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The (in)stability of process control mechanisms in reactive DC sputtering deposition

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The RSD model is currently the most advanced model to describe process curves during reactive DC magnetron sputtering deposition. It tries to implement the most essential chemical and physical processes to understand the most of the reactive sputtering process. The considered operation parameters in the model are the reactive/inert gas flow, the pumping speed, the discharge current/voltage/power and the target/substrate geometry. Together with the material dependent parameters like sputter yields, reaction coefficients, secondary electron emission yields,… they define the outlook of the process curves and especially their intrinsic instability properties which may manifest in hysteresis behavior. Indeed the RSD model is now capable in simulating a more broader range of process curves.
Getting control on the process and handling the possible hysteresis is one of the main concerns to obtain a desired thin film at an economical high deposition speed. Removing the hysteresis to establish stable process control is one way in obtaining these favorable deposition conditions. However, the approaches for hysteresis removal like increasing pumping speed/inert gas pressure or reducing target area, are either hard to establish or induce unfavorable working conditions. Another way is getting along with the hysteresis and access the unstable transition regime by feedback control which may make the process control more complex. However, it has been shown that this unstable transition regime can sometimes be operated stable when a right choice of controlling parameter is made. Its success depends basically on the material/reactive gas combination at hand and is primarily defined by the mutual difference in secondary electron emission yields of the metal and the formed compound. Such stabilization can for example be obtain for the Al/O_2 system while this is not the case for the Ti/O_2 system. Here the proposed solutions are investigated by the RSD model, with an emphasis on the origin why some material/reactive gas systems are intrinsic harder to control than others.

Keywords
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