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APPLICATION OF A CCD MATRIX FOR RECORDING THE SPATIAL LOCALIZATION AND ENERGY COMPOSITION OF X-RAY RADIATION FROM THE VOLUME OF AN ECR PLASMA SOURCE *)

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One of the primary and reliable methods for experimentally studying the hot component of ECR plasma is the detection of its radiation in the X-ray region of the electromagnetic spectrum. Most such studies rely on scintillation spectrometry methods, which combine sufficient simplicity with the reliability of obtained results [1]. Spatial visualization of both the plasma's own radiation and the radiation resulting from its interaction with components of the vacuum chamber can provide additional insights into the discharge structure and the processes generating the observed radiation.

The study presents experimental results on the investigation of soft X-ray radiation from the volume of the compact ECR plasma source CERA-RX, an original design [2]. The CERA-RX source consists of a cylindrical half-wave coaxial resonator (2.45 GHz, 0.01–10 W) supplemented with a target electrode. Under these conditions, the plasma's electron component predominantly undergoes azimuthal drift in the space between the electrodes of the coaxial resonator, caused by the radial inhomogeneity of the magnetic field within the resonator. The design features of the plasma source's magnetic system allow for adjusting the radial position of the ECR zone, thereby providing conditions for the effective deposition of hot electrons onto the lateral surface of the target electrode.

A modified digital camera based on a standard CCD matrix (SONY ICX285AL) was used as a radiation detector for the volume of the ECR plasma source. These enhancements allowed reliable detection of radiation in the 3–19 keV range with exposures of up to 15 minutes. The radiation detection mode, characterized by predominant single-photon counting in each matrix pixel (event rejection), achieved through optimized exposure times and software post-processing, enabled both the spatial localization of the plasma's hot component and an evaluation of its energy spectrum. Empirical verification confirmed this capability, determining the brightness function of the matrix pixels as a function of the energy of the characteristic lines of test samples. The resulting energy resolution was no worse than 1–1.5 keV. A similar approach to the use of CCD matrices in experiments investigating the hot component of plasma has shown dynamic progress in recent years in both methodologies and hardware advancements [3].

The analysis of the data obtained from the CCD matrix enabled the determination of the operational parameters of the ECR plasma source based on the localization and spectral composition of the radiation (presence or absence of characteristic lines). It was established that under these conditions, 90% of the radiation detected by the matrix originated from the target, while radiation resulting from interactions with atoms of the working gas and the walls of the vacuum chamber was practically absent. Additional experiments conducted using various dosimetric equipment and methods estimated the exposure dose rate to be approximately 30 R/h at a distance of 0.3 meters from the source, with a maximum gamma-photon energy of 50 keV.

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