Sputtering onto Large Area Static Substrates using the Swing Cathode

P. Morse, R. Lovro, M. Rost, and J. German, Sputtering Components, Inc.,
Minnesota, United States

THE COATING OF LARGE AREA STATIC SUBSTRATES

To reduce the probability of generating particles that can contaminate the substrate during the deposition processes, flat panel display makers do not move the substrate while the deposition takes place. To maintain the required coating uniformity along the length and width of the substrate that would be achievable in a standard large area coater, the magnetrons are installed in arrays that are specially designed to spread out the deposition flux. In the past the most common way this has been done is to use large planar magnetrons that have magnet packs that sweep side to side across wide “wall” of target material.

Large planar magnetrons with moving magnet packs work to deposit the required coatings but suffer from lower sputter rates and power densities due to inefficient target cooling, arcing caused by redeposition of sputtered material on areas of the target not actively being sputtered, and low target utilization. Rotary magnetrons address all of these issues but with the geometry constraints of target tubes instead of large flat targets. They lose the ability for a single source to scan along parallel to a static substrate's surface. To overcome the geometrical limitations of rotary cathodes they are arranged into arrays with overlapping sputter deposition profiles as shown in figure 1.

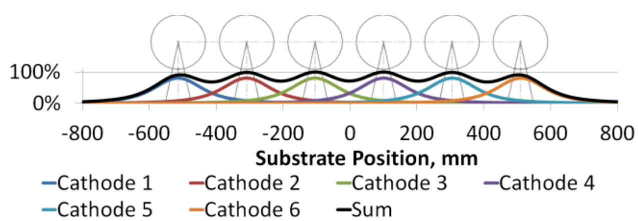

Figure 1: Simulated sputter distribution for a standard rotary magnetron static magnet bar array, +/-16% over 900mm.

An optimized array of standard rotary magnetrons can possibly meet or exceed the uniformity requirements of many processes but is still plagued with one key problem - the sputtered material distribution profile changes as the target material wears away as shown in the simulations in figures 2 and 3.

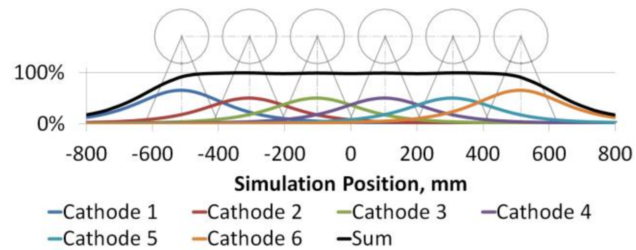

Figure 2: Optimized static magnet bar array using the QRM, varied power, and 175mm TTS, +/-1% uniformity across the center 900mm.

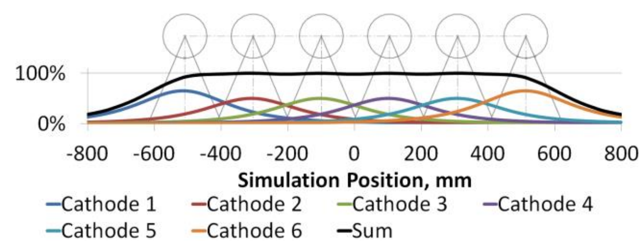

Figure 3: Simulated varied power deposition profile for an optimized static cathode array with used targets, the uniformity drops to +/-1.5%, different sputter rates would make the targets different diameters reducing the uniformity even further.

When optimized, a standard rotary magnetron array may seem like an adequate solution but there are other disadvantages that arise from a configuration like this. When the distance from the substrate to the target material (TTS) is 175mm, the target tubes need to be significantly longer than the height of the substrate-at least an extra 700mm. This leads to increased target material and coater costs. In addition, the large variance in power required to boost the deposition rates at the ends translates to the end targets wearing away much faster than the center targets. Having targets wear away at different rates can lead to uniformity issues that cannot be compensated for by adjusting the power ratios. To overcome all of these issues and limitation the magnet bar can be rotated with specific movement profiles inside the target tube using the Swing Cathode™.

THE SWING CATHODE™

The addition of a rotary axis on which the magnet bar moves independent of the target tube allows the Swing Cathode™ to overcome the optimization constraints of a standard cathode array and allows for the sputter flux profile compensation required as the target surfaces wear away. The construction of the cathode is a standard side mount cathode with the addition of bearings, seals, and a servo motor that allow the magnet pack to be precisely controlled.

Figure 4: Swing Cathode Assembly with the target rotation motor on the right and the magnet bar servo on the left

THEORY OF OPERATION

The motion profile used to control the magnet bar movement is a function of the array geometry and can be simulated and optimized for customer specific geometries. These simulations can be used to create a CAM motion profile table that is used to control the servo that turns the magnet bar. Figure 5 illustrates a typical 6 magnetron Swing Cathode™ array design for a 900mm long static substrate.

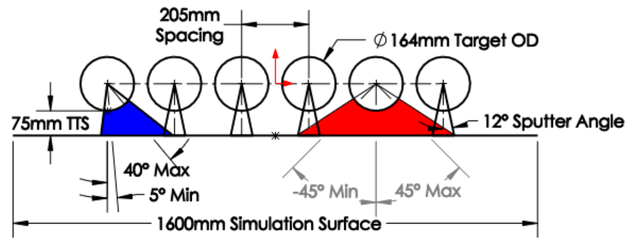

Figure 5: A six swing cathode layout using TRM magnet bars, 75mm TTS, and a 205mm cathode spacing.

The ability to set independent cathodes motions for each cathode can reduce or eliminate the need to run the cathodes at different power set points. The independent movement will help even out the erosion rate between the targets and reduce the amount of wasted sputtered material at the ends of the arrays as shown in figure 5. The resulting deposition profiles are much more efficient than the static profiles and are capable of reducing cycle times by running all of the cathodes at higher powers.

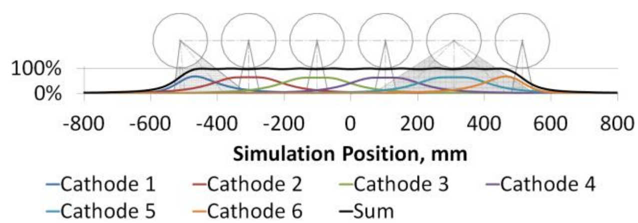

Figure 6: Simulated Swing Cathode Deposition Profile for the geometry in figure 5. The uniformity is better than +/-1%.

If used with the mQRM magnet bar at an initial TTS of 100mm with 225mm cathode spacing the swing cathode is capable of producing a coating uniformity within +/-1% over the entire lifetime of the target material.

CONCLUSION

The use of rotary cathodes renders the use of large moving magnet pack planar magnetrons obsolete for most large area sputtering applications due to the superior process stability, deposition rates, target material utilization, and target lifetimes achieved by the Swing Cathode™ assembly. The use of rotary cathodes with fixed magnet packs requires very specific array and system geometries to achieve uniformity requirements. The Swing Cathode™ enables the possibility of retrofitting existing planar magnetron systems with rotary magnetrons or the design of new compact efficient deposition systems.