

The Plasma Window: Star Trek technology for building better ships, airplanes and automobiles

Wednesday November 18 session JIIB (Plasma Applications Technology), begins at 15:00 in Room Chatham A/B

(Paper Summary) Plasma Window is a novel device that separates vacuum from atmosphere, yet is transparent to, and facilitates transmission of, electron beams to atmosphere without degradation for unprecedented propagation and welding in air.

Scientists at the U.S. Department of Energy's Brookhaven National Laboratory will report on the promise of a new welding technique developed by Brookhaven and Acceleron Inc., in which a plasma window is mated to a conventional electron-beam welder. This device has achieved low-power welds under normal atmospheric conditions with quality comparable to welds made in a vacuum.

Electron Beam Welding (EBW) provides the highest quality welds available with modern metal joining technology. EBW offers many advantages over all other welding techniques: low heat input at the weld zone; minimal thermal distortion; high depth-to-width ratios; precise, repeatable welds; and the ability to weld similar and dissimilar metals. Until now, however, high-quality EBW had several drawbacks, since it had to be performed in a vacuum (because electron guns, their extractors and accelerators must be kept at a reasonably high vacuum).

These limitations resulted in low production rates due to required pumping time and limits on the size of target objects, which also had to fit within the vacuum. Large objects, such as ships, cars, and airplanes, could not benefit from high-quality electron beam welding. Nor could the problem be solved by conventional non-vacuum EBW — due to degradation of electron beams through foils or differentially pumped sections, which compromise weld quality and require high electron-beam power.

A novel apparatus, called Plasma Window, utilizes plasma as vacuum-atmosphere interface. Electric and magnetic fields confine plasma whose pressure balances the atmosphere enabling welding electron guns to operate in vacuum bearing some resemblance to the Starship Enterprise, where “force fields” in windows and shuttle bays keep the ship atmosphere from escaping to space. In addition to sustaining vacuum atmosphere interface, the plasma has a very strong lensing effect on electrons that focus them to very small spot sizes resulting in very high current densities, which allow for “air-boring.” Air-boring is a phenomenon in which electron beams propagate in atmosphere without expanding (to perform high quality welds), unlike electron beams generated by conventional non-vacuum electron beam welders.

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Top Photo: A 20 mA 150 KeV electron beam propagating in air without expanding as a conventional non-vacuum electron beam would.

Bottom Photos: Sample electron beam welds made in a vacuum (L) and in air (R) using the plasma window device. Notice their height -to- width ratio similarity.

