Calculation of film thickness distribution onto disk substrates in multi-cathode magnetron sputtering system with plate targets

Anatoly Kuzmichev*[1] and Oleg Volpian[2]

[1]National Technical University of Ukraine "Kiev Politechnical Institute" (NTUU "KPI") – Pobedy Pr. 37, KPI-2230, Kiev 03056, Ukraine

[2]M.F. Stelmakh Research Institute – Polus – Vvedenskogo Str. 3, Moscow 117342,, Russia

Abstract

Magnetron sputtering is one of methods to prepare high quality thin film coatings for optical and electronic applications. Film thickness distribution onto substrates in magnetron sputtering systems is of great importance for designers of deposition apparatus especially for optic fabrication. Even small non-uniformity of thickness (~ 1 %) may be not allowable for precision optics. Calculations of film thickness distribution before experimental realization of new magnetron systems are shorter way to choice of the best sputtering geometry for obtaining desired film uniformity. This work deals with calculation of sputtered material transfer onto horizontal rotating disk substrates in the multi-cathode magnetron system with horizontal and inclined sputtered longitudinal plate targets. The quantity of sputtered targets is not limited but must be an even number. Accordingly, the targets are disposed symmetrically about the horizontal main axis so that the long sides of all plate targets are parallel to the main axis. A pair of targets forms practically one cathode with common "forward-back trace-track" of one magnetron discharge, sputtering these paired targets. Such configuration of targets allows maintenance of bipolar pulse magnetron discharges (e.g. as in dual magnetrons) which are very suitable for reactive sputtering and deposition of metal oxide. The disk substrates, number of which is limited only by the length of the long side of plate targets, are disposed over the targets and the substrate surface is parallel to the main axis of symmetry. The MathCad calculations of film thickness distribution, based upon the assumptions of cosine emission of sputtered species and their ballistic collisionless trajectories, are carried out by two stages. At the first stage, the sputtered species transfer onto the horizontal surface, which the substrates lie on, is calculated for determination of distribution of the species flows along the transversal coordinate axis. This coordinate axis is orthogonal to the main axis of symmetry. Then at the second stage, the transversal distribution is recalculated into the film thickness distribution along the radius of rotating substrate. The substrate center does not move along the transversal coordinate axis. The calculations were made for various sputtering geometry parameters and different sputtering intensity of targets. The possibility was found to obtain high uniform distribution (non-uniformity may be $<<$ 1%) of film thickness on horizontal rotating substrates that allows to recommend employing the multi-cathode system for precision optic fabrication.

Keywords: Multicathode magnetron system, Film thickness distribution, Bipolar pulse magnetron

*Speaker

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