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Modelling Industrial Scale Magnetron Sputter Processes

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Bespoke sputter-coating of engineering components is typified by extensive prototyping of both deposition hardware and process. Significant reductions in time and cost, plus the potential to optimise often competing hardware traits, are offered through the efficient application of modelling to the magnetron sputtering process. Electromagnetic modelling using Finite-Element Analysis (FEA) is well established and already developing in this direction: the Opera Simulation Software package by Cobham Technical Services, which combines magnetostatic and charged-particle models to provide a multi-physics solution, estimates the target erosion profile and sputtered flux distribution for single magnetrons [1].
Here a development version of Opera is applied to industrial scale sputter deposition systems having multiple magnetrons operating in the Closed Field Unbalanced Magnetron Sputtering Ion Plating (CFUBMSIP) configuration. Industrially relevant target materials (C, Cr, Ti, Si) are considered with focus on low friction graphite based coatings [2]. Sputtered flux uniformity and target erosion profiles are simulated for different magnetic arrangements of two to four magnetrons under a range of operating conditions (power, pressure, target). These data are used to predict the coating thickness and composition on rotating components of simple geometry e.g. piston pins. Validation experiments are performed under equivalent conditions and the results compared to the simulated data. Coatings are evaluated by ball crater, SEM and EDX/WDX; magnetic fields by Hall probe measurements and target erosion is profiled optically.
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[1] http://operafea.com/product/solutions-modules/sputtering/
[2] S. K. Field et al, Tribology Int. 37 (2005) 949-956

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