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Heavy particle transport in sputtering systems[1]

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This contribution aims to discuss the theoretical background of heavy particle transport in plasma sputtering systems such as direct current magnetron sputtering (dcMS), high power impulse magnetron sputtering (HiPIMS), or multi frequency capacitively coupled plasmas (MFCCP). Due to inherently low process pressures below one Pa only kinetic simulation models are suitable. In this work a model appropriate for the description of the transport of film forming particles sputtered of a target material has been devised within the frame of the OpenFOAM [1] software (specifically dsmcFoam [2]). The three dimensional model comprises of ejection of sputtered particles into the reactor chamber, their collisional transport through the volume, as well as deposition of the latter onto the surrounding surfaces (i.e. substrates, walls). An angular dependent Thompson energy distribution [3] fitted to results from Monte-Carlo simulations is assumed initially. Binary collisions are treated via the M1 collision model [4], a modified variable hard sphere (VHS) model. The dynamics of sputtered and background gas species can be resolved self-consistently following the direct simulation Monte-Carlo (DSMC) approach or, whenever possible, simplified based on the test particle method (TPM) with the assumption of a constant, non-stationary background at a given temperature. At the example of an MFCCP research reactor the transport of sputtered aluminum is specifically discussed. For the peculiar configuration and under typical process conditions with argon as process gas the transport of aluminum sputtered of a circular target is shown to be governed by a one dimensional interaction of the imposed and backscattered particle fluxes. The results are analyzed and discussed on the basis of the obtained velocity distribution functions (VDF).

[1] OpenFOAM, www.openfoam.org.
[2] T.J. Scanlon *et al.*, Comp. Fluids **39**, 2078 (2010).
[3] M. Stepanova, S.K. Dew, J. Vac. Sci. Technol. A **19**, 2805 (2001).
[4] A. Kersch *et al.*, J. Appl. Phys. **75**, 2278 (1994).

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