The formation of metallic plasmas in transient capillary discharges at high current

Article in Plasma Sources Science and Technology 15(3):538 · June 2006
DOI: 10.1088/0963-0252/15/3/033

Abstract

We report observations of the formation of a metallic plasma in a high aspect ratio z-pinch confined within a ceramic capillary. A series of experiments on different capillary geometries was undertaken in which titanium metal rings were used to promote the formation of a titanium plasma through preferential ablation. In an initial vacuum a titanium seed plasma is formed in the hollow cathode (HC) volume by a low energy laser spark. This pre-ionizing plasma is assisted in its expansion into the z-pinch volume by the electron beams generated by a pre-ionizing discharge in the capillary, due to the HC effect. Further intense e-beam activity occurs on applying the main driver current to the capillary electrodes before the discharge impedance abruptly drops to give rise to an ensuing high current z-pinch. A segmented titanium ring structure within the capillary promotes metal ablation. The discharges are performed in tubes of 60 to 110 mm length and 3 and 5 mm effective internal diameter. The main discharge current is provided from a small pulsed power switched coaxial line, at up to 150 kA. The generator may be configured to deliver two different rates of current rise and this is found to have a significant effect on the plasma dynamics. The plasma properties are obtained from observations of the axial x-ray emission. The diagnostics used are filtered Si diodes, filtered time-resolved multi-pinhole camera images and the time resolved soft x-ray spectrum from 3 to 20 nm. While a single species metal plasma is not obtained, a very significant proportion of Ti is achieved in the higher rate of current rise configuration. The fraction of Ti diminishes for the longest length discharges and for the larger diameter tube diameter, as does the observed z-pinch uniformity. There is a weak dependance of the electron temperature with tube geometry, but the plasma density falls substantially in the longer discharges. This coincides with diminished effectiveness of the transient HC.