# Partial Pressure Control in Reactive Sputtering

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## Introduction

Reactive Sputtering is used to produce functional coatings having properties that are suitable for a range of applications such as decorative, wear resistant, optical and magnetic thin films.

In Reactive Sputtering a target material (e.g. titanium or aluminium) is sputtered in the presence of a reactive gas (e.g. oxygen or nitrogen) to produce a compound such as TiN or $Al_2O_3$.

Both the coating rate and film stoichiometry are sensitive functions of the reactive gas partial pressure and control of this pressure is key to producing good quality coatings with reasonable deposition rates.

At low partial pressures film compositions (and therefore properties) are not ideal. At higher partial pressures the target may be poisoned by reaction with the reactive gas. The ideal operating point is between these two extremes and past attempts have focused on controlling the flow of the reactive gas in order to maintain the partial pressure within this region. This has proved unsuitable however due to inherent instabilities and in practice forbids a range of very useful film compositions between the high and low reactive gas partial pressures (Fig.).

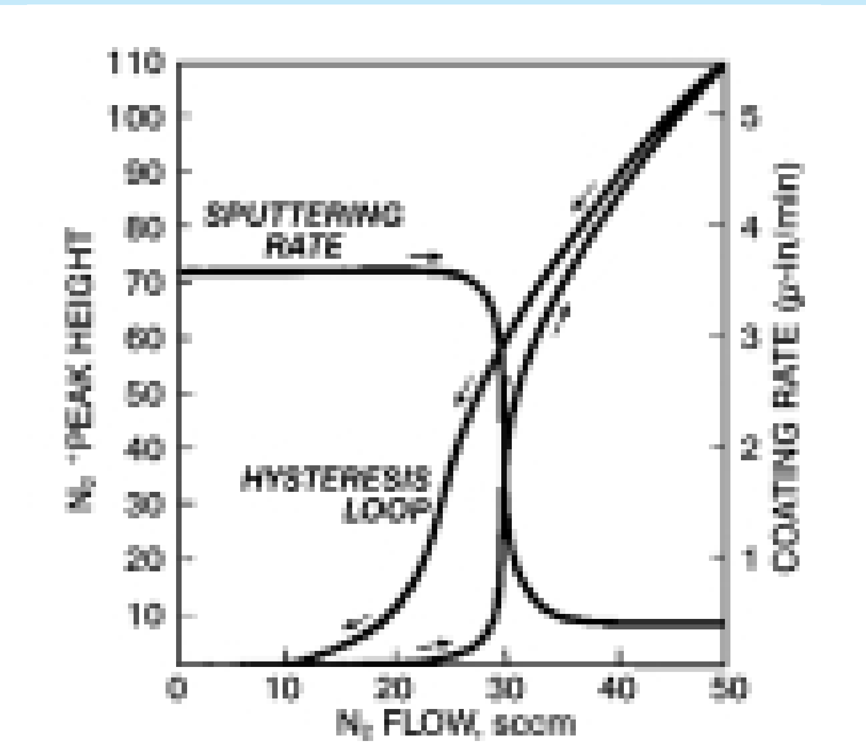



Fig. 1. The hysteresis curve for the reactive sputtering of titanium in an argon/nitrogen atmosphere using flow control of the reactive gas.

The solution is to control the reactive gas partial pressure directly, avoiding target poisoning and improving film composition and deposition rates (Fig. 2).

