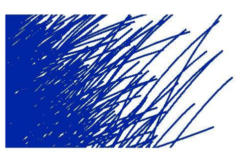

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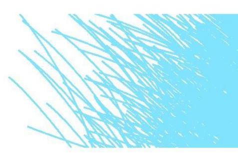

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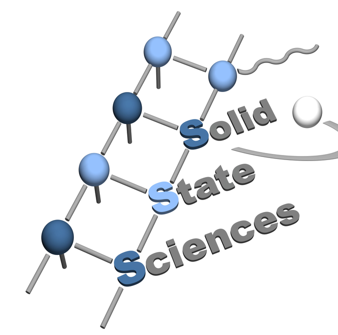


DRAFT
Dedicated Research on Advanced Films and Targets

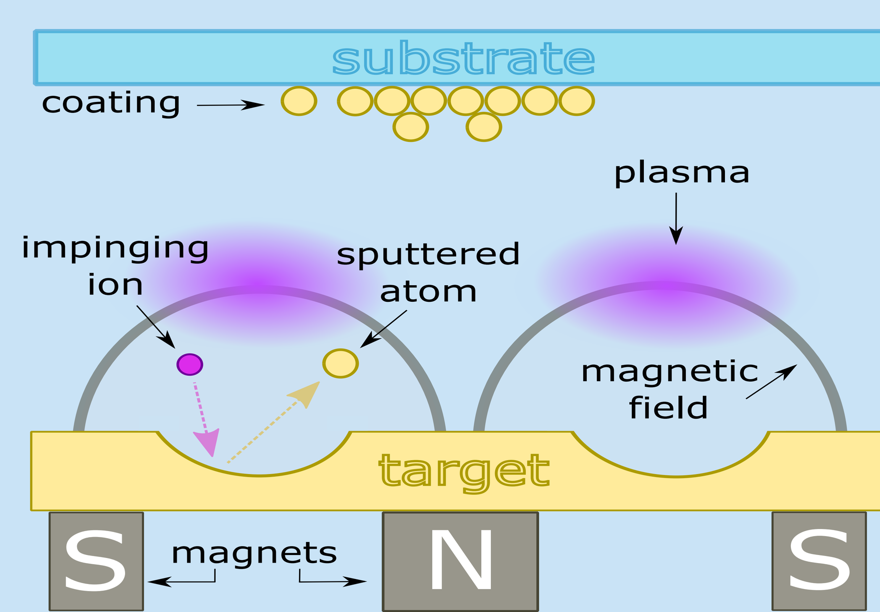
On the existence of a double S-shaped process curve during reactive magnetron sputtering

