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SUBGIGAWATT POWER LEVEL KA- AND W-BAND CHERENKOV OSCILLATORS WITH TWO-DIMENSIONAL PERIODIC SLOW-WAVE STRUCTURES *

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The original concept of powerful pulsed spatially-extended Cherenkov oscillators is being developed at the Institute of Applied Physics of the Russian Academy of Sciences (Nizhny Novgorod). A distinctive feature of the ongoing research is the use of high-current relativistic electron beams (REB) of tubular geometry, which allows increasing the total power of the oscillator by increasing one of its transverse dimensions while maintaining moderate current densities and electromagnetic field strengths. Under conditions of a large oversized factor, the spatial coherence of radiation is achieved by using two-dimensional (2D) distributed feedback (DFB). To implement 2D DFB, 2D Bragg structures are used, in which transverse wave flows synchronize the radiation of tubular REBs.

A spatially-extended Cherenkov-type surface wave oscillator (SWO) operating in the Ka-band is being developed on the basis of the "Sinus-6" high-current explosive-emission accelerator 0.5 MeV / 5 kA / 25 ns (IAP RAS), which forms oversized tubular electron beam with a diameter of about 40 mm. Oscillators of this type are characterized by deceleration of the main wave and provide a high impedance of electron-wave interaction. To operate in this frequency range, a 2D slow-wave structure (SWS) of cylindrical geometry with an average diameter of Ø = 44.3 mm (perimeter of about 16 wavelengths) and a length of about 16 cm was designed, having a 2D sinusoidal corrugation with a period of 7.75 mm, a depth of 3.5 mm and 16 azimuthal variations. The simulation of the SWO was carried out using the three-dimensional PIC code CST Studio Suite with parameters close to the experimental conditions. The simulation results demonstrate the establishment of a narrow-band oscillation regime with an output power of 0.4 - 0.5 GW and an electronic efficiency of ~ 25% at optimal parameters. The structure of the operating slow wave field has an azimuthally symmetric distribution and is a set of $TM_{0,n}$ – type modes of a cylindrical waveguide. In the initial experiments, in the calculated range of parameters, narrow-band radiation was registered at an operating frequency of about 32 GHz with an output power of ~ 0.2 – 0.3 GW. The radiation pattern of the output radiation, which was analyzed using a panel of neon lamps installed at different distances from the oscillator, was characterized by a pronounced minimum on the axis, which corresponded to the excitation of the calculated set of $TM_{0,n}$ – type modes. Currently, experiments are being carried out to optimize the configuration of the interaction space to achieve the calculated power.

To operate in the W-band (operating frequency ~ 75 GHz), the SWO was developed on the basis of the same electron beam formed by the "Sinus-6" accelerator. For this oscillator, a 2D SWS of cylindrical geometry was designed with an oversized factor Ø/λ ~ 10 (system perimeter ~ 30 wavelengths), a corrugation period of 3.59 mm, an azimuthal number of variations of 32, a corrugation depth of ~ 1 mm, and a total length of about 10 cm. The simulation demonstrated the establishment of a stable narrow-band generation regime with selective excitation of operating azimuthally symmetric wave at the calculated parameters. According to the simulation, the electronic efficiency of the oscillator is ~15 - 20%, and the expected output power level reaches ~ 0.3 – 0.35 GW. At present, a 2D periodic SWS of the W-band with the described geometry has been manufactured and the assembly of the oscillator has been completed. In the initial experiments, narrow-band radiation with a power level of ~ 0.2 GW was obtained in the calculated range of parameters. Experimental studies of this oscillator are currently in progress.

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