Space-charge effects during sputter deposition of MgO

Abstract
The influence of energetic negative ions originating from a poisoned planar magnetron target during reactive DC sputtering in Ar/O\textsubscript{2} is investigated. Measurements are done by energy resolved mass spectrometry and passive thermal probe measurements. When a comparison with results from an ion beam simulation code (IBSImu), a significant influence due to space-charge effects can be identified.

Experimental setup
The passive thermal probe and mass-spectrometer are aligned under the target erosion profile at a distance of 9 cm. Measurements are carried out on a fresh uneroded target. Erosion of the target influences how the energetic negative ions are emitted. The vacuum chamber is pumped down to a background pressure of 1E-6 mbar and the target is operated at a constant current of 0.44 A. Between the measurements the target is cleaned under pure Ar atmosphere (0.8 Pa) until a constant voltage is reached.

Simulation
- erosion profile = distribution of ejected particles
- particles emitted normal to the erosion profile surface
- energy = V\textsubscript{Discharge} * charge
- I\textsubscript{Probe} * V\textsubscript{Discharge} / S\textsubscript{Probe} = Energy flux
- only accounts for space-charge effects

Difference small vs large acceptance angle
- erosion = 1mm
- spreading at high densities

T - probe

Results

CeO\textsubscript{2}
The MgO simulations explain the maximum with an eroded target. However up till now we haven’t found an good agreement between experiment and simulation. For CeO\textsubscript{2} we found a good match using this technique. This results in a negative oxygen yield Y\textsubscript{O\textsubscript{2}} = 1.75 \%. P\textsubscript{CeO\textsubscript{2}} = P\textsubscript{MgO} \textbf{–} \textbf{N}\textsubscript{MgO} = 2*V\textsubscript{CeO\textsubscript{2}} and V\textsubscript{MgO} = V\textsubscript{CeO\textsubscript{2}}/2.
This makes that the space-charge effects are stronger in MgO making it a more complex problem.

Conclusion
It is clear that space-charge has significant effects on the distribution of energetic negative ions. Furthermore space-charge effects can explain the different behavior of energy flux and mass spectrometry. The strongest manifestations of space-charge effects are noticed where high densities would occur without space charge hence it does explain the deficit in energy-flux for a non eroded target. By comparison of the simulated energy flux with the one measured with the passive thermal probe it is possible to estimate the negative ion yield. Due to the stronger space charge effects when using MgO we haven’t found the correct current yet.

Mission statement
At DRAFT we want to become the recognized leader in the understanding of thin film growth by reactive magnetron sputtering and to enjoy research by experiments and simulations.