Numerical Investigation Of Bi-directional Pulsing In Dual Magnetron Sputtering

Abstract

Numerical investigation of Bi-directional Pulsing in Dual Magnetron Sputtering

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The synergistic approach of utilizing bidirectional pulsing yields a host of advantages crucial for modern thin film deposition, including unparalleled arc suppression and process stability, mitigation of the 'disappearing anode' phenomenon, higher deposition rates, and enhanced film quality.

This investigation proposes a COMSOL Multiphysics® simulation study to analyze these advantages of bidirectional pulsing in dual magnetron sputtering (DMS) systems. A two-dimensional (2D) model has been developed based on the work of Yusupov et al. [1], in which the magnetic fields of the two magnetrons are in a mirror configuration. The model's physics is defined by a cohesive coupling of the Electric Circuits, Plasma, and Magnetic Field modules within COMSOL. The results from the plasma simulation then serve as the input for a subsequent particle tracing simulation, which utilizes the Particle Tracing Module.

The simulation provides critical insights that are difficult to obtain through experimental diagnostics alone. Firstly, it visualizes the mechanism of arc suppression by mapping the temporal evolution of surface charge density on the targets and substrates, demonstrating how effectively charge buildup is neutralised before it can reach the threshold for dielectric breakdown. Secondly, the model predicts the Ion Energy Distribution Functions (IEDFs) at both the substrate and the target surfaces. This allows for a direct correlation between pulse parameters (frequency, duty cycle, voltage amplitude) and the energy of bombarding ions, which is a key determinant of film properties like density, stress, and adhesion. A comparison is also made between monopulsing and bidirectional pulsing under similar plasma conditions. This work establishes a cost-effective, simulation-driven methodology to deconstruct complex plasma physics, validates the established advantages of bidirectional pulsed DMS, and accelerates the design of next-generation sputtering processes.

Reference

References:
[1] Yusupov M, Bultinck E, Depla D and Bogaerts A 2011 Behavior of electrons in a dual-magnetron sputter deposition system: A Monte Carlo model New J. Phys. 13