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Technology Offer

Ion beam extraction apparatus and method for creating an ion beam

Ref.-No.: 1801-5973-WT

Abstract

This innovative ion beam extraction system enhances flexibility in beam parameter adjustment and improves the efficiency of ion beam generation. The system combines an ion source with an adjustable grid assembly, where grid spacing can be precisely controlled via a motorized mechanism. This setup allows for optimal perveance tuning and minimizes beam divergence, significantly improving performance under varying operating conditions. While primarily designed for Neutral Beam Injection (NBI) in fusion plasma applications, the technology is versatile, offering solutions for ion implantation, coating processes, and medical particle beam therapy. Its adaptability enables independent control of particle energy and current underscoring the technology's versatility across diverse applications.

Background

Traditional ion beam systems, such as those used in NBI for nuclear fusion reactors, rely on fixed grid spacings, limiting operational flexibility. In such systems, the power output of a neutral ion beam is tightly coupled to the extraction voltage, so that any reduction in beam energy significantly decreases beam power. This inherent inflexibility creates challenges in applications requiring dynamic adjustments to beam energy, such as ion implantation, fusion reactors, and medical therapies. To overcome these limitations, advancements in ion beam extraction technology are necessary to enable more efficient, adaptable systems that meet the demands of diverse and evolving applications.

Technology

This invention pertains to an ion beam extractor within an ion beam extraction (NBI) system, distinguished by its use of a movable grid. The ion beam extractor is designed for applications such as an NBI system in fusion plasma plants. As illustrated in Fig. 1, the system comprises three grids arranged to facilitate the ion beam extraction from an ion source, with a neutralizer device converting a substantial portion of the ion beam into a neutral particle beam for plasma injection. The plasma grid is adjustable along the beam axis by a motorized grid drive device, enabling precise control of the distance (d) between the plasma and extraction grids within a range of 5 mm to 25 mm. This adjustable grid distance (d) is controlled remotely via a computer, optimizing perveance in relation to a certain extraction voltage (V_{ex}) and extracted ion current (I_{ex}). The grid movement is precisely managed by multiple fine-threaded drive spindles, which are rotated by a pressurized air motor that drives the spindle nut, shifting the plasma grid parallel to the beam axis. Flexible vacuum feedthroughs maintain electrical insulation under high voltage while preserving the vacuum environment. This flexibility in grid distance adjustment enhances ion beam parameter optimization, supporting constant injection power over a wide range of voltages and currents, minimizing beam divergence, ensuring optimal beam quality and increasing operational versatility.

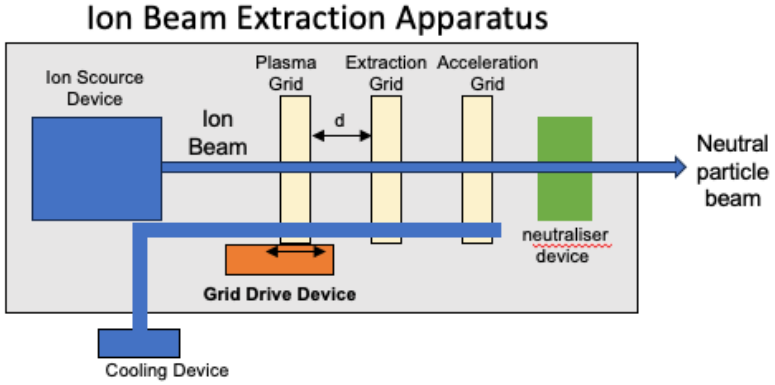

Figure 1: The ion beam extraction system includes the ion source device, three grids, grid drive device and neutralizer device. The grid drive device adjusts the distance between the plasma and extraction grids (denoted as "d"), optimizing the ion beam for conversion into a neutral particle beam.

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Advantages

- **Flexible Parameter Settings:** Adjustable grid spacing allows for precise control over ion beam parameters, allowing the system to adapt dynamically to various operational requirements.
- **Minimized Beam Divergence:** Optimized grid spacing reduces beam divergence, enhancing beam focus and overall quality for more efficient energy transmission.
- **High-Voltage Compatibility:** Electrically insulated, movable grids support operations at voltage potentials up to 1 MeV, ensuring safe and reliable performance in high-voltage applications.
- **Enhances Beam Stability:** Fine-threaded spindles and high-precision drive mechanisms contribute to stable grid movement, supporting consistent beam quality.
- **Remote Operation:** Computer-controlled grid adjustments allow for remote fine-tuning, enhancing safety and ease of use in critical environments.

Potential applications

- **Neutral Beam Injection (NBI) Systems:** Enhances efficiency and flexibility in plasma injection for nuclear fusion reactors, supporting variable plasma conditions.
- **Ion Implantation:** Provides precision control of ion currents and energy for semiconductor doping, enhancing manufacturing accuracy in microelectronics.
- **Industrial Coating Technology:** Enables advanced control for ion beam processes in high-precision coating, applicable in optics, tools, and surface treatment.
- **Medical Particle Beam Therapy:** Improves precision and control in therapeutic particle beam therapies, improving targeting accuracy for cancer treatments.
- **Ion Propulsion Systems:** Supports efficient and controlled ion generation for advanced propulsion in aerospace technologies.

Patent Information

PCT application (WO2021259446A1) regionalized in EP and US
Priority date: 22.06.2020 (PCT/EP2020/067321)

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