. The value for this variable is the distance between new target tube and the substrate. The first order of importance of the TTS is to match the sputter process. Most applications work with TTS values in the 100-150mm range while some may require larger TTS values. If your process and or chamber can accommodate a TTS range then

it is important to analyze the values within that range to determine if the motion profile would need to be changed during the life of the target material. This can be examined by decreasing the target diameter and increasing the TTS by half the amount of the target diameter change. If the resulting uniformity along the lifetime of the target material is acceptable then a single motion profile can be used at all times. If the uniformity is not acceptable over the lifetime of the target material then two or more motion profiles may need to be used as a function of the target diameter.

SIMULATION OUTPUT

The main visual output is the uniformity profile graph. This graph shows the resultant coating from the array as “Sum” and the contribution from each individual cathode as shown in figure 1. The edges of the substrate are shown as small black vertical lines along the Sum output line.

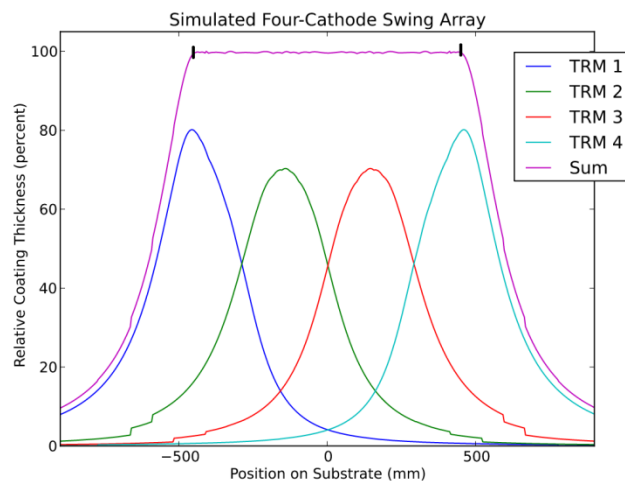


Figure 1: Deposition Uniformity Graph

The raw data for the deposition uniformity graph can be downloaded in a CSV format by clicking on the link named “Simulation Output”.

The data is automatically analyzed and provides statistics on the +/-percent uniformity across the center region (the entire substrate), the total percent of output deposited on neighbors (material deposited from one target to another), the total percent of output beyond the edge of the substrate

(material that is deposited off the substrate along the substrate width), and the percent of output not deposited on the substrate (total wasted material from the cathode array along the width of the substrate).

The other visual output provided by the simulation program is a 2D cross section of the cathode and substrate arrangement that includes a visualization of the dwell angle and times. The blue circles are the cathodes, the green horizontal line is the substrate, and the purple blocks represent the critical dwell angles and the amount of time spent at them. The further the purple blocks protrude from the blue circle the longer the dwell time.

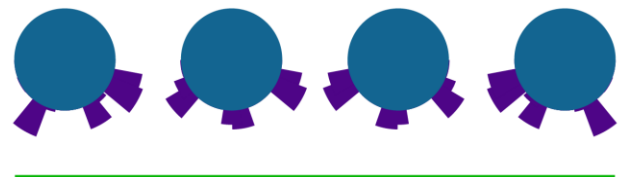


Figure 2: 2D Dwell Motion Visualization

By clicking on the link above the dwell motion visualization named “Cathode Configuration” all of the simulation settings and the motion profiles for each cathode are available in a text file.

SIMMULATION REFINEMENT

Another important feature of the Swing DUO™ software is the ability to put actual measured uniformity data back into the simulator and have it create a new optimization profile to help the user overcome uniformity problems. A table with the y-axis as a normalized (0-1 scale) uniformity and the x-axis as distance from the center of the substrate can be copied and pasted into the box labeled “Correction Data”. Once all of the other parameters are set correctly to match the system the data was created from, the simulator can create a new motion profile table to correct for the uniformity issues experience in the original test.