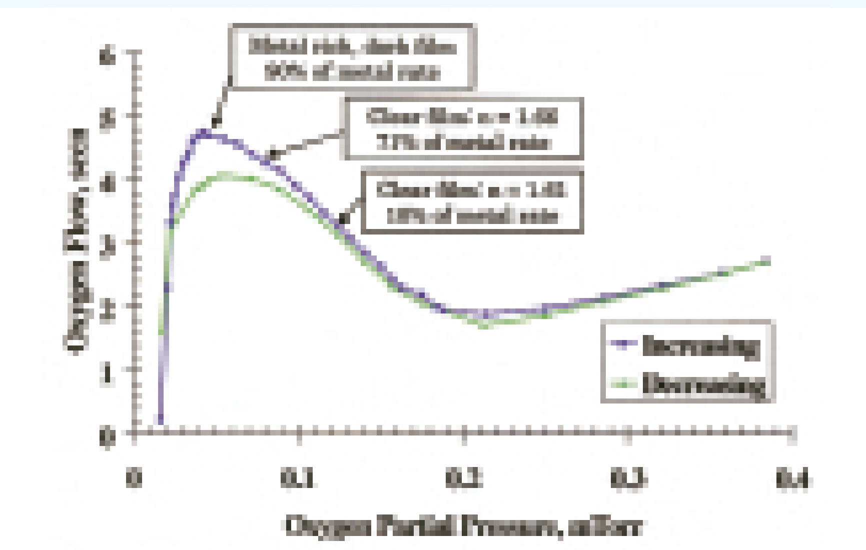



Fig. 2. Partial Pressure Control of index of refraction and deposition rate.

## HPR-30 Process Gas Analyser

Hiden Analytical's HPR-30 Process Gas Analyser is used to monitor the reactive gas partial pressures, providing the corresponding real time signal outputs for use in commercially available reactive sputtering control systems (e.g. Advanced Energy 'IRESS' controller).

The compact RGA/head manifold bolts directly to the coating chamber and samples process gases through a unique re-entrant aperture (Fig. 3).

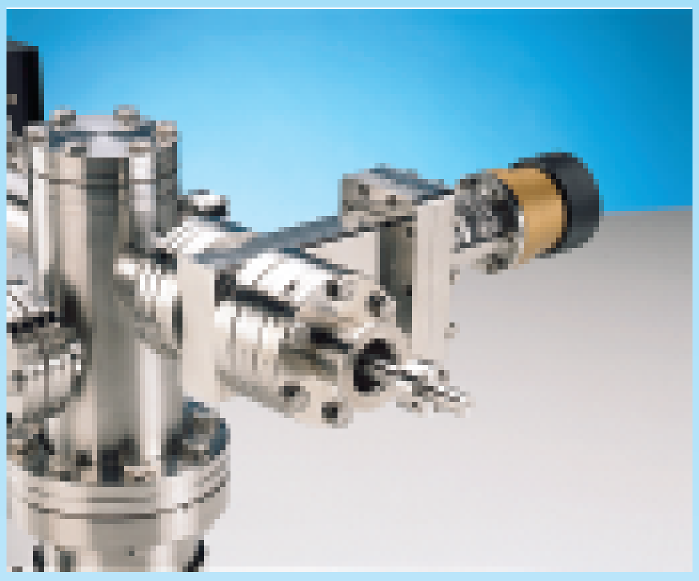


Fig. 3. Direct Partial Pressure measurement with the HPR-30 process gas analyser.

## Vacuum & Process Diagnostics

In addition to process measurements the HPR-30 is equipped with auto-switching inlet for accurate base pressure fingerprinting and vacuum diagnostics such as leak checking and contamination source identification (Figs. 4a and 4b).

