A NANOSECOND DISCHARGE-BASED X-RAY SOURCE IN ATMOSPHERIC PRESSURE AIR WITH A SUBNANOSECOND PULSE DURATION

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X-ray radiation characteristics from a diode filled with atmospheric pressure air were investigated A source of soft X-ray radiation with the FWHL less than 200 ps and exposure doze of about 3 mR per pulse has been created. The experiments have shown that massive-anode gas diodes filled with atmospheric pressure air are the sources of soft X-ray radiation with a subnanosecond pulse length. The largest exposure doses are reached when using pulses with the voltage pulse amplitude >100 kV, pulse edge length ≤0.5 ns and a potential anode made of metals with a great order number as well as at formation of a diffusive discharge in a gap. An exposure dose ~3 mR was obtained when using a tantalum anode and a contribution into the exposure dose was made by electrons with the effective energy of quanta equal approximately to 9 and 17 keV. Under conditions of a gas diode, the fraction of bremsstrahlung radiation in the measured exposure dose essentially exceeds the fraction of characteristic radiation. To obtain soft X-ray radiation, it is better to use a massive anode. Optimum conditions for generation and ejection of soft X-ray radiation from the gas diode are obtained under these conditions. Increase of soft X-ray radiation yield can be expected owing to optimization of the anode shape.

Maximum X-ray exposure doses downstream of the foil are attained in the case where the number and the energy of runaway electrons increase during their drift in the gap. This is realized under the conditions of supershort avalanche electron beam (SAEB) generation when the critical field for runaway of the electrons is attained not only near the cathode, but in the gap between the polarized plasma and the anode as well. Under the conditions of SAEB generation, the X-ray intensity increases primarily due to the deceleration of runaway electrons at the anode, and this results in high-power and short bremsstrahlung X-ray pulses. The maximum exposure doses were obtained with anodes made of metals of high atomic number. The X-ray pulse duration was ~0.2 ns at FWHL and was limited presumably by the resolution of the employed detectors.

In comparison with subnanosecond sources of soft X-ray radiation based on vacuum diodes, the sources with the gas diodes filled with atmospheric pressure air are notable for their simplicity and effectiveness and have long lifetime. When using a gas diode, there is no necessity to form a subnanosecond-length high-voltage pulse that considerably simplifies the pulser design and there is no necessity to use vacuum-dense comparatively thick foils for ejection of X-ray radiation that essentially increases reliability of the diode and simplifies its design.