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Experimental validation of plasma simulations applied to niobium coating by DC sputtering

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DC bias diode and DC magnetron sputtering are used at CERN for thin film deposition on vacuum components of various sizes, geometries, substrate and coating materials, e.g. amorphous carbon or non-evaporable getter on stainless steel, or niobium on copper radio-frequency accelerating cavities for particle accelerators. In this context, numerical simulations are studied in order to get insight of the physical phenomena and help the process optimization. A validation with respect to the experimental case is the first necessary step before application to new cases.
We present the benchmarking of a commercial 3D Particle-In-Cell/Monte Carlo code including plasma and transport modules, by comparing numerical results towards experimental data. In order to achieve quantitative validation, input parameters of interest for the simulations include buffer gas nature (i.e. argon or krypton) and ion bombardment induced secondary electron emission properties. Their influence will be detailed for diverse sputtering configurations of an experimental system (coaxial niobium rod cathode and stainless steel anode with or without axial solenoidal magnetic field, compact post-magnetron cathode with permanent magnets), enabling a range of working pressures spanning from 0.001 to 0.1 mbar. Comparison of experimental and simulated results is made in terms of plasma discharge voltage and current, local plasma parameters (as accessible through Langmuir probes) and thickness profiles of the coatings.
Applications to the coating of real radio-frequency accelerating cavities will be discussed with respect to the scaling-up from the simulation compatible low power to real process discharge power.

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