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Very-high-rate reactive deposition of thick, transparent oxide coatings by pulsed AC dual magnetron with molten targets

Jindrich Musil[1], Vaclav Satava[1], Pavel Baroch[1]

[1]University of West Bohemia, Department of Physics, Plzen, Czech Republic

musil@kfy.zcu.cz

This article briefly summarizes the evolution of reactive magnetron sputtering of transparent oxide films and improvements of this process with the aim (1) to eliminate the hysteresis effect, (2) to suppress the arcing at the target and (3) to increase the deposition rate a_D. Main differences between (1) single magnetron and dual magnetron and (2) DC, pulsed DC and pulsed AC reactive process are explained. Special attention is devoted to the target power density used in reactive magnetron sputtering and to differences in this process when cold, hot and molten magnetron target is used. It is shown that the reactive deposition of transparent oxide films from molten target is a combined process in which both the sputtering and the evaporation of the target material participate simultaneously. At high target power densities $W_{ta} \geq 50$ W/cm^2 (this value depends on the target cooling) averaged over pulse period the ionized evaporation of the target dominates over the sputtering and the deposition rate a_D of the transparent oxide film is greater than its deposition rate $a_{D\,MM}$ at the end of the metallic mode with cold target, i.e. $a_D >> a_{D\,MM}$. These statements were demonstrated on the very-high-rate (up to 814 nm/min) reactive deposition of thick (up to 8000 nm) transparent silicon dioxide coatings containing low amount (<5 at.%) of Zr on a stationary substrate located at the substrate-to-target distance $d_{s\text{-}t}$=100 mm by the pulsed AC dual magnetron with molten target operated at $W_{ta} \geq 50$ W/cm^2. It is shown that these reactively sputtered transparent Si-Zr-O coatings are very elastic and exhibit excellent resilient properties. The very-high-rate reactive deposition of thick transparent Al_2O_3 coatings is also reported. Performed experiments indicate that there are no principal reasons which prevent to increase the deposition rate a_D of thick transparent oxide films to several micrometers per minute, maybe several tens of micrometers per minute.

Keywords
Transparent oxide films
Reactive sputtering
Molten target
Ionized evaporation
High deposition rate