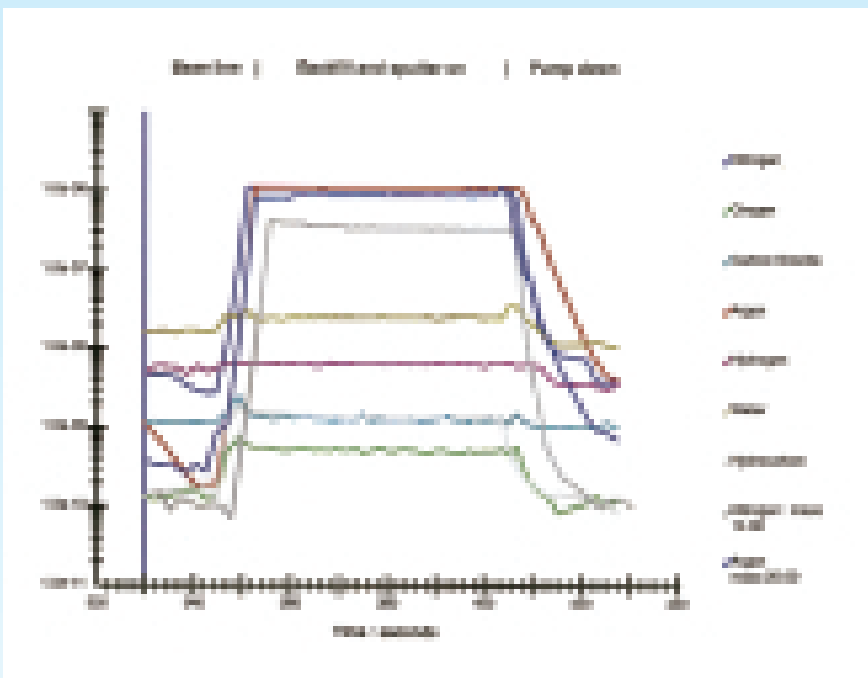
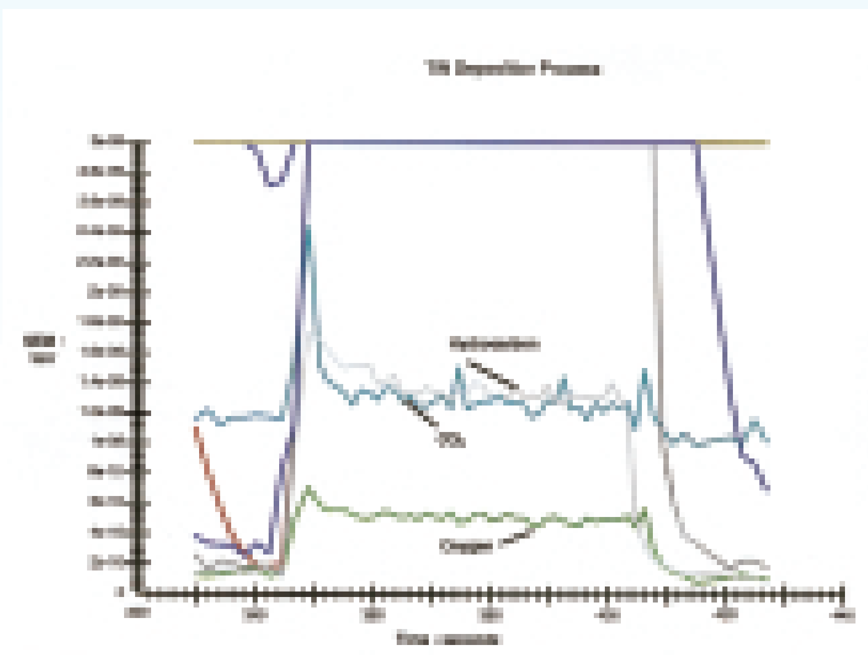


Fig. 4a (above) and 4b (below). Auto-switching inlet provides baseline vacuum diagnostics before and after process. The in-process background levels of hydrocarbons and oxygen below are in the ~100ppm range.



## Multi-Gas Reactive Sputtering

Two-gas reactive sputtering is sometimes used for decorative/functional coatings and has possible use for e.g. new high-k dielectric materials.

With flow control there are trapping zones where one of the reactive gases can trap the target in a poisoned mode (Fig. 5a) and which can only be recovered from by removing both of the reactive gases. Control of both reactive gases avoids this (Fig. 5b).

