Ion and Neutral Beams

Neutral Powers

The problem of heating a fusion plasma to thermonuclear temperatures has been successfully addressed by the development of systems that inject beams of neutral atoms. Neutral particles can be injected into a magnetically confined plasma because they are not affected by the magnetic fields. Once inside the plasma, they ionize and transfer their heat to the plasma.

Neutral beam injection systems have been used on fusion devices for over 30 years, and the ion source and accelerator technologies developed for these systems have led to applications in physics research, environmental studies, defense, aerospace, materials processing, manufacturing, and medicine.

The creation of a neutral beam begins in an ion source like the one shown below that produces a plasma. Ions (charged particles) are extracted from this plasma and accelerated to form a beam. The beam is coupled to a neutralizer, in which most of the ions are converted into energetic neutral particles. The unneutralized (charged) component of the beam is magnetically deflected away, leaving the neutral particles.

In addition to their usefulness in heating a fusion plasma, beams of atoms or molecules moving at high speeds interact with surfaces in several ways. The surface may be etched by physical or chemical reactions with the particles. Thin films may be deposited on the surface or "grown" from chemical reactions between the particles and the surface. Energy may be transferred between the particles and the surface. Ions can be implanted in the surface. The rates at which these interactions with surfaces take place depend on the energy of the particles, which is typically given in millions of electron volts (MeV).

If the ions are to be accelerated to energies of less than 0.1 MeV, positive ions are generated and then neutralized. For energies above 0.1 MeV, it is more efficient to start with negative ions and neutralize them.

The program to develop neutral beams for fusion has produced high-current sources of positive and negative ions of hydrogen and deuterium, the elements of principal interest for fusion applications, and accelerators that can accelerate these beams to energies of 0.1 MeV, with 1.3 MeV a potential development in the future.

Long-pulse positive ion sources were produced by RCA for heating the plasmas in the Tokamak Fusion Test Reactor and the DIII-D tokamak, the lead experiments in the U.S. magnetic fusion program. Related development has led to metal vapor vacuum arc, or MEVVA, sources, which can produce positive ion beams from all solid metallic elements. This type of source, which can be combined with plasma processing, is beginning to find commercial applications. ISM Technologies, Inc., is using these sources to process surfaces for improved resistance to wear and corrosion.

Negative ion sources are also finding applications in areas as diverse as defense, high-energy physics, and medical research. A negative ion source has been supplied to Grumman Aerospace Corporation for the Neutral Particle Beam Program of the Strategic Defense Initiative. Development of