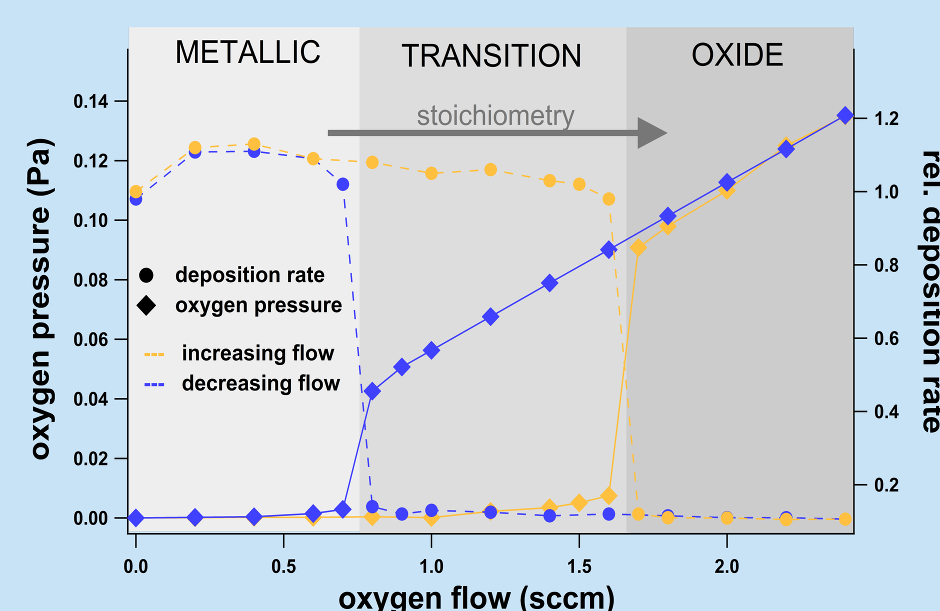
Abstract

The four dimensional parameter space (discharge voltage and current, reactive gas flow and pressure) related to a reactive Ar/O_2 DC magnetron discharge with an aluminum target was acquired by measuring current-voltage characteristics at different oxygen flows. The projection onto the pressure-flow plane allows to study the well-known S-shaped process curve. This novel experimental procedure guarantees no time dependent effects. The obtained process curve appears not to be unique, but rather two significantly different S-shaped curves are noticed which depend on the history of the steady state target condition. As such, this result has not only an important impact on the fundamental description of the reactive sputtering process. It can also have its consequences on the typical feedback control systems for the operation in the transition regime of the hysteresis during reactive magnetron sputtering.

Reactive Magnetron Sputtering Deposition

- Magnetron: magnetically enhanced glow discharge
- Sputtering: ejection of atoms by energetic particle bombardement
- Deposition: formation of a thin film or coating





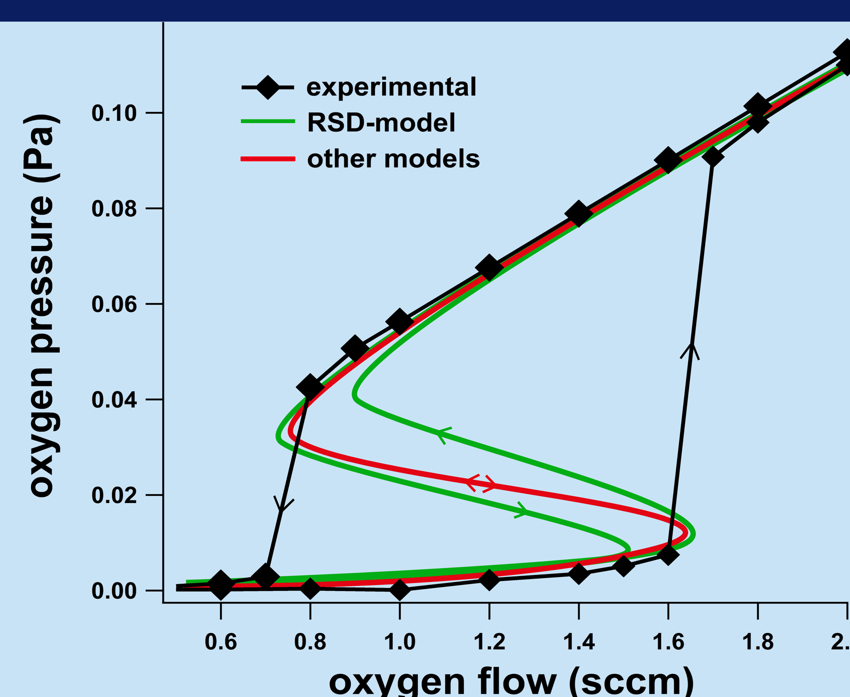
- Reactive: addition of reactive gasses allows compound formation of variable stoichiometries

→ exhibits unwanted hysteresis effects!

Modelling the process = elucidating origin of hysteresis

other models

- hysteresis effects caused by avalanche mechanism at the substrate level
- single S-shaped process curve is unstable in transition region
- S-shaped curve experimentally verified using feedback systems



RSD-model [1-3]

- hysteresis effects caused by avalanche mechanism at the substrate level AND at the target level
- double S-shaped process curve is unstable in transition region[4]
- existence double S-shaped curve not yet vouched due to irreversible effects