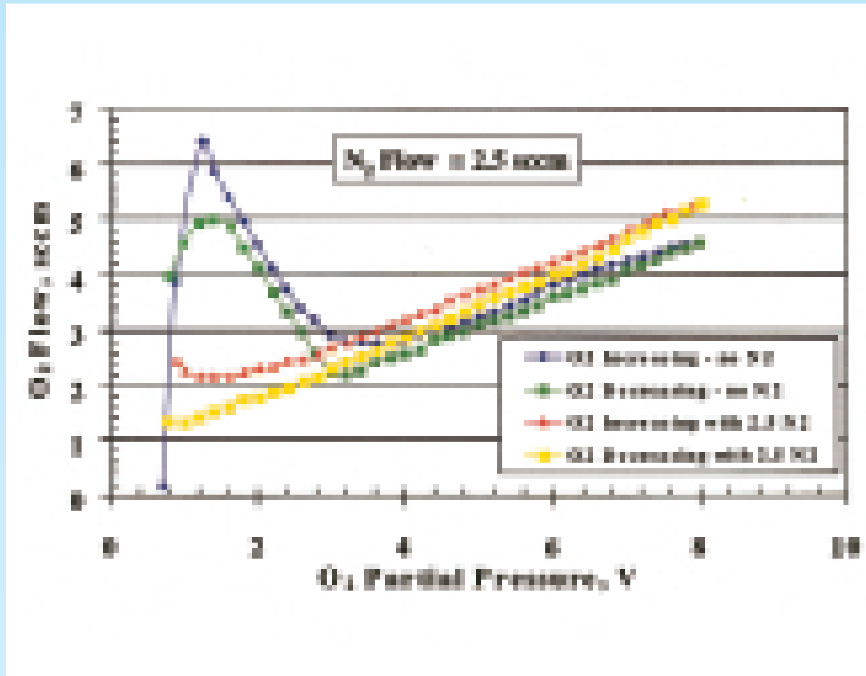
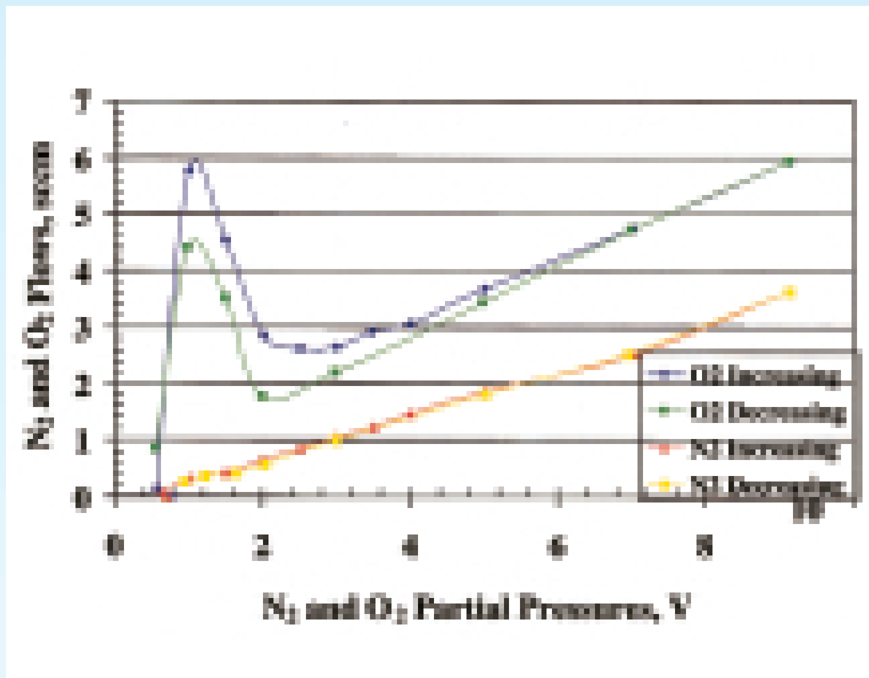



Fig. 5a (above). The addition of $N_2$ flow accelerates target poisoning for $AlO_xN_y$ but can be avoided with two-gas Partial Pressure Control (Fig. 5b, below).




## Conclusions

Partial pressure control allows stable operation in processing regions unavailable with simple flow control.

The deposition rate for the nitride increased from 0.4 to 3.5 microns.inch/minute by the use of partial pressure control.

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