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Influence of Electrode Materials and Plasma Conditions on Fusion Rate in Inertial Electrostatic Confinement Fusion System

Fusion within Inertial Electrostatic Confinement (IEC) devices occurs through three primary mechanisms, primarily influenced by plasma conditions and the electrodes material: beam-beam interactions, beam-background gas collisions, and beam-target interactions with electrode surfaces. Beam-background and beam-target fusion mainly contribute to neutron production. The rate of beam-background fusion increases with ion energy and gas pressure, leading to higher fusion rates at elevated electric field in the plasma.

Beam-target fusion, which is influenced by the electrode material, plays a significant role, particularly at lower electric field in the plasma. This study investigated various materials to elucidate the effect of plasma conditions and electrode materials on the fusion rate within the IEC system. It was found that titanium (Ti) electrodes are more effective than stainless steel (SS) due to their higher deuterium retention capacity. Ti electrodes facilitate fusion reactions more efficiently by providing a larger reservoir of deuterium atoms for incoming ions. Experimental results indicate that neutron production rates (NPR) in Ti-based IEC chambers are three to four times higher than those in SS chambers. Furthermore, prolonged operation of Ti anodes enhances NPR as deuterium continues to accumulate on the electrode surface, thereby further improving fusion efficiency.

Optimizing plasma conditions in conjunction with selecting appropriate electrode materials is crucial for maximizing IEC fusion performance. Materials with superior deuterium absorption and retention offer a practical approach to increasing neutron yield, making them an optimal choice for IEC applications targeting higher fusion rates and enhanced efficiency.

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