X-ray diagnostics of high-current discharge in a high-pressure gas

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Results are presented from experimental studies of self-constricted discharge in dense hydrogen at initial pressure of hydrogen up to $10MPa$ and current amplitude up to $1.6MA$ with current raise rate $dJ/dt \sim 10^9 - 5 \cdot 10^{10} A/s$. An experimental complex for flash x-ray radiography diagnostic and self-SXR detecting is described.

The aim of these studies was to increase the energy density in the discharge channel, to investigate mechanisms for energy transfer from the discharge to the ambient gas, and to determine the parameters of the plasma [1]. The main diagnostic problem for such conditions is high density of the discharge channel. Only x-ray methods can manage direct diagnostic of inner channel plasma.

The experiments were performed in axial geometry. The diameters of steel electrodes were $20mm$ and the discharge gap was $5 - 20mm$. Detail description of the experimental setup can be found in [2].

1. Flash radiography

The X-ray diagnostic system for determination of metal vapour concentration, based on pulsed X-ray source with hardness of $20 - 50keV$ and X-ray CCD camera, was designed. Two samples of nanosecond generators (with duration of pulses $10 - 20ns$ and $50ns$) and two types of X-ray tubes (through-target and anticathode) were designed and used.

Experimental data on spatial metal vapour distribution in discharge gap, provided by electrode erosion, were obtained (fig. 1). The result of experiments show that main part of metal vapours concentrates to the axis of discharge channel.

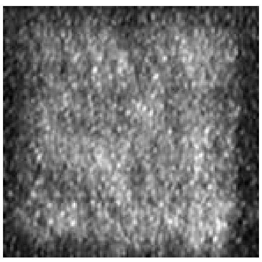

Fig. 1: *Radiography image of discharge gap at* $20\mu s$ *after initiating discharge with current amplitude* $600kA$

2. X-ray self-radiation

Designed complex for detecting SXR from the discharge channel and difficulties with its development are described in [3]. Typical signal of SXR from channel is shown on fig. 2.

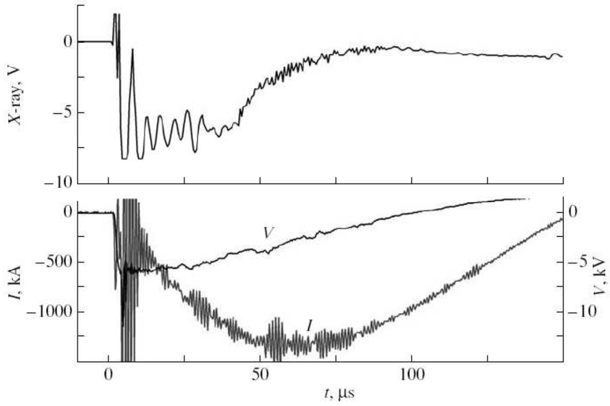

Fig. 2: *Typical oscillograms of current, voltage and x-ray signal*

The brightness temperature of external hydrogen shell surrounding the discharge channel was $1 - 9eV$. It was measured by two monochromatic pyrometers with effective wavelengths 694 and $550nm$. The SXR intensity was measured with $SPD - 8UVHS$ photodiodes. Temperature of the central zone, from which SXR is registered, achieves several hundreds eV. SXR hardness was increased with current raise rate but visible brightness was decreased.

The constricted discharge channel surrounded by hydrogen shell can be used for producing pure photoionized hydrogen plasma, for modelling various astrophysical phenomena.

References

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