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Design and Development of a Multi-Functional DC Glow Discharge Plasma Reactor for Targeted Surface Engineering and Thin-Film Synthesis

Abstract:
The transition from fundamental plasma physics to translational material science requires robust, scalable hardware capable of precise plasma-matter interactions. While plasma processing is a staple in semiconductor manufacturing, there is a lack of accessible, versatile systems capable of handling the diverse requirements of 2D/3D nanomaterials, polymers, and complex oxides in a single environment. This work presents the indigenous design and development of a Customized DC Glow Discharge Plasma Reactor optimized for the dual purpose of surface modification and plasma-assisted thin-film deposition.
This work details the design and indigenous development of a multi-functional DC Glow Discharge Plasma Reactor engineered for dual-mode operation: Surface Modification and Thin-Film Deposition. Drawing from our previous research—which demonstrated that the reactor effectively modulates the electrical conduction mechanisms and dielectric characteristics of rare-earth orthoferrites by controlling oxygen vacancy density through plasma dose management. It also aims to enhance β-phase nucleation in Graphene/P(VDF-TrFE) reinforced polymer composites films —a result traditionally difficult to achieve without high-temperature annealing. The reactor features a variable-gap and dc power supply, parallel-plate electrode geometry and a multi-gas inlet manifold for Air, Ar, N2, or O2 that maintains precise working pressures between 10-2 and 10-3 mbar. To ensure material versatility, an integrated water-cooled substrate holder allows for the simultaneous processing of heat-sensitive composite polymers and high-temperature ceramics without structural degradation.

Keywords: DC Glow Discharge; Thin-Film Deposition; Surface Modification; Graphene-Polymer Composites

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