Measuring the process curve, a novel experimental procedure

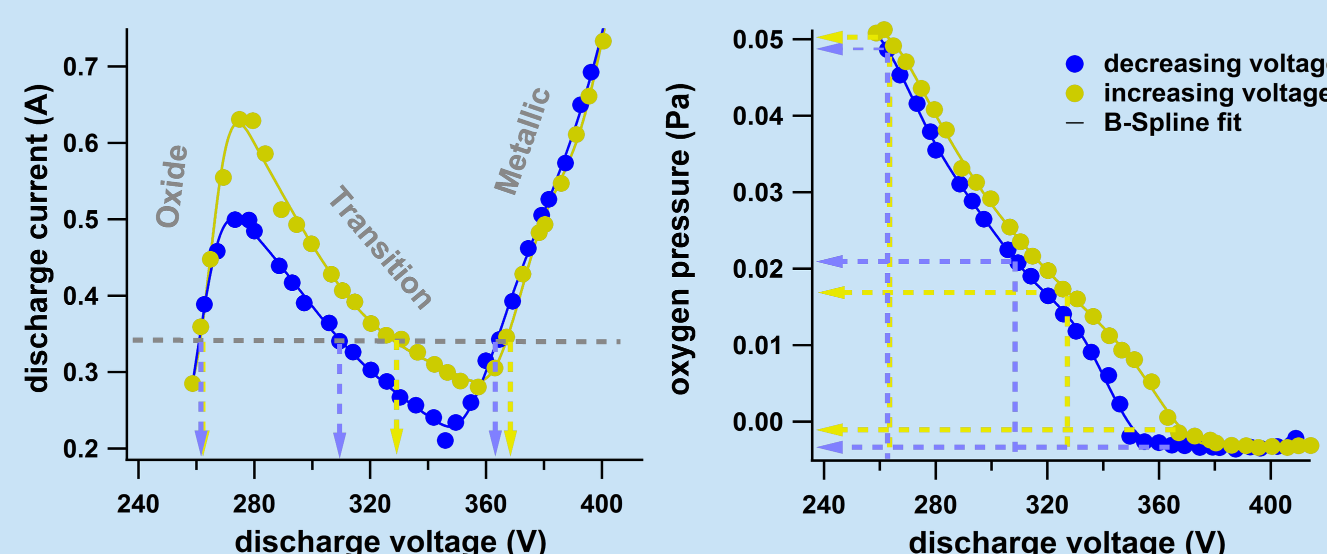
voltage controlled operation allows to stable operate in the transition region

↓

measure discharge current and oxygen pressure by varying voltage at fixed flow

↓

repeat at different oxygen flows



perform B-spline fitting to I-V and P-V curves

↓

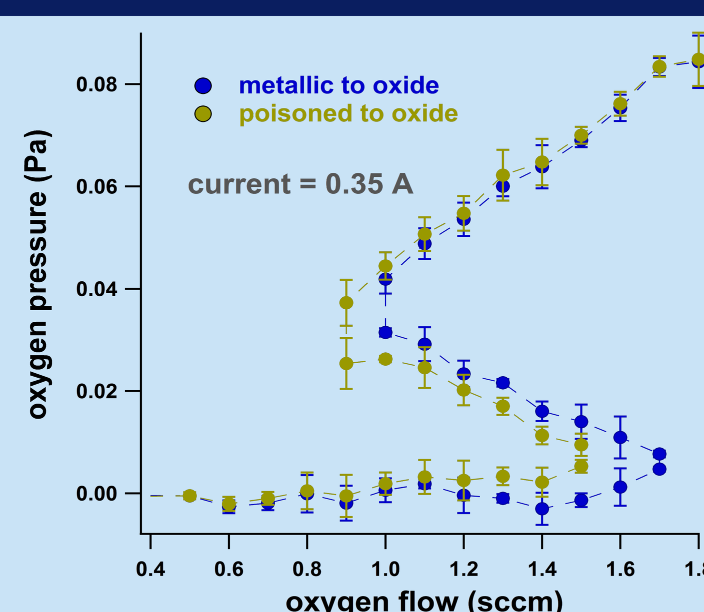
fill up the entire four dimensional (I, V, P, Q) parameter space

↓

project onto P-Q plane

Results and conclusion

- The experimental procedure excludes irreversible time dependent effects
- Two significantly S-shaped process curves are obtained depending on the history of the system
- The RSD-model succesfully predicts this fundamental behaviour



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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.

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