Technology Offer

Adaptive deflection technology to reduce thermal hotspots caused by charged particles

Ref.-No.: 1402-6785-WT-FG

Abstract

In fusion reactors and similar high-energy technologies, charged particles can strike certain surfaces and cause significant localized heating. This can lead to material fatigue and component damage. The invention presented here uses an innovative method to reduce the thermal stress by deflecting the particles. By controlling magnetic and electric fields, the point of impact of the particles is continuously shifted so that the thermal load is distributed over a larger area. Temperature-controlled adjustment of the deflection ensures effective heat dissipation and extends the life of critical components.

Background

Neutral beam injection (NBI) is used in fusion reactors for heating the plasma to high temperatures. High energetic neutrals are generated in NBI facilities by: accelerating ions exiting an ion source; neutralizing a major part of the accelerated ions to generate high energy neutrals; and separating residual accelerated ions from the high energetic neutrals by means of a constant magnetic field, which, due to the Lorentz force, diverts the ions to a collector plate. In conventional NBI facilities the diverted ions deposit up to 50 MW/m² onto a very limited area of the collector plate, leading to strong local thermal overloading of the collector plates. A more uniform distribution of the heat load is needed, so as to avoid undesirable hotspots on the collector plate.

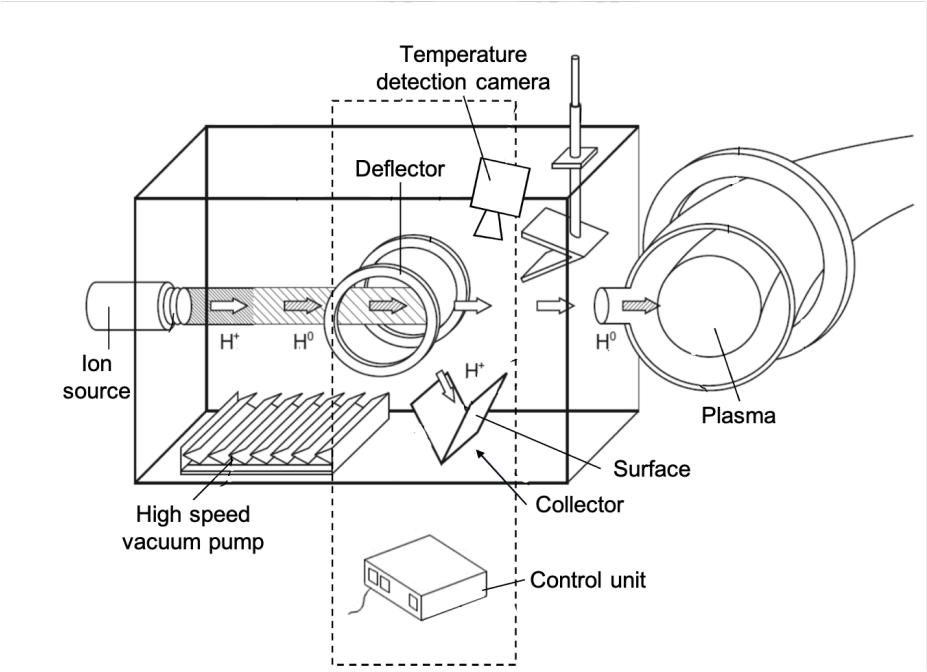

Figure 1: Schematic of the novel NBI facility designed to reduce thermal hotspots caused by high energetic charged particles. Charged particles (H^+ ions) are deflected after neutralization by a (periodically) varying magnetic/electric field to allow for a more uniform heat distribution on the collector plate. A temperature sensing camera monitors the heat distribution while a controller adjusts the deflection of the particles in real time. This prevents hot spots and evens the thermal load on the surface.

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de

Technology

The technology facility uses magnetic and/or electric fields that vary periodically in time in order to influence the trajectory of charged particles/ions and vary their points of impact on the surface of the collector (Fig. 1). Particularly effective is the combination of two magnetic fields acting in different spatial directions. The continuous or incremental change of the field strength spreads the impact point of the particles over a larger area. Accordingly, the thermal load is distributed more evenly and the formation of local hotspots is avoided. The formation of local hotspots can be more efficiently prevented by controlling the field strength based on real-time temperature measurements. An infrared camera or other temperature sensors monitors the heat distribution on the collector surface, and a control unit adjusts the field parameters based on the monitored heat distribution.
This technology can be incorporated in existing conventional NBI facilities, thereby reducing their thermal peak load on the collector plate and minimizing their energy consumption required for cooling mechanisms.

Advantages

- **Effective heat distribution:** Reduces local hot spots by deflecting particles.
- **Extended life:** Protects components from thermal overload and material damage.
- **Energy Efficiency:** Reduces the need for additional cooling mechanisms.
- **Flexibility:** Adaptable deflection of particle beams in multiple spatial directions.
- **Real-time control:** Dynamic deflection adjustment based on temperature measurements.

Potential applications

- **Fusion reactors:** Protection of ion traps and other heat-sensitive components in NBI facilities.
- **Plasma technology:** Improved material durability in high-temperature applications.
- **Particle Accelerators:** Controlling the deflection of charged particles for experiments and industrial applications.
- **Satellite and space technology:** Protecting sensitive components from particle radiation.
- **High-power laser systems:** Heat dissipation in optical components exposed to charged particles.

Patent Application

PCT (not published)

Contact

PD Dr. Wolfgang Tröger Senior Patent- & License Manager, Physicist
Phone: +49 (0)89 / 29 09 19 – 27
eMail: troeger@max-planck-innovation.de

Dr. Franz Gadelmeier Patent- & License Manager, Physicist
Phone: +49 (0)89 / 29 09 19 – 13
eMail: gadelmeier@max-planck-innovation.de