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Plasma Shield for In-Air and Under-Water Beam Processes[1]

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As the name suggests, the Plasma Shield is designed to chemically and thermally shield a target object by engulfing an area subjected to beam treatment with inert plasma. The shield consists of a vortex-stabilized arc that is employed to shield beams and workpiece area of interaction from atmospheric or liquid environment. A vortex-stabilized arc is established between a beam generating device (laser, ion or electron gun) and the target object. The arc, which is composed of a pure noble gas (chemically inert), engulfs the interaction region and shields it from any surrounding liquids like water or reactive gases. The vortex is composed of a sacrificial gas or liquid that swirls around and stabilizes the arc. In current art, many industrial processes like ion material modification by ion implantation, dry etching, and micro-fabrication, as well as, electron beam processing, like electron beam machining and electron beam melting is performed exclusively in vacuum, since electron guns, ion guns, their extractors and accelerators must be kept at a reasonably high vacuum, and since chemical interactions with atmospheric gases adversely affect numerous processes. Various processes involving electron ion and laser beams can, with the Plasma Shield be performed in practically any environment. For example, electron beam and laser welding can be performed under water, as well as, in situ repair of ship and nuclear reactor components. The plasma shield results in both thermal (since the plasma is hotter than the environment) and chemical shielding. The latter feature brings about in-vacuum process purity out of vacuum, and the thermal shielding aspect results in higher production rates. Recently plasma shielded electron beam welding experiments were performed resulting in the expected high quality in-air electron beam welding. Principle of operation and experimental results are to be discussed.

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