Suppression of arcing in DC pulse reactive magnetron sputtering

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Reactive magnetron sputtering of electrically insulating compounds suffers from arcing and hysteresis effect. Both phenomena are undesirable and need to be eliminated or at least strongly suppressed. It is well known that the arcing at the target can be easily avoided in DC pulse dual magnetron operated in the bipolar mode. To avoid arcing at the target of a single magnetron in the reactive sputtering of thin films is a more difficult task. This paper reports on the suppression of the arcing at the target of a DC pulse single magnetron during the reactive sputtering of alumina thin films. For this study an unbalanced magnetron (UM) with Al target of 100 mm in diameter was used. The UM was operated in a pure oxygen, i.e. in the oxide mode of sputtering, at the pressure $p_{O_2} = 1$ Pa and was supplied by a DC pulsed Advanced Energy Pinnacle™ Plus+ 5/5kW power supply operating in the bipolar current mode at the repetition frequencies ranging from 5 to 100 kHz and with the duty cycle $\tau/T$ ranging from ~1 to 0.5; here $\tau$ is the pulse length and $T=1/f_r$. Main attention was concentrated on the effect of (1) the pulse length $\tau$, (2) the repetition frequency $f_r$ of pulses, (3) the target power density $W_{ta} = P_{da}/S_t$ averaged over the pulse period and (4) the transient phenomena connected with switching-off pulses on the number of hard arcs generated during the reactive sputtering as a function of the film deposition time $t$; here $P_{da}$ is the power to magnetron averaged over the pulse period and $S_t = \pi r^2$ ($r=50$ mm) is the area of the target. Obtained results will be presented in details. Also, waveforms of the voltage $U_d(t)$ and current $I_d(t)$ of the magnetron discharge will be given and their effect on the film deposition rate $a_D$ will be explained.

Keywords
Reactive sputtering
Single magnetron
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Arcing
Film deposition rate