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Complex Ionized Media and Contamination Control in Semiconductor Industry

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The field of Complex Ionized Media (CIM) delves into the physics of interactions between nano- to micrometer-sized dust particles, ionized gases (plasmas), ionizing radiation, and external electric fields. Beyond the well-studied steady-state gas discharges, these plasma systems can be non-quasi-neutral or highly transient in space, time or both.

This overview introduces the field and highlights several emerging applications where CIM is crucial. These applications include nanoparticle contamination control in the semiconductor industry [1,2] and Extreme Ultraviolet (EUV) lithography [3], and in electron microscopy, nuclear fusion, and space exploration [4].

Figure 1: Two deflecting electrodes create a horizontal electric field in the afterglow region of an inductively coupled radiofrequency plasma. This field influences the trajectories of falling microparticles, which were previously electrically charged by the plasma.

For such applications, the electrical charge that dust particles acquire from the surrounding plasma, and their interaction with it, are crucial for further development and understanding. Therefore, these aspects need to be thoroughly investigated.

This contribution will discuss past and current experimental research on particle charging processes and plasma-particle interactions, particularly in the spatial, temporal, and spatiotemporal afterglows of low-pressure plasmas. The influence of plasma parameters and system geometry will be examined, along with the significant role of the material properties of the particles interacting with the plasma.

The presented research will demonstrate that by applying plasma afterglows and externally generated electrostatic fields, the trajectories of microparticles can be extensively controlled. Plasma-based concepts for nanoparticle contamination control, especially in the semiconductor industry, will be discussed, and future research necessary for the success of these methods will be proposed.

References

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