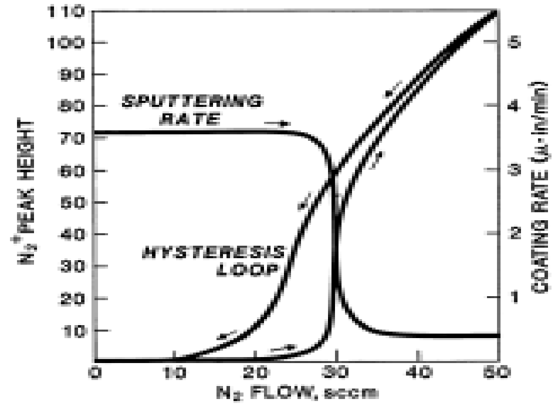
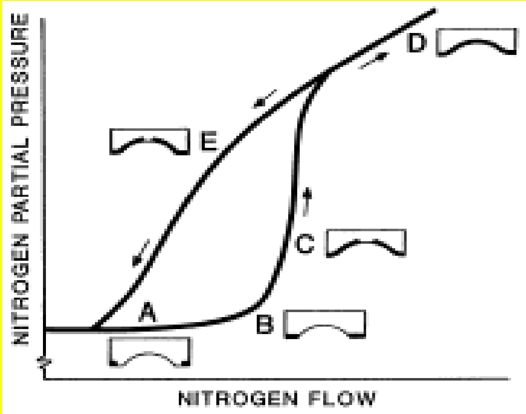


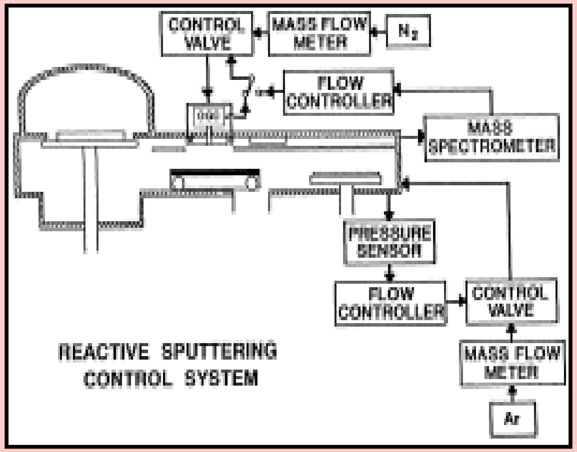

# The Key to Reactive Deposition

GENCOA

*The reactive sputtering process tends to be highly unstable. The reason for instability is illustrated on the left; which shows the metal sputter rate in a nitrogen gas atmosphere. As the $N_2$ flow is increased there is a sudden drop in deposition rate which correspond to the target surface becoming fully covered 'poisoned' by reaction product (which sputters at a low rate). Commonly, a high rate reactive deposition process will be operated between B&C. To work successfully in this region a rapid reactive gas control system is required.*

*Gas Control Solutions: The reactive sputtering process is unstable since any event (e.g. arc) can unbalance the amount of gas relative to the amount of sputtered material available. Hence, the target can quickly become fully poisoned (D), and even by reducing the gas flow (E), this will take time to recover back to the partially poisoned state (A). A gas control system is hence required to very rapidly adjust the amount of reactive gas in a system based upon a 'direct measure' of the amount of sputtered material in the plasma available to consume the gas. High levels of plasma ionisation (energy) makes the control 'envelope' bigger and control easier since the reaction of gas with sputtered atoms is favourable.*

*Mass Flow Control: This can work well if the chamber has a very high pumping speed relative to the target area being sputtered. The method is simple and robust but the pumping costs are high.*
*Mass Spectrometry Based Control: A high speed gas control system can be based around Mass Spectrometry which sense's and rapidly adjusts the gas going into the system (see below and Reactive Sputtering Inc.).*




*Voltage Control: This uses the change in the target voltage with reactive gas pressure to control the process. It is a non-intrusive and low cost method, but relies in a large voltage shift with gas input to operate, and is hence not suitable for all materials.*
*Lambda Sensor: This is a gas sensor located close to the deposition environment. It uses a direct measure of the sputtered species to control gas flow. (Applied Films technique).*
*Plasma Emission Monitoring (PEM): This is most common method if gas control and can also be used in combination with other techniques if required. An optical light signal from the plasma is passed through a monochromator or monochromatic filter. The level of intensity of this signal at a specific wavelength is proportional to the degree of target poisoning. Since the signal is 'at the speed of light' combined with the use of 'fast' electronics, the response times of the system very quick leading to good control.*
*Single channel systems (see Gencoa's reactaflo info) or multi-channel systems (FEP & Von Ardenne) are available on the market.*

*Small scale applications were the target size is around 0.5m or less in size are relatively simple to control with one of the aforementioned methods.*
*Large area coating however is much more difficult since the gas response times are much longer due to longer gas lines, and also uniformity of gas over a large area is hard to achieve in combination with the quick gas response time. In most cases a multi-channel system is required with multiple inputs. The control parameters need to be set in-situ since targets material, gas type, power, pumping, gas flow, & uniformity / rate requirements varies in different machines.*
*Gas valve type is also important aspect. The most commonly used valve is a piezo-electric which very rapidly adjusts the gas flow.*
*Gas delivery tube design needs to ensure that the gas gets from the valve to the system as quickly as possible. Hence,the valves should be on the chamber wall and small tube bores used. Also a flexible gas output mechanism is helpful to adjust gas distribution along the target length.*